Toward a Theoretical Model of a Successful Women and Minority Engineering Program (work in progress)

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Toward a theoretical model of a successful WMEP program

With the emergence of engineering education programs, there is at last a structure and approach to train engineering professors for the university and college levels. But engineering diversity administrators generally learn their job as they do it. The first women in engineering program was founded at Purdue in 1969, and programs for minority engineers or multicultural engineering in the 1970's. The leaders of these programs come from a variety of backgrounds, including disciplinary engineering and higher education. But, to date, there is no program specifically designed to train engineering diversity program directors.

As a result, new program directors typically learn from reading what others have done in the literature, participating in groups like the National Association of Multicultural Engineering Program Advocates (NAMEPA) and Women in Engineering Pro-Active Network (WEPAN), and engaging in conferences like Collaborative Network for Engineering and Computing Diversity Conference (CONECD) and the American Society of Engineering Education annual conference (ASEE). In some instances, a new director may have the opportunity to learn from a previous director, or they may have been the product of such a program. In neither case, however, is it possible for new directors to understand and learn every aspect of planning and strategy. Even if the previous director desires to impart all that they know, it is possible that there is knowledge or meta-knowledge that they, themselves, are unaware they possess.

Another challenge is the lack of widespread understanding of the state of the art in diversity, equity, inclusion, and belonging from a practitioner standpoint. The community exists in a state of functional dichotomy between those designated as researchers and practitioners. In addition, there are many members of the academic community who are not aware of either the current state of practice OR research. This disconnect frequently results in exhortations that reflect the past and ignore the progress that has been made to date.

This paper comprises a case study of a successful and long-standing Women and Minority Engineering Program at NC State University from the perspective of the program director. It will discuss a theoretical framework for the components of a complete program and how the various pieces of the framework map to practice.

Background

> "In a comprehensive study of successful programs and practices in minority serving institutions, intentionality, that is a "calculated and coordinated method of engagement…to effectively meet the needs of a designated population" was the common thread that distinguished successful initiatives from less successful ones (NASEM, 2019, page 4). This intentionality includes assessing students' needs, articulating clear objectives for courses and programs, implementing evidence-based strategies, and monitoring success using data (NASEM, 2019)."

National Academies of Sciences, Engineering, and Medicine. (2019). *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25257.

The SECI Model of Knowledge Creation: Socialization, Externalization, Combination, Internalization (Nonaka, 2009) introduced a definition for tacit versus explicit knowledge in organizations. The model was originally conceived as a means to understand the way that knowledge is created and exchanged within organizations. Tacit knowledge is defined as "acquired with little or no direct instruction," "practically useful," and "cannot be fully articulated." Explicit knowledge is easily articulated and easily communicated.

Tacit knowledge is related to the type of knowledge contained in “hidden curriculum” (Snyder, 1971) in colleges and universities. But tacit knowledge appears elsewhere. In the course of performing a job function, many of us acquire a great deal of knowledge of how we perform our jobs that is not only tacit, but sometimes that we sometimes do not know that we have. However, if we are to spread knowledge of a successful program implementation, we need a way to articulate both tacit and explicit knowledge. This paper presents a thought model about how the work of the Director of a successful program is organized.

Composing a model of how diversity programs at colleges and universities should and/or do work, as viewed from outside is likely to result in lists of events, which are clearly a part of explicit knowledge. A program has mentoring. It has bridge programs. It may include a variety of career programs or speaker programs. What is typically invisible from outside is that these events and programs are outward manifestations of planning and practices that come from both research and experience and a combination of tacit and explicit knowledge.

What may not be evident from the external view is the relational work and the research that scaffolds the activities that are externally visible. Even the explicit knowledge that comes from research is not always easy to identify or completely articulate. It also frequently varies from program to program. The research that scaffolds practices in diversity programs comes from a variety of sources, and, interestingly, those sources are sometimes disconnected from each other. Research clusters in different professional venues sometimes duplicate efforts. Even within engineering and computer science, it is possible to find conference presentations that duplicate previous work from prior years, but do not necessarily advance it.

There is scholarship about women and minoritized populations in all types in engineering. There are practitioners who design and make decisions about events on a daily basis. Some of the journals/conference venues where work is presented are more linked to academia, like ASEE. Within ASEE, presentations in the Minorities in Engineering Division (MIND) and the Women in Engineering Division (WIED) may overlap with presentations in the Precollege Division (PCEE) and the divisions aligned with specific disciplines.

There are journal /conference venues that engage more industry, like the Institute of Electrical and Electronics Engineers (IEEE), the American Society of Mechanical Engineers (ASME), the

American Society of Civil Engineers (ASCE), etc. that also produce recommendations and work related to diversity. There are venues more tied to computing and computer science, like the National Center for Women & Information Technology (NCWIT), Tapia, Grace Hopper. And there are venues that align directly with issues related to diverse engineers and computer scientists, like the Society of Women Engineers (SWE), the American Indian Science and Engineering Society (AISES), the Society of Hispanic Professional Engineers (SHPE), the National Society of Black Engineers (NSBE), and others. In addition, there is work at department head conferences, like the Electrical and Computer Engineering Department Heads Association (ECEDHA) and similar. The overlap, duplication, and disconnection in diversity work among these many bodies is unavoidable. It represents dichotomies between academia and industry/government, between practitioners and researchers, between disciplines, and even between those who work with issues related to gender and race/ethnicity.

This wide assortment of venues for the exchange of explicit research knowledge means that practitioners in diversity programs face difficulties in sifting through research that will help them design and implement their programs. Many of us simply implement the same programs that others do, because we lack the time to become fully versed in the ever-increasing pool of research and literature.

In practice, there are many people who are both practitioners and researchers. There are disciplinary researchers who become aware of, or motivated to become involved in, the issues associated with underrepresentation. What is needed is more connection between and among the siloes that exist and between research and practice, whether it is in the form of individuals who have the capacity to span the areas, or through more connection in professional venues. In the case of Women and Minority Engineering Programs, these disconnects can represent a barrier to effective program implementation. They also certainly make it difficult for those new to diversity work to become aware of the "state of the art."

In the ecosystem spanned by the many areas of activity are practitioners who work to implement programming that will have the effect of increasing diversity, equity, inclusion, and belonging in the engineering and computer science student population and beyond. They work in Women and/or Minority Engineering, in Women in Science and Engineering, and other types of programs. This paper will present a case study of a long-term, successful program. The model presented attempts to include both explicit and tacit knowledge.

Modeling a WIE Director Position

This case study presents a discussion of how a Director of a Woman in Engineering Program at a large, public university organized the work associated with the program over the entire course of the program's history, from 1998 to today. The program has been judged to be successful (see,

for example, Education Editors, 2021), which is one reason to look more deeply to describe how it has been managed over the past 25 years.[1]

The work associated with diversity, equity, inclusion, and belonging at NC State College of Engineering takes many forms. As stated before, the programmatic efforts are the most visible, but they are not the bulk of the work. The model described in this paper take the form of a three-dimensional coordinate system. This approach was selected to illustrate three sliding scales with opposing aspects. The axes are shown orthogonal to one another, but that is not actually intended to be a part of the model. The angle between axes is not intended to imply any relationship.

There are three axes of activity associated with the work:

1-Strategic versus tactical

2-Relational versus performative

3-Systemic versus individual

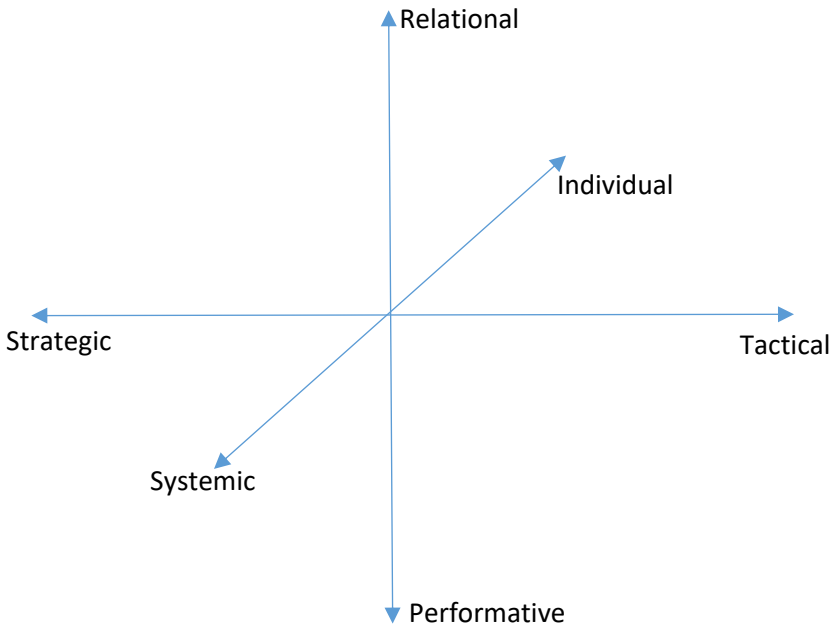

Figure 5: The three axis model

[1] It is acknowledged that calling a program "successful" is a matter of opinion. In addition to the article cited, some outcomes data have been provided in Appendix 1. It is understood that these data do not show causality, but they do provide context. A future, more comprehensive work, will provide more thorough details.

The axes

The three axes, taken two at a time, define twelve sections. The complete Women in Engineering program effort requires all twelve sections be considered. One person in the position may emphasize one segment over another, but a lack of effort in one or more can degrade the potential for success. In addition, most practitioners find one or more of these defined work areas to be more difficult than others. The best way to ameliorate this phenomenon is through partnerships and teamwork.

The three axes define sliding scales of effort. First, the relational/performative axis, which defines the nature of the work as regards to working with people. The second axis, of strategic/tactical defines how work is done with regards to implementation, and the third axis, systemic/individual defines the level of the work with regard to impact.

Relational/Performative

Activity that is relational is accomplished by developing individual or small group relationships. Relational work takes time and deliberate intent. An example of relational work is mentoring an individual student to help them understand how to contact faculty members requesting undergraduate research opportunities. It may be spending time casually chatting with groups of student to understand the things that are affecting them during particular times of the semester.

One might conclude that relational activity includes an open-door policy where students know that they are welcome to enter to chat or ask for help without making an appointment. This is not enough, however, to accomplish the kinds of objectives meant by the relational axis in this model. Research has shown that, in the absence of other relationship building, simply having an open door may not accomplish objectives. (Metz, 2007).

The word “performative” is used in its traditional definition, which does not have the negative connotation that contemporary usage may attach. It simply means doing. Performative activity involves “being seen,” but in a way that allows students to feel supported. It may be showing up to a student performance or a fraternity induction ceremony. It involves investing the currency of time and being seen to do so.

Performative activity can seem like it has little impact in the moment, however, students notice who shows up. This increases their trust and makes them more likely to approach a faculty or staff member when they need help. In this way, both performative and relational activity is about building relationships, just from different approaches.

Strategic/Tactical

Strategic work requires long and short-term planning. It means understanding desired outcomes and ensuring that planned activities are consistent with those outcomes. Sometimes it means saying “no” to something that may spend the capital of funds, energy, or time without results that are consistent with the program outcomes or are not sufficiently beneficial for the outcomes relative to expenditures. (It is important to note here that outcomes are not simply number of students served. An activity that serves fewer students but accomplishes a greater depth and

breadth of outcomes for those individuals may merit a larger expenditure than one that serves greater numbers only lightly.)

Tactical work is usually short-term and aimed at accomplishing a specific outcome, frequently in the moment. From a performative standpoint, it involves actual program implementation. It may involve engaging in conversation with faculty in a department where students are experiencing negative outcomes or contacting teachers of students who are struggling for personal reasons to ask for more lenient treatment.

Systemic/Individual

Systemic work frequently involves identifying and working to remove barriers. It may mean offering training to departmental faculty members on ways to be more supportive of students affected by external circumstances (like the recent pandemic or the deaths of multiple Black individuals at the hands of police). Systemic work seeks long-term change and includes multiple types of advocacy.

Individual work includes mentoring and developing trust and relationships. From the outside, work of this type may simply appear to be "extra" or ingratiating oneself with students. However, without trust and relationship, students are less open to participating in programs or even showing up. Post-pandemic, programs across campus have experienced significantly lower attendance, but attention to building the kind of trust symbolized by individual work in the model has kept attendance high in the WMEP programs.

In addition, in the post-pandemic era of heightened issues with mental health and wellness on campus, the kind of trust established through individual efforts can sometimes allow students to seek help from those trusted individuals, when they might not otherwise do so.

Explaining the model further

The following illustrations consider two axes at a time and define the types and motivations of activities that correspond to each. Although the axes have two extremes, they do include actions that may reside at some middle point along the axes and possess qualities of both. The axes are not intended to appear numeric in any way.

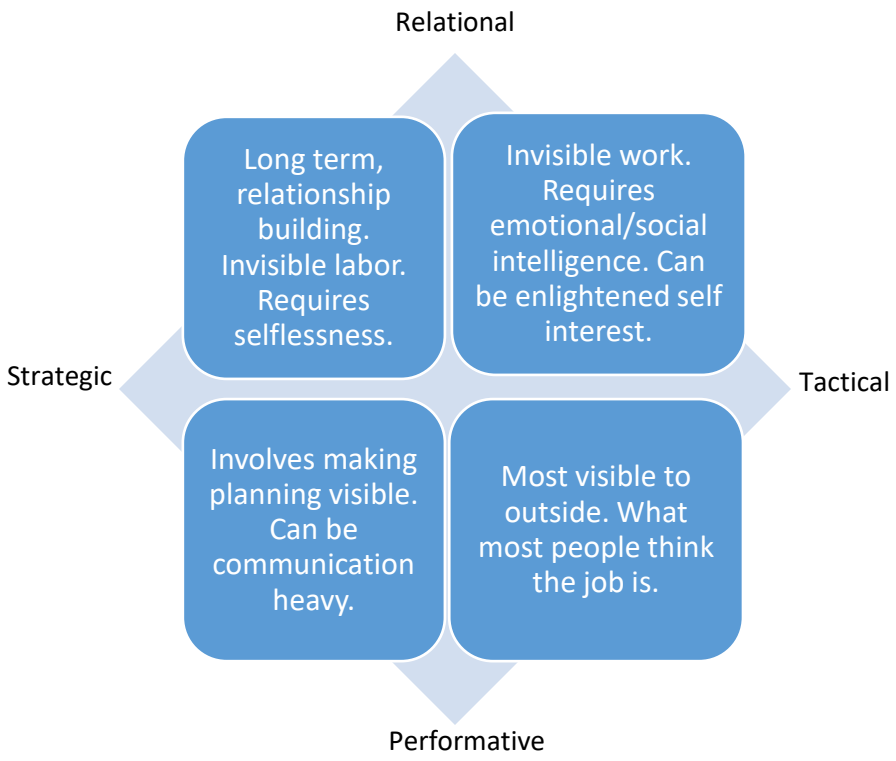

Figure 6: Regions defined by Relational/Performative and Strategic/Tactical axes

Relational is used here as relating to people. A relational action involves effort to understand and empathize and build relationships. Performative, by contrast, means actions designed to "be seen." These are actions that are concerned with reputation-building. For some women, performative work may not be natural, particularly if they were raised in a place that has a more traditional approach to gender roles.

Strategic work tends to be long term, on the scale of months, but could be longer. This work is about laying groundwork, putting things in place for the future, positioning events or relationships to have impact at a later date, and similar activities. Tactical work is "in the moment." It can be the implementation of a program that has been planned over time. Tactical work may involve responding to circumstances or taking advantage of serendipity. The adage "success is when preparation meets opportunity" may apply to tactical work.

The four regions defined by these axes range from invisible labor to very visible actions. In the strategic/relational region in figure 6, the reference to selflessness requires further explanation. Work of this type may mean doing favors or performing tasks without immediate possibility of reward. This type of behavior, not unlike the concept of accumulating karma, is not mercenary, and does not keep score. An example of this type of work is meeting with a potential funder who appears uninterested when being told about one's programs, but who indicates interest in a program in a particular department. A strategic/relational attitude would lead one to discuss that program and make the connection with individuals in the department. This interaction may not result in funding for one's own program, but does accumulate good will and usually results in support for one's own program down the road.

Relational/tactical work may involve seeking out individuals who may have the potential to assist in one's own work. It is not easy for many introverts, and it may even look opportunistic, but it doesn't have to be. Emotional intelligence can moderate whether the approach is welcomed.

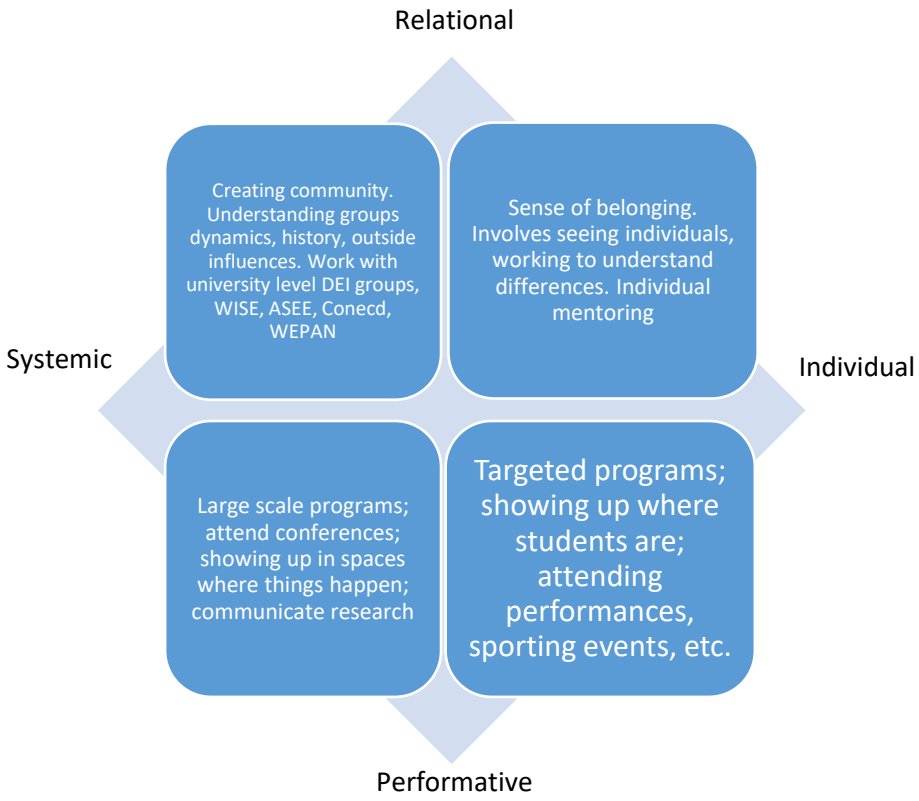

Figure 7: Regions defined by Relational/Performative and Systemic/Individual axes

The job of being a Women and Minority Engineering Program (WMEP) Director is always about students. Sometimes work must be done to accumulate knowledge and connections that will enable better service. This can be a balancing act, such as in the case of systemic/performative work that might involve serving in leadership roles in societies. This kind of performative act can serve to enhance the reputation of the University, which eventually enhances value for students, but it can also serve to help do the job of the WMEP Director. Being reputed as an engineering program that is friendly to women and/or underrepresented minority students feeds directly into recruitment.

In contrast to the systemic/performative region is the performative/individual region. In everyday usage, the term "performative" might have a negative connotation, but that is not how it is used here. Attending performances, being seen at sports events, and other performative actions can show students that one cares about them as individuals. This has been a very effective way to create community and build lasting student relationships that bring alumni back to participate and contribute to the College. It can also overlap or progress to individual/relational actions.

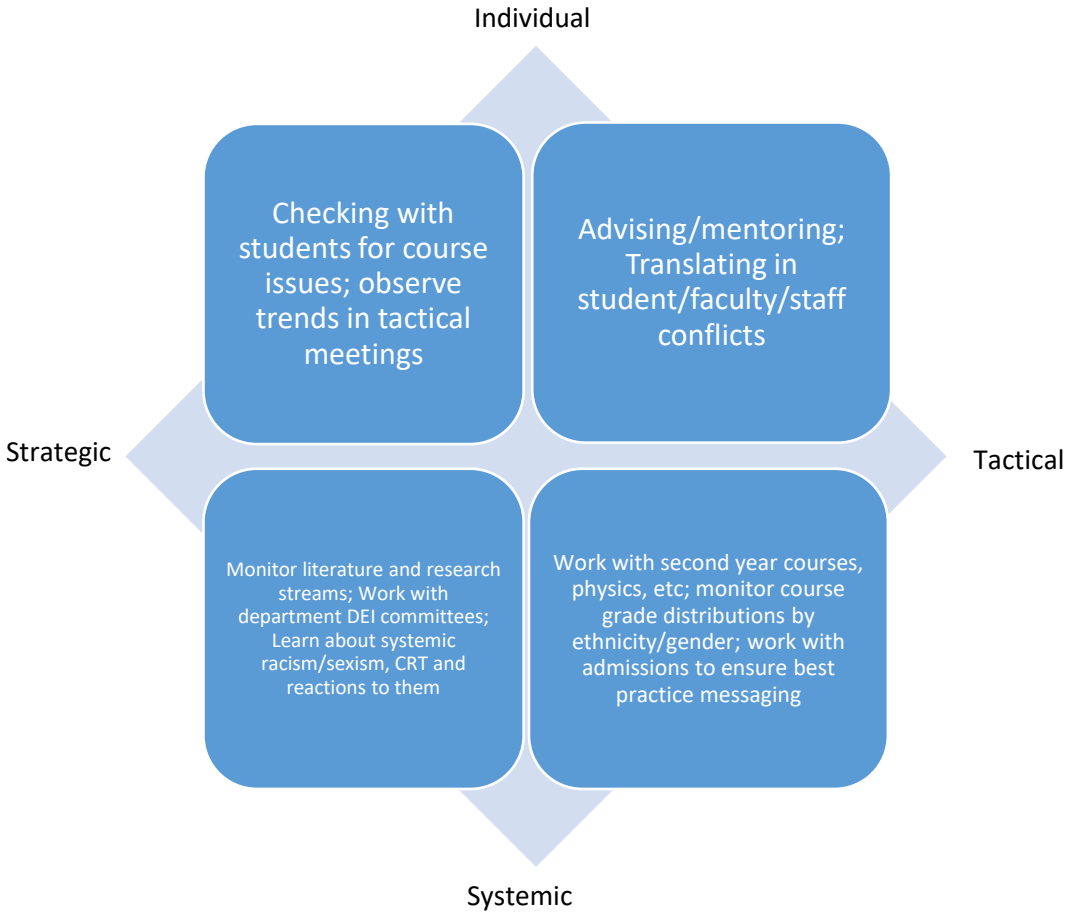

Figure 8: Regions defined by Individual/Systemic and Strategic/Tactical axes

The regions defined in figure 8 involve a substantial amount of activities that can be invisible to those who are outside of the program. Particularly because scholarship in these areas is ongoing and vital, it is important to keep abreast of new thoughts and new ideas. Because we and our students live in a very dynamic world, it is also important to keep abreast of happenings and how they affect the lives and emotions of our students.

The summer of George Floyd's death and what followed was very impactful for students (and faculty). Without an effort to understand how Black students might feel and talk about events

and how White students might feel and talk about the same events, directing a WMEP program will not be responding to the most urgent needs of students.

Connection to research

The model above ties directly to the body of knowledge about what contributes to the success of women and other groups underrepresented in engineering. Diversity programs are designed based on a broad array of research-based practices. Some examples of connections to practices are enumerated in table 1.

Table 1: Examples of connecting research to practice

Research-based principle	Model region	Example reference
Increased sense of belonging	Relational/Individual	Huang, P. M., & Brainard, S. G. (2001). Identifying determinants of academic self-confidence among science, math, engineering and technology students. Journal of Women and Minorities in Science and Engineering, 7, 317–339.
Faculty/student interactions	Individual/Performative	Kuh, George & Kinzie, Jillian & Buckley, Jennifer & Bridges, Brian & Hayek, John. (2006). What Matters to Student Success: A Review of the Literature.
Messaging	Tactical/Systemic	National Academy of Engineering. 2008. *Changing the Conversation: Messages for Improving Public Understanding of Engineering*. Washington, DC: The National Academies Press. https://doi.org/10.17226/12187.
Mentoring	Individual/Tactical	Washington, V., & Mondisa, J.-L. (2021). A need for engagement opportunities and personal connections: Understanding the social community outcomes of engineering undergraduates in a mentoring program. *Journal of Engineering Education*, 110(4), 902–924. https://doi.org/10.1002/jee.20422
Bridge programs	Tactical/Performative	Bottomley, L., & Titus-Becker, K., & Smolensky-Lewis, H. (2009, June), *Escape To Engineering: A Summer Bridge Program For Women In Engineering* Paper presented at

		2009 Annual Conference & Exposition, Austin, Texas. 10.18260/1-2--5254

Conclusion

Practitioners who work in the area of diversity programming do their work in a variety of ways, none of which are the same. The model discussed in this paper comes from the analysis of how a Women in Engineering Director constructed her work from the creation of a program through twenty-five years of practice. The program has been successful in meeting goals from a recruitment and retention standpoint. This model is offered as an example, not necessarily as a prescription. Because, from the outside, the work of a women or minority engineering program director can be largely invisible, this model allows the visualization of aspects of the work that are not generally articulated. Only one of the eight regions that the model defines includes the externally visible work that others generally see. A practitioner of diversity programming can use this model to consider other aspects that may help them meet their own goals on behalf of students, hopefully leading to greater persistence and success for a more diverse engineering profession.

This work-in-progress suggests a way of articulating the various aspects of work in one program. Future work will include a study of whether the model is an accurate representation of programs at other institutions as well and will also include more specific examples of program design.

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Appendix 1

Although there are many measures of success, one approach is through the consideration of recruitment and retention variables. The following graphs give a very high-level measure of recruitment and retention outcomes for the Women and Minority Engineering Programs at NC State University.

Figure 1 shows the percentage of women in the first year engineering class since 2012, and figure 2 shows the percentage of underrepresented minority students in the first year engineering class since 2017. These measures are an indication of successful recruiting and yield, which are correlated, but represent different programmatic efforts.

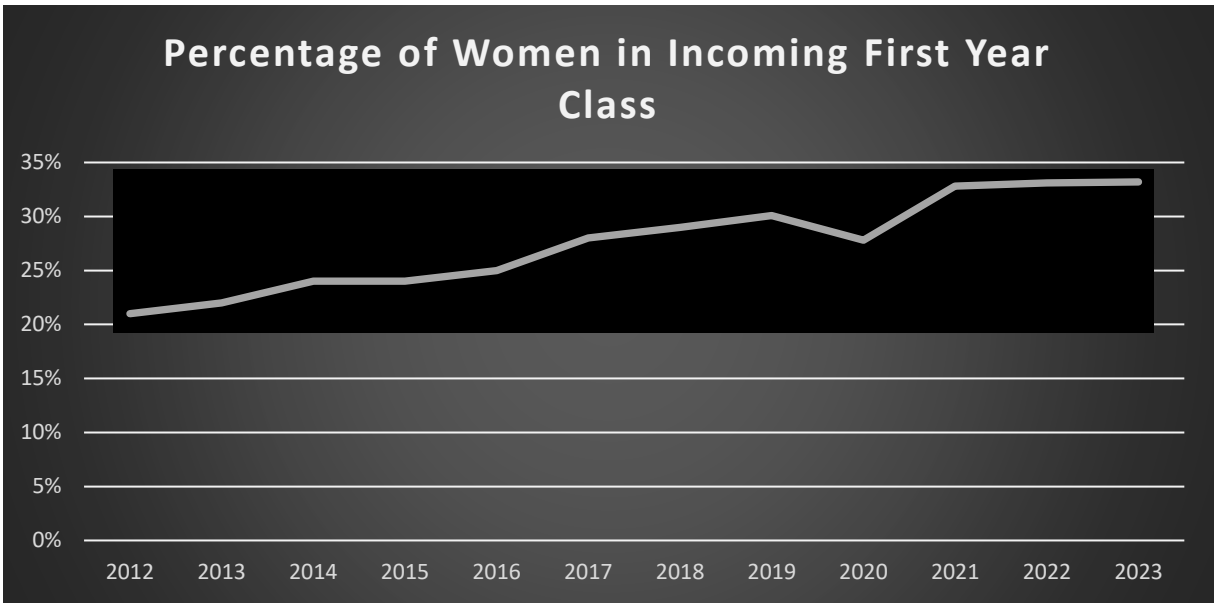

Figure 1: Pecentage of students identifying as women in first year engineering class

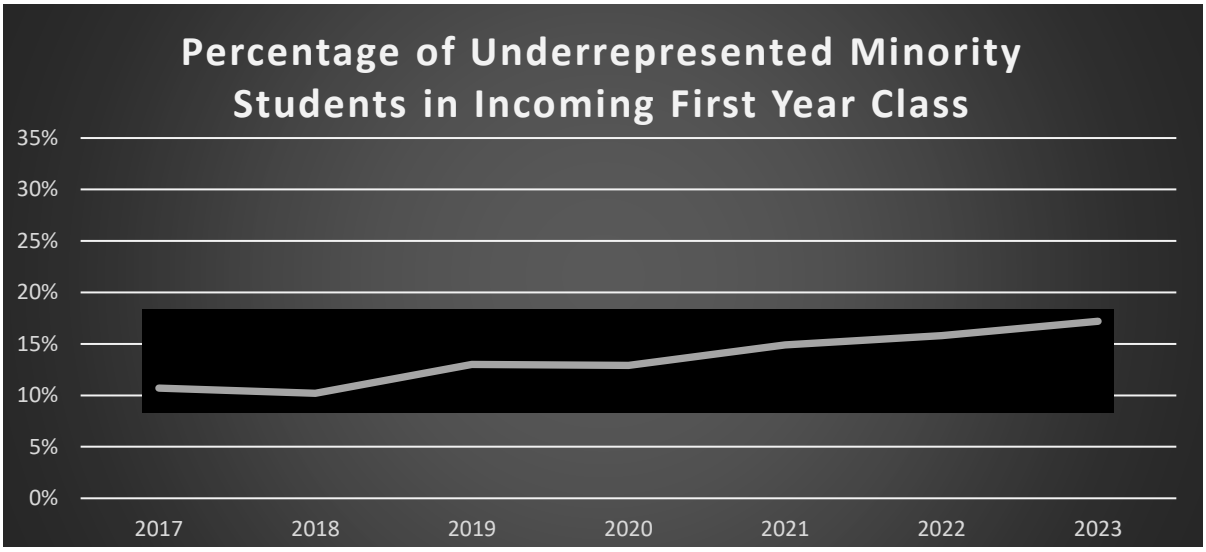

Figure 2: Percentage of students identifying as minority in the first year engineering class

For retention variables, two graphs are shown. Figure 3 shows retention to second year by sex and race/ethnicity. Figure 4 shows six year graduation rates for the same groups. Retention to second year is an important measure for our program, because students enter their departments, typically, after a common first year. Six year graduation rates are our measure of choice due to the number of students who work full time while studying, do co-ops, and related circumstances.

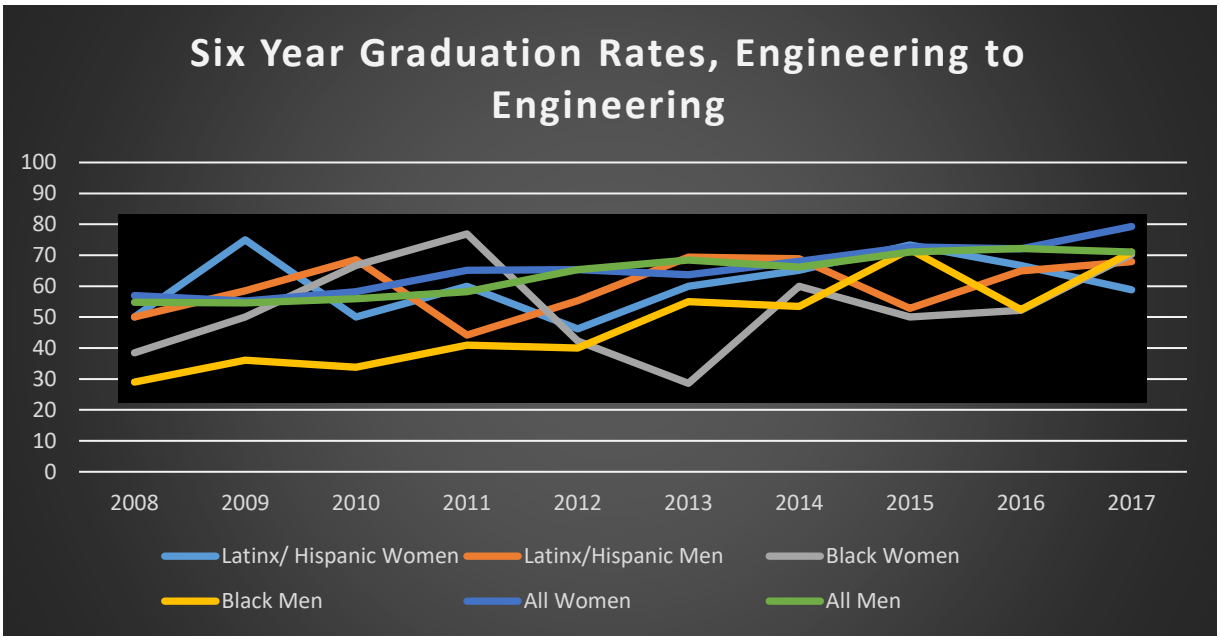

Figure 3: Six year graduation rates for students who start in engineering and graduate in engineering

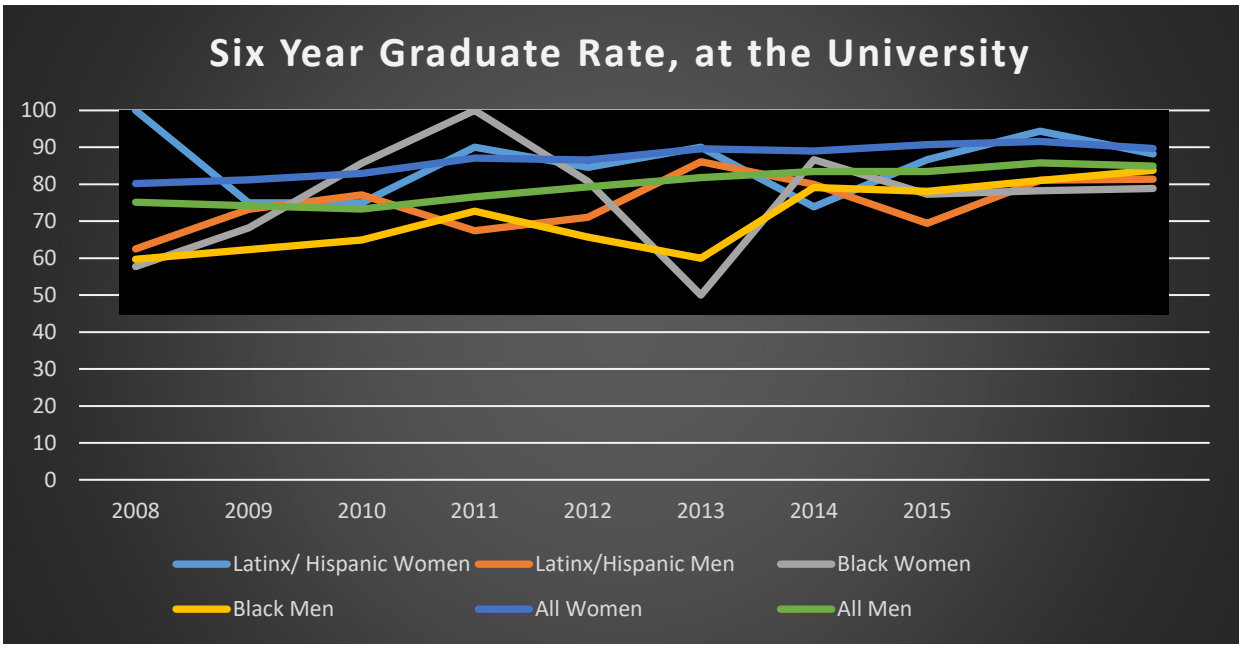

Figure 4: Six year graduation rates for students who started in engineering at the university

The volatility in figures 3 and 4 is due to lower numbers in various groups in the early years, when incoming classes were between 900 and 1000. Incoming first year classes are now approximately 1800 students, and the percentages of intersectional groups are higher. Overall, all

groups have improved in each of the metrics from figures 1 through 4, which we count as success, even though not perfection[2].

[2] It must be stated that the Women and Minority Engineering Programs cannot take credit for all of these successes. However, the greatest programmatic changes have taken place in these programs.