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WIP: Using Human-Centered Design and Data analytics to improve student access and success in an undergraduate pre-engineering program

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***Abstract*—** This WIP project focuses on the declining STEM proficiency in the United States, requiring universities to explicitly focus on and understand students' needs. It explores students' learning experiences, attitudes, and challenges in pre-engineering at a public university in Michigan. College access and success are some of the most pressing issues confronting the United States in post-secondary education. This work aims to address and investigate the barriers perceived by students while entering pre-engineering, understand their experiences during the program and examine pre-engineering through professors' and academic advisors' lenses. Thus, focusing on the challenge framed: "How might we understand students' learning experiences, attitudes, and struggles about the support provided in pre-engineering?".

This three-phased, concurrent mixed methods study follows a ToC (Theory of Change) framework utilizing the human-centered design (HCD) process to examine the current pre-engineering program at a public university in Michigan. The ToC framework assists in planning, monitoring, and evaluating the specific goals of a pre-engineering program and articulating long-term outcomes and interventions to improve student experiences. ToC prioritizes the voices/perspectives often left out of the discussion about change. Several participants (students, professors, and academic advisors) who are directly impacted by the success of the pre-engineering program are invited to participate in this study, and their perspectives are adequately addressed. The HCD method includes interviewing and understanding student needs and using contextual inquiry to address and investigate the experiences/needs of students, professors, and academic advisors w.r.t student success in pre-engineering.

The first phase is a qualitative exploration of a student's experience during pre-engineering admission and their experiences during the program. This is done by collecting (survey and interview) data from pre-engineering students (current and alumni). Preliminary insights help design interventions to improve the program. The impact of these interventions is analyzed using a follow-up survey of current pre-engineering students some months later. In the second phase, qualitative interviews and observations will probe significant results by studying pre-engineering professors' and advisors' perceptions and experiences. The responses from both phases will be analyzed using a mixed (quantitative and qualitative) methodology to better understand different participants' perspectives based on numeric trends and respective detailed perspectives. Findings from these two qualitative phases are used to deepen understanding of the perceptions of the students, professors, and advisors. Thus, identifying factors most strongly associated with pre-engineering program success. Lastly, phase three includes a co-design session that focuses on getting feedback on new ideas to improve the current pre-engineering program. This phase uses ToC to document the impact participants seek to achieve and all the intermediate steps to ensure that respective activities and resources are well aligned to achieve the desired change.

This work examines the factors contributing to a successful pre-engineering program at a public university in Michigan. It attempts to elaborate and identify the support needed in a pre-engineering program to assist students better. Additionally, recommending ways to create a successful pre-engineering program may give students more opportunities to follow academic and professional paths.

Keywords—Theory of Change, human-centered design, enrollment, retention, college access, recruitment, education.

I. INTRODUCTION

Science, technology, engineering, and mathematics (STEM) education focuses on educating future generations to be successful in their professions. A decline in STEM proficiency has been reported in America, leading to significant regression from its position as a global leader in math and science. Debbie Myers, general manager of Discovery Communications in STEM Diversity Symposium concluded: "International comparisons place the U.S. in the middle of the pack globally." For the United States to achieve a competitive advantage, there is a need to encourage young people to develop a passion for learning and specifically encourage minorities and females to pursue STEM careers [1].

Another report named "Rising above the Gathering Storm" indicated that the U.S. is losing market share in math and science competence [2]. College access and success are among the most pressing challenges confronting the country, where higher education attainment is a critical criterion for student achievement and economic advancement. Moreover, the United States will not achieve the required level of educational attainment without eliminating the significant inequalities across demographic groups [3]. It requires explicitly focusing on the inclusion and retention of underrepresented minority (URM) groups, including women, first-generation students, and certain racial and ethnic groups, including African American, Latino, Native American, etc. [4].

Despite effective attempts to improve college access and degree completion for students from lower socioeconomic status (SES), considerable gaps exist [5]. Enrollment is decreasing by 2.6 percent every year [6]. Students from low-income families, students who are the first in their family to attend or complete college, and students from racial and ethnic minority groups all have much lower rates of achievement than the national average [7]. According to the Current Population Survey [include citation], roughly 2.3 million 16- to 24-year-olds were not enrolled in high school in 2016 and did not have a high school diploma or equivalency degree. These status dropouts had a rate of 5.2 percent for White students, 8.6 percent for Hispanic students, and 6.2 percent for Black students [8]. Additionally, students from lower socioeconomic status backgrounds are five times more likely to drop out of high school than those from higher socioeconomic backgrounds [6]. These vast disparities show that effective initiatives are needed to enhance low-SES students' access to education and address racial divisions and inequality.

To promote college access and success for low-income and first-generation students and address various barriers, particularly for students from historically underrepresented groups in higher education, there is a need for a multifaceted, systematic approach as well as involvement from a variety of stakeholders [7],[9]. To address this challenge, we must first understand the students' pathway from college admission to graduation and the support they require along this journey.

Students take a wide range of pathways to pursue their STEM careers, and sometimes they face barriers along the path to earning a degree. These barriers may include departmental, institutional, and national policies and the frequency of institutional-level engagement with students [10]. One pathway includes pre-engineering (PENG) programs, which give students the fundamental competencies, knowledge, and abilities needed to transition to an engineering bachelor's program, which significantly impacts students' careers. PENG programs are often designed to support students in strengthening their math and science foundations and providing necessary academic help, without which students enrolling in bachelor's programs may typically end up not completing the program, repeating math subjects, and not matriculating in upper-level engineering courses, while also accumulating debt. Preliminary research findings provide a starting point to study and recognize the economic limitations faced by the students of specific Zip Codes and assist University administrators and policymakers in formulating strategies to attract and enroll more students [11].

II. RESEARCH QUESTIONS

A. The guiding research questions for this study are as follows:

- In what ways does the PENG program help students to succeed academically?
- To what extent and in what ways does the University's frequency of engagement with students prior to PENG college admission affect their college access and success perception?
- How do PENG students describe their program experiences at a public University?
- How can we redesign the PENG program to better support students?
- What similarities exist between under-recruited Zipcodes in Michigan and student representation in the PENG program at a public University?

These guiding questions help in examining students' needs, comfort issues, and concerns about the support provided in a PENG program and further assist higher education personnel in enhancing their office's tools and processes to better support students and use data more effectively to better track, identify, and support students.

B. Abbreviations and Definitions of Technical Terms

- STEM — Science Technology Engineering and Mathematics.
- GPA — Grade point average.
- ToC — Theory of Change
- HCD — Human Centered Design
- CECS — College of Engineering and Computer Science
- START — Student Advising and Resource Team
- Pre-engineering programs (PENG) — pre-college programming and curriculum that supports engineering pathways

III. PURPOSE OF THE STUDY

The results from the preliminary work provide the researchers with additional insights into the community characteristics that admitted students represent and also reinforce the need to address variation of educational access to resources within Zipcodes. In addition, some questions remain unanswered. For instance, what percentage of students in the preliminary analysis followed a PENG pathway? How does the experience of PENG students differ from Undergraduate engineering students whose pathway did not begin in the PENG program? How might a university work with target students to develop an effective program? Thus, the current study focuses on the experiences of PENG students at a public University and their perception of its impact and success on their pathways.

This study examines the PENG program by gathering information, analyzing data, and learning about the students' college access, enrollment, and success. Research related to PENG programs is limited, especially considering students' experiences and perspectives for program improvement. This work aims to address and investigate the barriers perceived by students while entering PENG programs and understand their experiences during the program. In addition, we examine the PENG program through professors' and academic advisors' lens. Thus, focusing on the challenge framed: "How might we understand students' learning experiences, attitudes, and struggles about the support provided in a PENG program?".

This research starts with understanding student learning experiences, attitudes, and struggles with the support provided in a PENG program. It includes interviewing students,

asking them to share their experiences within this program, and examining their behavioral needs and issues. Furthermore, it helps understand their PENG perceptions and the improvements they need from an advising standpoint. The next step involves analyzing academic support and mentoring techniques, specifically in PENG programs. It involves interviewing professors in the PENG program, and the academic advisors including the Student Advising and Resource Team (START) to enhance their office's tools and processes to better support students.

IV. REVIEW OF LITERATURE

Developed nations, including the U.S., have had severe shortages of competent engineers. Recent research indicates that one factor contributing to this scarcity is low student enrollment and high retention rates, which are significant issues in higher education, particularly in STEM education [12]. There is a critical need to broaden the domestic STEM workforce [13]. Also, there is a need to address challenges and barriers to the involvement of traditionally underrepresented communities in STEM fields (e.g., minorities, women, individuals with disabilities, military veterans, and individuals from lower socio-economic backgrounds). This will ensure that all citizens can fully engage in a globally competitive, knowledge- and technology-intensive economy [14].

The COVID-19 epidemic made a significant impact on fall 2020 enrollments. As per data from the U.S. Department of Education's National Center for Education Statistics, college and university enrollment decreased by 651,774 students (i.e., more than 3%) from fall 2019 to fall 2020 [15]. Total undergraduate enrollment at degree-granting postsecondary institutions in the United States declined by 9% between fall 2009 and 2020. (i.e., 17.5 million to 15.9 million students) [16]. A recent report from National Student Clearinghouse Research Center [17] showed that in spring 2022, overall postsecondary enrollment declined by 4.1 percent or around 685,000 students compared to spring 2021. This includes both undergraduate and graduate students.

One direct cause for the decline in student enrollment at an undergraduate college can be explained using the pyramid effect, where PENG programs and other engineering prerequisite courses in K–12 public schools are at the bottom of the pyramid, and university engineering graduates are at the top [18]. Since fewer students attend the bottom of the "pyramid," or PENG programs, leading to fewer graduates at the top of the pyramid. This obstruction in the flow of students from PENG to college needs to be addressed. Thus, the next section of the literature review discusses the research focused on PENG programs and the importance of collecting and analyzing students' data.

In today's era, several institutions provide pre-college PENG programs to encourage students to pursue undergraduate degrees in STEM education. Such initiatives focus on specific goals to increase the enrollment and retention of underrepresented STEM students, including African Americans, Hispanics, Native Americans, and possibly Asian-Pacific [19]. This section aids in understanding the literature that centers around the development and implementation of PENG programs in the United States.

For instance, the PENG Instructional and Outreach Program (Pre-IOP) was developed to increase the number of skilled high-tech professionals, particularly among historically underrepresented groups (minorities and women). A thorough communication campaign promoting the benefits of careers in science, technology, engineering, and mathematics (STEM) introduced a PENG curriculum in middle and high schools to achieve this goal [20].

The integrated Teaching and Learning (ITL) Program at the University of Colorado at Boulder created a PENG outreach program for K–12 instructors and students to inspire students about the benefits of PENG topics. Program effectiveness was evaluated based on

participants' feedback, long-term results, and evaluation of instruments created for teachers' classroom use [21].

PENG programs have proven quite effective in enabling students, particularly underprivileged students, to pursue an engineering degree. Mitchell [22] created a vocational decision-making model as a foundation for the Greater Chicago Area Program (GCAP) for Minorities in Engineering, which lacked a theoretical foundation. This study investigated the issues in minority PENG programs and the factors leading to increased minority student attrition in these programs. The factors discovered during this study are essential for completing the GCAP program.

McCharen et al. [23] analyzed the PENG students' retention rates at the College of Engineering at Oklahoma State University entering college. This included a comparison between the retention rates of students from a developed PENG program of study from a regional career technology center and the general university students during the same period.

A minority engineering program (MEP) was developed to address African American students' non-cognitive and cognitive needs. The objective is to retain students in the College of Engineering by providing them with the fundamental skills needed to excel in their chosen major [24]. These programs are most often found at flagship institutions.

V. FRAMEWORK

Due to limited research on the evaluation of PENG programs in higher education, much remains unknown about the student's perspective. From a broad perspective, previous research shows different metrics commonly used by school officials to assess the success or failure of a PENG program. A program outcome evaluation based solely on student enrollment and student performance metrics often leads to narrowed insights and does not center the students' voice and experiences. To date no research has articulated/investigated what constitutes an effective PENG program that considers student learning experiences, professors' perspectives, and academic advising department expectations. There is a need to discover characteristics that contribute to program performance by identifying which factors help the students achieve their desired results.

This study uses theory of change (ToC) framework to build a bridge between students' perceptions, experiences, and program goals. ToC is a comprehensive and collaborative approach where participants (groups/individuals) in a planning process state their long-term goals, identify the interventions, and specify the conditions necessary for them to be accomplished. These goals are represented visually in a causal framework as desired outcomes. The ToC framework offers a functional model that describes different interventions (such as a single program or coordinated initiative), resulting in specific outcomes while keeping the implementation and evaluation process transparent [25].

Educational programs/initiatives for both students and educators are typically designed and evaluated by teachers, principals, policymakers, curriculum coordinators, and other major stakeholders in the field of education [26]. ToC framework in this research focuses on the PENG program's ideation, development, and improvement at a public University. Thus, leading to enhancements in the educational outcome, student experiences, and quality of teaching and learning. This work will assist the university in understanding the students' perspectives. Thus, improving student experience and success rate, particularly for students from low SES communities and the areas with low enrollment trends.

VI. METHODOLOGY

This involves application of HCD methodology which includes observing and interviewing the participants, including PENG students, professors, and academic advisors (CECS and START). This step involves asking students to share their experiences and struggles with the support provided to them throughout the program. Professors and academic advisors answer questions regarding classroom environment, program goals, academic support, advising, mentoring techniques, etc., Surveys and interviews are conducted to understand the participants' experiences and perceptions regarding the PENG Program.

A. PENG Program Description

The PENG program at the University was established in Fall 2019 and now it is in the fourth year of its operation. This program is designed to assist students in building and strengthening their math and science fundamentals to succeed in the College of Engineering and Computer Science (CECS) curriculum. Undergraduate students interested in Engineering or Computer Information Science can apply one of two methods to the CECS. This includes (1) Admission directly into a CECS major or (2) Admission into PENG. (Table I)

TABLE I. ADMISSION PATHWAY TO CECS IN A PUBLIC UNIVERSITY IN USA MIDWEST

1. Admission directly into a CECS major

Freshman Requirements:

- Students with a GPA of 3.5 or higher AND an SAT of 1200 (ACT of 25) or higher, or
- Students who have completed at least Pre-Calculus (Math 105 or equivalent) with a C grade or higher, or
- Students who place into Calculus 1 (Math 115) or higher on their placement exam or via the following automatic placements:
  - SAT math section score of 620 or higher
  - ACT math score of 26 or higher
  - 3, 4, or 5 on an AP Calculus exam
  - 5 or higher on an IB Mathematics SL exam or a 4 or higher on an IB Mathematics HL or HL Further exam

Transfer Requirements:

- Students who have completed Calculus II (Math 116 or equivalent) elsewhere with a C grade or higher AND have an overall GPA of 2.75 or higher.

2. **Admission into PENG Program**

Freshman Requirements:

- Students who satisfy the university's undergraduate admissions standards, but do not meet the above admission criteria for direct admission into CECS.

Transfer Requirements:

- Students will be required to show an overall transfer GPA of 2.75 or higher.

PENG students at this University work collaboratively with Student Advising and Resource Team (START) to enroll in appropriate classes, ensuring and improving their likelihood of success in the rigorous curriculum ahead. START includes New Student Advising, Peer Advising Learning & Success (PALS), and Health Professions Advising (HPA). START assists students in building a solid foundation for success as they begin their

academic journeys. Students in the PENG program must complete the transition requirements (Table II) and declare their major within one calendar year or during their first 30 credit hours, whichever comes first. For the purposes of this study, they are considered PENG alumni once they select a major.

TABLE II. TRANSITIONING FROM PENG TO CECS MAJOR

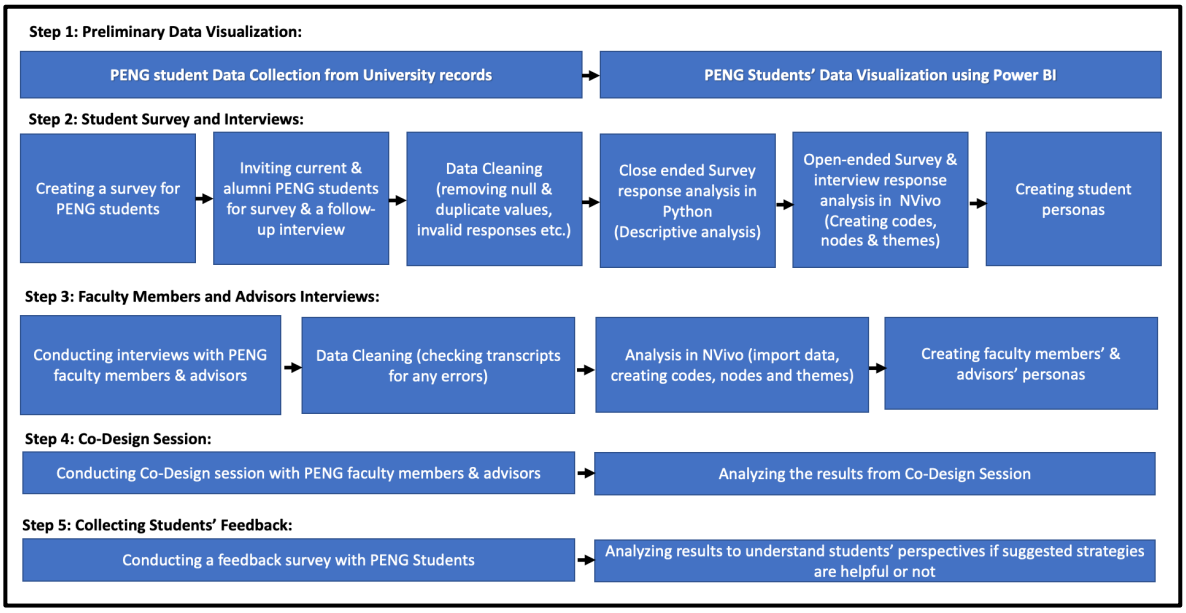
Transitioning from PENG into a CECS Major:

- Freshmen can transition once they successfully complete Pre-Calculus (Math 105) with a C grade or higher AND complete General Chemistry I (Chem 134 or 144) with a C grade or higher.
- Transfer students can transition once they successfully complete Calculus II (Math 116) with a C grade or higher.
- All students transitioning into a CECS major are expected to be in good academic standing overall (2.0 GPA or higher).

B. Population Description and Data Collection

This work involves three major population categories including (1) College advisors (START and CECS) that play a significant role in program implementation, (2) Students currently enrolled in PENG program as well as students who graduated in recent years (3) faculty who teach courses in the PENG program who have the current information on the program progress and outcomes. Figure I represents the process for data collection and analysis for this study.

FIGURE I: REPRESENTATION OF PROCESS FOR DATA COLLECTION AND ANALYSIS



Surveys, interviews, and co-design meetings will be used for primary data collection. And secondary data collection involves PENG students' data from the College records including students' demographic information such as gender, ethnicity, high school name and the current academic standing. This study uses a Power BI dashboard to access PENG student data, encompassing comprehensive information on students' demographics, academic status, enrollment information, and more. Study involves three-phase sequential research as follows:

Phase 1:

This phase uses a survey process to question current and previous PENG students. This is followed by an interview process to gather more in-depth information. All interviews are done at the University campus, at the participants' convenience, or via zoom call governed by an interview protocol. The study focuses on two key elements, i.e., students' perception and experience of the University admission process (e.g., the decision to pursue higher education, course expectations, etc.) and their experience during PENG. The survey and interview questions help us understand the students' learning experiences, attitude and perception towards the current program and their struggles with the support provided in PENG, specifically from an advising standpoint. For instance, "What factors, in a students' opinion, contribute to a successful PENG program?". The results from Phase 1 yields data about the strength of factors suggested by the students that may contribute to the successful PENG experience.

Phase 2:

This phase involves interviewing professors (who teach courses MATH 080, MATH 090, MATH 105, MATH 115, MATH 116, ENGR 100, and CHEM 134, respectively, in the PENG program) and academic advisors (START and CECS) of the PENG program. This helps collect data and analyze current PENG recruitment criteria, academic support, and mentoring techniques to better support students. For instance, sample interview questions include "What factors, in your opinion, contribute to a successful implementation of a PENG program at the public University?", "How can we improve students' PENG experience to reduce the dropout rate and increase student success?"

Phase 3:

This study phase involves a co-design session where PENG students, faculty members, and advisors are invited to work collaboratively to address student concerns/challenges in the PENG program at UM-Dearborn. During the session, participants share their perspectives and insights regarding students' challenges to identify potential solutions and strategies to address these concerns. This session allows participants to work together to develop strategies considering each other's diverse perspectives and experiences with PENG students and the program. Thus, creating a safe and inclusive environment where all voices could be heard and valued. This approach is designed to foster a sense of shared ownership and responsibility for addressing student concerns and to ensure that the resulting solutions are effective, feasible, and sustainable. This is informed by summaries of participants' interviews from the previous two phases, which will be presented as design persona to lessen the potential power dynamics within the session between the students, faculty, and advisors. The goal is to bring together a group of individuals from the community (study participants), ask them to collaborate on design decisions, and have them look into alternative solutions. This is done by utilizing a human-centered design process based on the ToC framework, which starts with outlining the problem, including the identified root causes and stakeholders, defining the desired end goal, and articulating how activities are expected to lead to outputs, outcomes, and eventually impact. Table III describes the definitions and descriptions of each stage of the TOC framework. Thus, the HCD process will help collect information for each stage. The following section outlines the steps to gather and integrate participants' input using a human-centered design process.

Thus, phase 3 focuses on generating ideas and strategies for addressing PENG students' most critical pain points and needs, utilizing the Theory of Change (ToC) framework to guide the idea-generation process. The group will use the ToC framework to address students' needs, challenges, and pain points identified in the previous phases. The group will utilize personas, post-it notes, whiteboards, and markers to generate strategies and solutions. This approach aims to develop evidence-based strategies tailored to the specific needs of the PENG students. Moreover, the ToC pamphlet requires participants to develop a monitoring and evaluation plan to track progress and outcomes.

This mixed methodology approach provides a valuable opportunity for faculty members, advisors, and PENG students to collaborate and work together meaningfully, with the ultimate goal of improving the educational experience for PENG students.

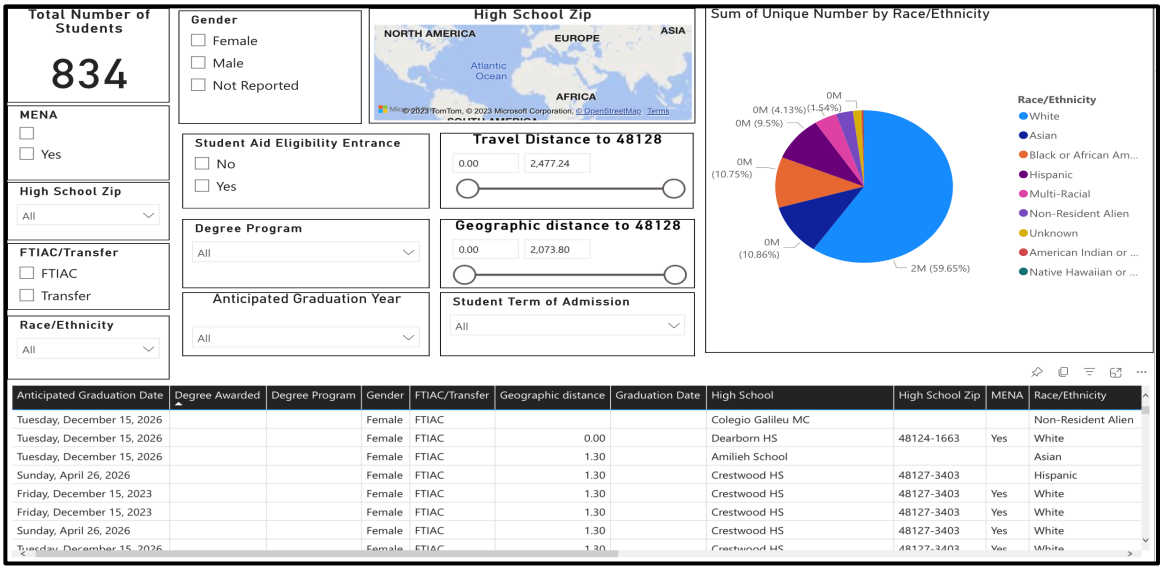
TABLE III. TOC STAGES

TOC Steps	Description
Inputs	Resources needed to meet the project goals. For instance, funds, equipment etc.
Activities	Tasks/initiatives required to take place for each output to take place.
Outputs	Immediate results of activities required to accomplish the outcomes
Outcomes	Intended and the unintended changes that result from the project outputs
Impact	Systematic long-term changes derived from outcomes.

C. *Preliminary Analysis and Results*

Data visualization using a dashboard is an initial step and a supplemental viewpoint for understanding the student population in various ways. A dashboard provides a comprehensive overview of the student population by visualizing key data points and metrics clearly and intuitively. It helps identify trends and patterns that may be difficult to see otherwise. Figure II shows a Power BI dashboard that helps visualize the comprehensive data on the PENG student population. This data presented in the dashboard is obtained from the university's student information system and covers the PENG student population from fall 2019 to winter 2022.

FIGURE II: DATA VISUALIZATION USING POWER BI



Preliminary findings show that the PENG student population at the university consists of 834 students, with 526 First Time-In-College (FTIAC) and 308 transfer students. Most PENG student population is male, with females comprising only 34%. Additionally, 85.70% of the students are eligible for student aid at admission. The PENG student population is diverse, with 59.65% (497 students) identifying as White, 10.75% (89 students) identifying as Black or African American, 10.86% (91 students) identifying as Asian, 9.5% (79 students) identifying

as Hispanic, and 4.13% (35 students) identifying as multi-racial. The dashboard further displays that 3.08% (26 students) identify as Non-Resident Alien, 1.54% (13 students) as Unknown, and 0.36% (3 students) as American Indian or Alaska Native.

Moreover, the dashboard presents information on the student's residential and high school Zip codes, providing crucial contextual details about the student's environment. Specifically, the dashboard facilitates the visualization of a map showcasing students' primary residence Zip codes, revealing that 94.48% of students live within a 50-mile radius of the university. This finding aligns with prior research indicating that most public college students tend to enroll within 50 miles of their permanent residence. These results highlight the significant influence of location on student enrollment decisions [11].

This data collected from the University helps examine if there is any relationship between under-recruited Zipcodes in Michigan and student representation in the PENG program at a public University. This is done by collecting and reviewing students' primary residence Zipcode information and comparing it with the findings from the preliminary phase. Preliminary research shows that Zipcode level demographic attributes such as minority population, internet access, travel distance, educational level, total population, and college-eligible population contribute to students' enrollment decisions. Therefore, this work helps recognize the economic constraints faced by the students of particular Zip Codes, provides new insights into the community characteristics that admitted students represent, and aids university administrators and policymakers in developing strategies to recruit and enroll more students [11].

Phase 1:

The survey data was collected using Qualtrics (https://www.qualtrics.com) and was sent out to 834 (currently and previously enrolled) students in the PENG program. A total of 200 responses were received, resulting in a response rate of 24 percent. The survey comprised of closed-ended and open-ended questions where closed-ended questions are focused on PENG students' demographics, academic status, and experiences in the program. Moreover, open-ended questions aimed to explore the challenges faced by students during their time in the program. For instance, one such open-ended question is, "How could the student experience at this university be improved?"

Descriptive statistics in Python (version 3.9.1.) is used to gain insights into the distribution of the responses to these closed-ended questions. For example, preliminary analysis show that most of the respondents were 19 years old or younger (n = 129, 75%) at the time of admission and that a relatively diverse mix of races and ethnicities is represented in the sample. Additionally, it is found that a significant proportion of the respondents (80.62%) reported being FTIAC students, while the remaining respondents (19.38%) reported transferring from another institution and that the most common academic majors were in the College of Engineering and computer science. It is also observed that many respondents had high academic standing, with a large percentage reporting a high school or previous institution GPA of 3.0 or higher.

When asked about the highest level of education achieved by their parents/guardians, a significant proportion of students (26.16%) reported that their parent(s) or guardian(s) graduated from college, followed by high school or equivalent (GED) at 21.51% and completing a master's degree or equivalent at 20.93%. The distribution of education levels for the parents or guardians provides valuable information about the educational diversity of the survey sample, which can be used to identify potential gaps in the program's outreach efforts. Understanding the educational background of the survey participants can also inform program improvements and help to promote equal access to educational opportunities. The results also indicated that 50 percent of the respondents are employed part-time, with 7.56 percent employed full-time and 2.33 percent self-employed. Moreover, 35.47 percent of students reported being unemployed. This information can be helpful for the University in

understanding their students' employment status and providing support or resources for those who may need it.

The aforementioned descriptive analyses are merely a subset of the overall examination of the closed-ended survey responses. Furthermore a thorough and comprehensive analysis is necessary to gain a deeper understanding of the data. Additionally, the responses to open-ended student survey responses and the interview transcripts will further be analyzed using NVivo, a computer-assisted qualitative data analysis software (CAQDAS) This involves importing open-ended survey responses and the interview transcripts into NVivo, assigning codes to text passages/survey responses and coding data into categories related to challenges, needs, and suggestions mentioned by the students. For instance this may include 'Orientation', 'Registration', 'Financial Aid', 'START Advising', 'Resources availability,' etc. Thus, using NVivo, responses will be examined and coded according to the relevant themes that emerge, resulting in a set of categories that captures the key issues and concerns raised by the students.

The resulting survey and interview data will be used for the final analysis, capturing the full range of student perspectives and experiences. Overall, NVivo will allow for a comprehensive understanding of the needs and challenges faced by students in the PENG program. The analysis will provides valuable insights into the factors affecting student success and suggest evidence-based recommendations for PENG program improvement. Furthermore, these codes and nodes identified in the analysis of the open-ended survey questions and the interviews will be used to inform the development of student personas to address the needs and concerns of PENG students, followed by scenario design utilizing storyboards to understand their challenges, motivations, needs, etc. The scenario depicts the PENG Program admission pipeline, participants' experiences, etc. The personas and scenarios will help define the design challenge, i.e., "How might we understand students' learning experiences, attitudes, and struggles about the support provided in a PENG program?".

Phase 2:

This phase of the study includes interviews with PENG professors and advisors to gain their perspectives on the challenges and needs of students in the program. The data analysis process for these interviews will be similar to the student interviews. The interviews will be transcribed and imported into NVivo to code and categorize the data. The responses will then be analyzed to identify common themes and patterns compared with the themes from the student interviews. Additionally, these codes and nodes identified from the transcripts analysis will be used to inform the development of personas to address the needs and concerns of PENG students. Thus, allowing for a comprehensive understanding of the students' challenges and needs in the program from students, faculty members, and advisors' perspectives. These themes will present a variety of perspectives from different individuals, supported by diverse quotations, illustrations, or examples. In addition, potential themes will be identified using Word Cloud Queries. This will be based on the most frequent terms used by the participants to respond to specific interview questions.

Finally, the participants' (Students, professors, and advisors) perceptions of the aspects that lead to effective PENG programs will be compared to answer the question"Are there disparities in how students, professors, and advisors perceive the effectiveness/success of PENG programs?".

Phase 3:

This phase of the study involves a Co-design session focusing on getting feedback on new ideas to improve the current PENG program. Formulation of questions such as "How Might We" will serve as the foundation for a brainstorming session. Thus, the results from this design workshop (Co-Creation Session) for the PENG students, advisors, and faculty members will give us new ideas to improve the current PENG program. This phase uses ToC to document the impact participants are seeking to achieve and all the intermediate steps to ensure that respective activities and resources are well aligned to achieve the desired change.

The ToC pamphlets will serve as a valuable tool for mapping out the steps and resources needed to achieve the desired changes, ensuring that the strategies developed are grounded in the needs and perspectives of the target audience and community.

These three phases will aid in comprehending and addressing the problem based on ToC. Participants' ToC documentation sheets will be examined further. This entails identifying the underlying factors, outlining the intended result, outlining the short and long-term outcomes required to attain the desired result, and defining the actions necessary to fulfill these results. It also lists the key assumptions and their validity (if any).

VII. ASSUMPTIONS

During this research, several assumptions are made regarding the PENG program at a public university. Additionally, assumptions have been made concerning the experiences of PENG students, faculty members, and advisors, and the factors contributing to the program's success. It is assumed that PENG students at a particular public university are representative of PENG students at other institutions. While this may be a reasonable assumption, the experiences of PENG students at other institutions may differ in important ways. It is possible that the findings of this study at this point may not be generalizable to other PENG programs at different institutions. While the study's recommendations offer practical and actionable steps for improving PENG programs, these recommendations may need to be tailored to individual institutions' specific contexts and needs. It is also assumed that the participants in this study provided accurate and truthful responses to the survey and interview questions. While every effort was made to ensure the validity and reliability of the data collected, participants may have provided incomplete or inaccurate responses. Lastly, it is assumed that the interventions recommended in this study can be implemented without significant financial or logistical barriers. While the recommendations presented here are intended to be feasible and practical, it is possible that implementing them may require substantial resources or changes to existing policies and practices.

VIII. ANTICIPATED FINDINGS

From a broad perspective, previous research shows different metrics commonly used by school officials to assess the success or failure of a PENG program. Commonly used metrics evaluate a program's outcome based only on increased student enrollment, student grade performance, etc. However, this research investigates what aspects constitute an effective PENG program considering student learning experiences, professors’ perspectives, academic advising department expectations, and school administrators. There is a need to discover characteristics that contribute to program performance by identifying which factors help the students achieve their desired results. This study is being designed in such a way that it aids in building a bridge between students' needs, perceptions, experiences, and program goals.

Several colleges in the United States have implemented and supported the college-level PENG program. This work attempts to expand the current state of knowledge on successful PENG programs. This study defines success in PENG programs and identifies the elements that are expected to increase success. A successful PENG program is seen to accomplish and encourage students in their academic progress. Thus, interviewing PENG educators as well as current and former students and academic advisors from a public University will aid in the identification of potential success factors for PENG programs. These exploratory findings may yield new insights in understanding PENG students' experiences at a public University. This includes redesigning the PENG program to better support students and use data more effectively to better track, identify, and support students. Additionally, it could point up additional concerns that need to be addressed – concerns prompted by the data analysis and the research questions that the researcher had not envisioned originally in the research.

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