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Transforming Engineering Education Is Possible! A Descriptive Case Study of Reimagining Engineering Education and Delivering a Wake Forest Engineering Student Experience Promoting Inclusion, Agency, Holistic Learning, and Success

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"If you always do what you always did, you will always get what you always got."
Albert Einstein

ABSTRACT

The inaugural cohort of engineering students arrived at Wake Forest University (WFU) in August 2017, just six weeks after the founding chair and faculty arrived on site. No website, no vision, no curriculum, no equipment, no operating budget existed when the founding team arrived. A newly renovated building, what was an old tobacco warehouse, was the new home for WFU Engineering. A liberal arts research university, WFU has a strong academic reputation and students are expected to explore the academic landscape before declaring a major in the sophomore year (spring semester typically). According to admissions, the number of students that were expected to enroll in the first engineering class (fall 2017) was about 26 (15% of whom would be women). On the first day of engineering class, 55 students had enrolled (more than double of what was expected). Within three years, Wake Forest Engineering had nearly 200 students, of whom 40% were women and 25% were students that brought racial and ethnic diversity. There were 43 inaugural WFU Engineering graduates in May 2021 and the new department was already the 4th largest and the most diverse among the 30 departments in the College of Arts and Sciences. This paper shares the story, from the perspective of the founding chair, of building Wake Forest Engineering and some the strategies that led to (a) an inclusive and diverse student and faculty body, (b) a flexible and innovative curriculum, (c) pedagogies that empowered students, (d) partnerships that enabled transformation, (e) a vision to redefine the culture of engineering education and the department. The strategies used reflected tradition and innovation, evidence-based and exploration, agility and compliance, student-centeredness, and external perspectives. Amid start-up mode and the Covid pandemic, the grueling work of accreditation was high stakes. WFU Engineering is now ABET accredited and has achieved unprecedented outcomes, including being recently ranked #14 by US News and World Report in the category of Best Undergraduate Engineering Program Rankings (no doctorate). The successes and challenges are presented in this paper. Transformative change is possible in engineering education and in engineering departments. Intentionality and evidence-based strategies are a must. There are many implications for new and established engineering departments from this case study. In fact, strategies described in this case study have the potential to transform higher education departments and institutions.

I. INTRODUCTION

The role of higher education and its impacts towards advancing citizens towards economic prosperity, to enrich the human experience through knowledge and perspective, to be a force for good and human flourishing, to produce the next generation of leaders in our society, to advance knowledge discovery and community empowerment are well established (Rudolph, 2021; Rhodes, 2001). Along with the many benefits that higher education offers citizens, communities,

and our society, there is also considerable skepticism. The Chronicle of Higher Education has recently pointed to the lack of quality teaching which the public and students value but often times is not a priority and not rewarded equally to research at many higher education institutions (McMurtrie 2023), ineffective use of teaching evaluation processes (McMurtrie 2023), extreme costs of higher education that keep increasing, etc. The public's declining faith in higher education is a concerning and a pivotal moment in the history of higher education. Public expectations of higher education are good teaching and meaningful learning to lead to well-informed citizenry and a skilled workforce (McMurtrie, 2023). We must adapt or we will not survive. We have in fact already seen this with many small universities that shut down or barely survived. Higher education must reimagine and rethink its ways.

Millions have been invested to transform higher education and certainly STEM and engineering education. Sadly, while society and incoming students value the role of engineers and engineering, engineering education also lags in the same way that higher education lags behind. Although engineering education (in contrast to many educational programs that have no external accrediting body) has ABET accreditation to ensure that some minimum standards of learning and student experience are implemented, engineering education has a way to go. Many investments from diverse sources have supported engineering education in diverse ways - interdisciplinary learning, student centered pedagogies, more inclusive environments, etc. - but the results have been inconsistent and unsystematic across the landscape of engineering education. Some of the specific criticisms of engineering education are listed below:

- Linear and rigid curricula
- Outdated curricula
- Inflexible and siloed curricula
- Lecture predominant classroom learning environment
- Overemphasis on theoretical knowledge (in contrast to more practical and applied knowledge and learning experiences)
- Unwelcoming classroom cultures
- Inadequate diversity that does not reflect our community demographics
- Classrooms not authentically representing engineering practice
- Faculty that care more about research over education
- Faculty that lack professional experience in industry settings
- Siloed engineering departments
- Inadequate interdisciplinary and cross-disciplinary learning environments
- Change that is slow even when we know practices that are more effective
- Limited engagement with engineering professionals and learning that connects to real-world engineering practice

Immense investments have also been made the last three decades with engineering education as a field transitioning to being a research discipline. In fact, in 2005, the Journal of Engineering Education transitioned to only publishing engineering education research over engineering education practice. Other journals launched (e.g. Advances in Engineering Education) to disseminate engineering education practice. Ultimately, though, we have learned that research to practice translation is important and so is practice to research translation. Figure 1 grounds this

motivation to recognize that back-and-forth translation between educational practice to educational research is essential to transformative education and learning.

Figure 1: Visual of research to practice translation to support transformative engineering education. (Karlin et al. 2016)

In this paper, we highlight the journey of launching a brand-new engineering program with a founding chair who is both an engineering education researcher and engineering education practitioner. This is a story that demonstrates how educational research (from engineering, social sciences, and beyond) guided educational practice at Wake Forest Engineering, as did educational practice guiding questions and ideas that informed educational research (applied and fundamental). A guiding question in sharing this journey (and in guiding the author in her role as the Founding Chair of Wake Forest Engineering) was and is:

What strategies support a transformative engineering education experience leading to inclusion, innovation and positive impact for our students and our communities?

This paper will focus on the work that impacted the student experience. Future papers will shine light on the work of building the faculty and staff team, faculty development, the benefits and challenges of the organizational structure, specific elements of curricular and pedagogical innovation, operational structures and decision making, etc.

II. METHODS

This paper is a descriptive case study detailing the visioning and building of Wake Forest Engineering. It is written from the emic perspective of the Founding Chair who happens to also be an engineering education research scholar. This descriptive case study offers a chronological account of key activities that impacted the student experience, including (1) department vision, mission, identity, (2) curriculum structure and development, (3) student advising, (4) pedagogical strategies, (5) integrative learning approaches, (6) course level learning, (7) supporting co-curricular experiences, etc.

A descriptive case study is one that can offer insights into a complex situation or a unique or rare situation with in-depth unpacking of the events, people interactions, procedures, processes, and strategies that led to a particular outcome that is of interest to others (Yin 2012; Noor 2008). Unpacking the building of a brand-new engineering program represents an opportunity for not only other new engineering programs/departments/units, but a unique opportunity to even established engineering programs, which are often described as slow to change, to witness different strategies and unique approaches to rethinking and reimagining engineering education.

The primary sources for this descriptive case study are documented artifacts within the archival documents of building WFU Engineering. These artifacts include documented processes and procedures, vision documents, annual department reports, student survey results, facilitation guides, presentations to stakeholders, accreditation documentation, program brochures, curricular documents, team documents, etc.

This descriptive case study is presented from an emic perspective, which is an insider's perspective to the building of WFU Engineering. The insider is the founding chair of WFU Engineering and the author of this paper, who also happens to be an engineering education researcher who has worked with social scientists, education researchers, assessment and measurement methodologists, and diverse scholars from many disciplines over the past 20+ years. Due to the emic perspective, first person will be used throughout this paper. The founding chair's emic perspective offers insights from a leadership, administrative, and management perspective, as well as the perspective of building a team, interfacing with diverse stakeholders (e.g. from recruitment of students to pitches with donors to engagement with industry to building partnerships within the institution, etc.), managing departmental budgets, supervising over 30 personnel (full-time and part-time), teaching across the engineering curriculum, interacting with administrative leaders across the institution and the local community, etc. While there are many advantages to an emic perspective and the unique perspective of a founder and leader overseeing program development to understand the in-depth complexity of the situation, there are certainly also limitations to an emic perspective, which is a single view.

My journey to the position of Founding Chair of Wake Forest Engineering is non-traditional. I am a naturalized citizen, first generation college student, first generation engineer, and first-generation PhD. I had also served as a founding engineering faculty at a previous institution (for nearly 10 years) and had experience with policy and administrative work at the National Science Foundation for two years immediately preceding joining WFU. I also came to WFU as the only experienced ABET expert - Engineering Accreditation Commission (EAC) program evaluator, team chair, and commissioner - within the Wake Forest Engineering and across the whole institution.

Unlike the traditional organizational model in higher education where Engineering is its own College or School, Wake Forest Engineering resided and resides as a department within a College of Arts and Sciences (aka College). The College is home to 30 departments (with Engineering being the 29th) and 26 interdisciplinary programs. The College Dean when Wake Forest Engineering launched (six initial years) was a historian and had no prior experience building new departments or programs, no experience with engineering education, and no experience with ABET or other professional degree accrediting bodies. The WFU academic

organizational structure with the College offered and offers many benefits and many challenges. It is beyond the scope of this paper to lay all those out. As the highest ranked engineering faculty and engineering leader on the WFU campus, I functioned as an Engineering Dean both in the responsibilities I had and in the various roles engaging with internal and external constituents (e.g. ABET, industry partners, professional schools, other university units, donors, sponsors, parents, students, etc.). Thus, I did the job of an Engineering Dean and Engineering Chair in one position.

II. LAUNCHING WAKE FOREST ENGINEERING

Launching Engineering at Wake Forest University (WFU) has a 25-year story. There were many individuals over a period of 25 years who had been advocating for Engineering to exist at WFU - the School of Medicine (which is a separate and independent entity from the main Wake Forest campus), science departments, and the professional schools. Reasons that halted the idea prior were space, resources, and administrative advocacy at the highest levels, etc. Two things happened in 2016. An external firm had been hired to conduct an admissions study and discovered that WFU was losing out on top students who wanted to pursue engineering at WFU, but engineering did not exist as an option. Thus, WFU was losing out on top students. Second, an old tobacco warehouse 2.5 miles away from the main campus within a budding innovation district, known as Innovation Quarter, had become available. Leveraging tax credits, the cost of renovating such a building looked promising and now finally a reality. Some of the same champions who advocated for Engineering before came with a proposal to the then Provost (Rogan Kersh), who supported the idea of having engineering at WFU. The then President (Nathan Hatch) saw the launch of Wake Forest Engineering as part of his legacy too. In fact, during then President Hatch's retirement in 2021, I was invited to present on Wake Forest Engineering as a legacy program and initiative for President Hatch. These three things - enrollment opportunity, space becoming available, and support at the highest levels of administration - made Engineering a reality. The WFU Board of Trustees approved the new Department of Engineering in 2016 as did the College Faculty (by majority vote and not with unanimous support). The then College Dean (Michele Gillespie) was new in her role and inherited Engineering's existence. Members of the College Committee on Academic Planning had shared with me that Gillespie initially did not support Engineering being at WFU but in what felt is an "overnight change" the message changed, and she started to support Engineering existing as a Department in the College.

I was appointed and publicly announced as the Founding Chair of Wake Forest Engineering in January 2017. **Figure 2** shows the position description as advertised in 2016 that I applied to. This position description lays out what was originally conceived for Wake Forest Engineering – one BS Engineering degree, one minor, and one concentration. Within months of starting though, I removed the minor and concentration from the books because I knew that kind of messaging would limit recruitment to students who wanted biomedical engineering only (when in fact I was already getting inquiries for other engineering disciplinary applications. This position description lays out some of the responsibilities I would eventually have and lays out what I shared during my negotiations – 70 graduates per year would suggest a program size of at least 300+ students and 7-8 faculty would not be adequate. In fact, the original budget I saw for the department revealed an underestimate of resources across all areas (faculty, staff, equipment,

etc.). I shared my concerns about this underdeveloped plan during my hiring negotiations, but the then Dean asked me to trust her and I did. My contract working at the National Science Foundation and personal reasons (e.g. expecting my fourth child) prevented me and my family from moving to Winston Salem, North Carolina until July 2017. Considering that the inaugural group of students would be arriving August 2017 (a non-negotiable start date) and the program and curriculum planning had not happened, I advocated for one additional faculty hire (beyond the planned two) to help launch the new department. During the spring 2017 semester, I served on the search committee with three colleagues (e.g. Keith Bonin, then Chair of Physics, Pete Santago, then Chair of Computer Science, and Rebecca Alexander, Chemistry Professor and then newly appointed Director of Wake Downtown) to hire the three founding faculty - Elise Barrella, Elizabeth Boatman, and Michael Gross - one recently promoted as a tenured Associate (Michael Gross) and two tenure-track Assistant Professors. They officially started on July 1, 2017, and we all arrived in our new home at Wake Downtown, the Innovation Quarter building that would be home to Engineering, the first week of July, just six weeks before welcoming our inaugural engineering students. At the time of our arrival, there was no website, no curriculum, no vision, no identity, no operating budget, no equipment, and no furniture in many of our spaces. No full-time staff were part of the founding team, but three part-time staff (Tommy Murphy, Amanda Tingle, Brian Smith) that supported other units at Wake Downtown were available to support the new department upon launch. The founding team arrived on site in July 2017 and met together for the first time just six weeks before the inaugural group of students were to arrive on campus for the first ever, first-year engineering class. A couple of weeks earlier, I worked to add some website content on a new Wake Forest Engineering website (current website being - https://engineering.wfu.edu/).

Engineering had been allocated one-third of the renovated footprint in the building - about 13,000 sq ft of spaces, mostly empty, unfurnished labs. The two other programs in the building (Wake Downtown) were an interdisciplinary major (Biochemistry and Molecular Biology) and a new chemistry concentration (Medicinal Chemistry). Although new facilities had been allocated to the new Engineering Department, these facilities did not have furniture or equipment. They were an empty canvas upon which to build the new department. Regarding the curriculum, there were two first year course titles on the books – EGR 111 (Introduction to Engineering Thinking and Problem Solving) and EGR 112 (Introduction to Engineering Measurement and Analysis). No operating budget existed for the new department, so five-year planning started as the founding chair was on site (fall 2017). The new Department of Engineering resided and still resides within the School of Arts and Sciences (also known as the College) and became that newest (since over 20 years) and 29th department in the College. The College is organized around five Divisions and Engineering joined Division 5 which comprised of biology, chemistry, computer science, health and exercise science, mathematics, and physics.

While the three founding faculty had prior experience teaching, they had never been part of early-stage program building and curriculum design of an ABET accredited interdisciplinary engineering degree. This was also the case for all the faculty and staff that were hired in years 2 to 6. No other member of the faculty/staff team had ever been part of an academic start-up department, whose one primary goal was ABET accreditation. Thus, the shared vision setting work was essential not only for the program but for team building. The WFU Engineering team (faculty and staff, full-time and part-time, visiting and permanent) grew annually for the next

four years - adding 5-7 folks annually. The intensity and amount of work cannot be described in words. Visioning, planning, execution, feedback gathering, refinement and continuous improvement was happening all at once and continuously. We were flying the airplane and building it all at the same time. The pandemic added even more layers of complexity, workload, and stress in what was an already remarkably complex situation. Most of the faculty hired were tenure-track (7) or newly tenured (2) and this meant that in midst of program and department development, they had to establish a research track record. In fact, as founding chair, I too had to both teach every semester (even take an overload a few semesters so as not to overload the rest of the faculty) and remain research active. An extreme and unsustainable workload that the Dean's Office did very little to alleviate.

Excerpt from Wake Forest Engineering Department Chair Position Description (2016)

The new Department of Engineering, approved this year at Wake Forest University, is being established within the Undergraduate College…When fully operational in 5-6 years, the Department of Engineering will be capable of conferring about 70 undergraduate degrees per year, with graduates holding a Bachelor of Science in Engineering degree. One concentration that is expected to be included is a track in Biomedical Engineering. In addition, the Department is expected to administer a newly approved minor in Biomaterials Science and Engineering... The Department of Engineering is expected to consist of 7 tenure-track faculty members and a professor of the practice, supplemented by associated faculty in other departments within Wake Forest University, such as the Biomedical Engineering graduate program.

The Department Chair position for this new department at Wake Forest presents an exciting opportunity for an innovative and enterprising leader to build an Engineering Department from the ground up. The Department Chair is charged with overseeing the recruitment and hiring of high-quality faculty to establish the Department at Wake Downtown. In addition, the Chair must lead faculty in their mission of education, research, and service. This charge includes working with faculty and the university to develop the Department's vision, to articulate and implement a Departmental strategic plan, and to achieve the goal of creating an innovative educational environment for engineering students. The Engineering Chair and faculty will be expected to work together toward the goal of establishing ABET accreditation soon after graduating the first class of students from the program. The Chair is also charged with promoting the Department through alumni, donor, community, and industrial engagement. The Chair will be responsible for establishing a new Engineering Department that operates within, and embraces, Wake Forest's culture as a leading collegiate university in the US. The new Department will be responsible for providing major and minor courses, as well as for teaching lower-level courses to non-engineering majors, including first-year seminars on topics in engineering.

The Department Chair is expected to be a tenured full professor in the College; however, exceptional applicants at the senior associate level may be considered. The Department Chair of Engineering reports to the Dean of the Undergraduate College and serves as the chief administrative officer who is responsible for the Department's administration, hiring, and promotion as well as the budget under the University's budget model. A successful candidate will:

- Possess an outstanding record in research, teaching, and service – areas critical to the University's mission and Pro Humanitate motto.
- Demonstrate successful leadership in research, education, and service.
- Recruit, develop, and retain outstanding faculty; support faculty in research and educational endeavors; and guide the mentorship of junior faculty.
- Work effectively and collaboratively with faculty and administration to develop the Department's vision, to create a roadmap for establishing a high-quality Engineering Department, and to integrate the Department's vision, plan, and goals with those of the College and University.
- Promote the Department by engaging alumni and donors to enhance Departmental resources.
- Engage the greater Winston-Salem community and industry in Winston-Salem as well as inside and outside of North Carolina.
- Work with faculty and staff to establish ABET accreditation for the Department.
- Be committed to diversity among students, faculty, and staff.
- Communicate effectively with all constituents including students, faculty, staff, parents, alumni, and members of the community.
- Represent the Department at University, College, and public activities.

The desired start date for this position is **January 1, 2017**. To ensure full consideration, applications should be received by **September 1, 2016**; however, applications will be considered until the position is filled. Salary is commensurate with skills and experience.

Figure 2: Excerpt from posted Wake Forest Engineering Chair position description.

In May 2017, I was informed by the WFU Admissions team that we should be expecting about 26 students (15% women) to enroll in the inaugural engineering class, EGR 111 (Introduction to Engineering Thinking and Practice). The reality on August 2017 was that 55 students had enrolled in EGR 111. By the end of the first year, 60 unique students were enrolled in one or both of the first-year engineering courses. Within three years, the program reached about 200 students and became the 4th largest department in the College and one of the most diverse (e.g. gender, race, ethnicity, first generation, etc.). **Figure 3** shows Table 1 of our Wake Forest

Engineering ABET Self-Study which is a standard table and format showing the student enrollments at the time of the ABET visit which for us was Fall 2021. Wake Forest Engineering currently has over 220 students across all four years.

	Academic Year		Enrollment Year				Total
			1st	2nd	3rd	4th	
Current	2020-2021	FT	64	46	46	43	199
1 year prior to current	2019-2020	FT	62	49	43	0	154
2 years prior to current	2018-2019	FT	95	44	0	0	139
3 years prior to current	2017-2018	FT	60	0	0	0	60

*We are proud to have 40% female students in our program.

Figure 3: Table 1 of our Wake Forest Engineering ABET Self-Study showing enrollments as of Fall 2021.

III. SHARED VISIONING OF WAKE FOREST ENGINEERING

In this section, I highlight the shared visioning process that took place during the first three years of launching Wake Forest Engineering. Unlike other brand-new engineering departments and brand-new departments in general, visioning and execution was happening concurrently for Wake Forest Engineering. Most brand-new engineering programs have 2-3 years of planning prior to the arrival of students, Wake Forest Engineering had six weeks.

The vision of the four-year curriculum launched using a ***backward design process*** where, as a team, we needed to start to envision the kind of engineering graduate we desired. The four-year curriculum would be the vehicle to embody this WFU Engineer. Although this visioning exercise launched immediately, so that it would influence the content and pedagogy of our first-year engineering courses, ***visioning*** continued as an exercise of various forms throughout the first three years. The Founding Chair sought out to find several facilitators who could support a series of shared visioning exercises and also support documentation of the work (considering how much work the founding team had to do to launch the new department). Dr. Anita McCauley had just been hired to be the first STEM faculty development member of what has now become the WFU Center for the Advancement of Teaching. I invited Dr. McCauley to serve as facilitator at many of our visioning meetings and she accepted. She supported WFU Engineering during the first two years. Together, Dr. McCauley and I met regularly to lay out a plan and to develop appropriate exercises to support the visioning work. I brought engineering context, resources, literature, and guidance as Dr. McCauley's background was in biology and this was her first time supporting program development at this stage of development (in contrast to some experience she had with established science departments). Because of how important culture setting was to me (even more important to curriculum as a foundation), we leveraged the Fall 2017 semester to ***identify our shared values*** for our new Department and continued discussions about what makes an top performing team. Their behaviors, communication, operation, etc. We also had weekly 2-3 hours meetings (sometimes longer) on curriculum development. Topics of coverage working with Anita included aligning College and University

mission and vision with our curricular visions, brainstorming ways to achieve aspiring design features in our curriculum, developing program outcomes to drive course structure and course learning outcomes, etc. The result was a 25 page document that reflects a summary of this immense amount of visionary work together as the team was growing. I also knew that our work was not done and that we needed to leverage the hiring process to continue both culture setting and building our curriculum. So, I invited Anita to facilitate 1-hour long curriculum planning sessions within the two-day on-site faculty interview process. With three candidates per position (and we had three tenure-track Assistant Professor faculty openings Spring 2018), this meant that we had 9 candidates visiting within a couple of months. This intentional strategy not only helped us in identifying candidates that were comfortable within an academic start-up, but it also helped candidates make an informed decision about the department they would join and what would be expected of them as founding faculty. Further, though, these curriculum planning sessions embedded within the many faculty interviews we had allowed us to make progress with visioning our curriculum, the kind of WFU engineering graduate we desired, the kind of learning we wanted to take place in our courses and across the curriculum, and the kind of pedagogies we need to deploy.

Vision of a WFU Engineer

One of the first visioning exercises (summer and fall 2017) was envisioning our Wake Forest Engineering graduates. What are the attributes of an ideal Wake Forest Engineering graduate? What do they know? What are they doing? What are they thinking? What are they feeling? Where are they working? What kinds of jobs do they have? Etc. We shared and discussed articles that described what employers wanted out of engineering graduates, reviewed prominent sources like the National Academy of Engineering Engineer of 2020 and Educating the Engineer of 2020 (The Engineer of 2020; Educating the Engineer of 2020), and even envisioned what a liberal arts engineer looks like compared to the traditional model of engineering education. We envisioned their resumes and what they looked liked. ***Figure 3*** represents just some of the attributes that we came up with in describing the attributes of the WFU Engineer. ***Figure 4*** shows what I presented to the team and what was part of my interview as chair. A vision of what our graduates' resumes would look like. The actual list of attributes was pages long. It was not so much the content on that list but the mindset it put us in. We knew our list of attributes was different from what we had experienced in our own educational journeys and different from the typical model of engineering education offered. We were willing to imagine a different engineering graduate and believed that society demanded a different kind of engineer. This would mean though that how we educate them will need to look different and that was the goal ahead of us. We would look back to this list of WFU Engineer attributes to remind us of our vision and as our team grew, and I would share the document with our new colleagues (even in midst of our accreditation work). This iterative approach was important as it served as a reminder to the founding team that was building in the midst of visioning (i.e. flying the airplane as it was flying). As chair, I would remind the team that the vision of the WFU Engineer would need to be embodied by us - the WFU Engineering faculty and staff. What we expected of our students and graduates, we would need to model even if we were not trained in the model of engineering education we were working to achieve. As we engaged with industry partners and engineering advocates, we would invite them to help us envision the WFU Engineer and eventually once we had students, we invited them during class time to help us envision what they

would be doing and how we could embody a liberal arts model to engineering education. As an example, one of the first assignments in our first engineering class - EGR 111 (Introduction to Engineering Thinking and Practice) - was a personal statement of what each student hoped to do with an engineering degree and where they envisioned they would be after graduation. This was not an easy assignment but one that we would give back to students on graduation day (nearly 4 years later). Similar visioning assignments like an Independent Development Plan (IDP) would be part of the curriculum too and would continue to be improved by the founding faculty team (e.g. Melissa Kenny, Kyle Luthy, Kyana Young, Courtney DiVittorio). Ethical Leadership assignments and Career Readiness assignments in capstone design, etc.

***Figure 3**:* Some of the attributes we had envisioned for the WFU Engineer

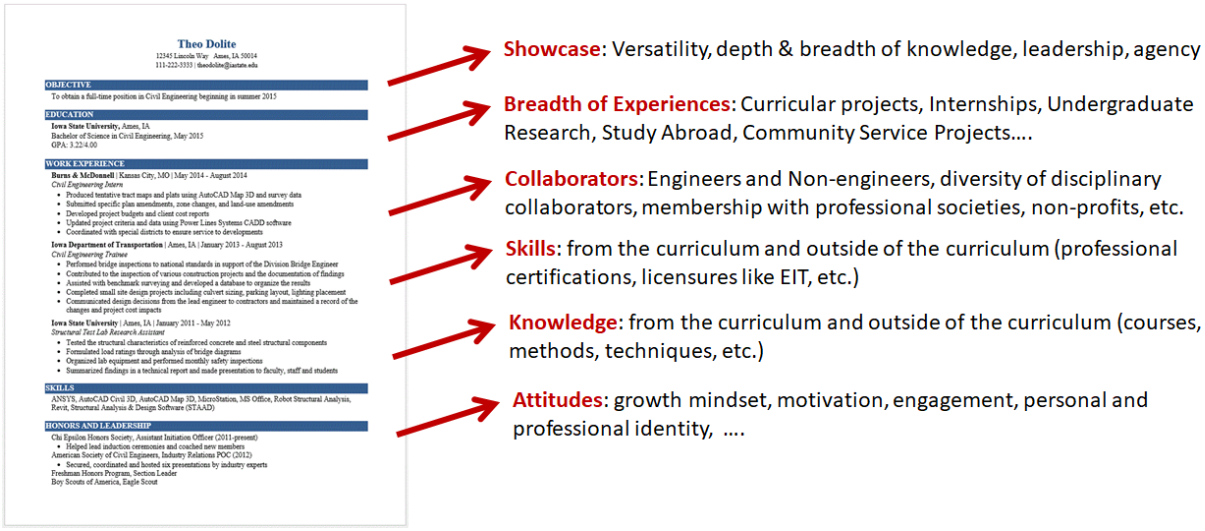

Figure 4: Ideal resume schematic of a WFU Engineer showcasing their versatility, interdisciplinary, diverse set of high impact learning experiences, etc. From presentation slides by Pierrakos presented during her interview and with stakeholders.

Vision of Program Features

Along with vision setting exercises like envisioning the WFU Engineer, the founding faculty and staff team undertook benchmarking as a strategy to support all kinds of programmatic development work. As new faculty and staff were hired, ***benchmarking*** exercises became a regular strategy for each one to understand the landscape of whatever thing was the focus of the task (e.g. first year engineering curricular, co-curricular programs like externships, facilities

benchmarking, advising, budgeting protocol, space design, etc.). Benchmarking involved other engineering programs in the US and international benchmarks as well. Faculty would bring their discoveries to department meetings and discuss the purpose and features of what existed at other universities. We would discuss the features and aspects of these benchmarked ideas and what aspects we wanted to adopt and how we would modify them to meet the needs of our students and our program.

Along with benchmarking that continued during the first five years of WFU Engineering, it became very important for the faculty and staff team to understand the relevant perspectives of other stakeholders. Students perspectives were accompanied by employer perspective, by perspectives of colleagues across campus, by community perspectives. Whether the faculty and staff team realized this intentionality, diverse voices and perspectives were invited to join department meetings often. All the full-time and part-time staff supporting the department were also invited to attend department meetings. In fact, staff traditionally did not attend department meetings across other WFU College departments so the change WFU Engineering made sent a message of inclusion to supporting staff who had immense expertise to offer and an opportunity for uniting a team and not soloing it. Even more, I started to invite colleagues from across campus to our department meetings and retreats (and all the engineering classes I was teaching). Colleagues from history, philosophy, computer science, anthropology, entrepreneurship, business, art, physics, medicine, ethics, etc. I also started inviting practicing engineers to our meetings and all the classes I taught. Me modeling these cross-disciplinary invitations was to encourage engineering faculty to see the value of bringing diverse perspectives to the engineering classroom.

When students arrived in the first class, we asked them why they came to WFU and why WFU engineering. We invited them to share what a liberal arts engineer means to them and what their hopes and dreams were. This fierce commitment to the student perspective and ***shared visioning*** continued to guide us and drive us in building the program.

Vision of a Our Engineering Culture

Culture was very important for me as the Founding Chair and important to the founding faculty team as well. Within a few weeks of coming together (summer 2017) and laying a solid enough foundation to prepare our first-ever course (that we all co-taught together fall 2017) - EGR 111 (Introduction to Engineering Thinking and Problem Solving), the focus of our conversations moved to thinking about culture. As an initial exercise to culture setting, I wanted the team to identify a set of shared values that would define the culture of our new department. I reached out to Dr. Melissa Clodfelter, who at the time was leading the university's Professional Development Center, and she was up for the challenge. Through a series of facilitated exercises that guided the faculty and staff team to reflect on past departmental experiences (what was good about the culture and what was not as good), value priority exercises, and lots of discussion, the team agreed on a set of six shared values - *empowerment, integrity, inclusion, compassion, growth,* and *joy.* These values began to be operationalized in every layer of our work (i.e., classroom environment, faculty-student interactions, faculty-faculty interactions, reward structures, curriculum development, collaborations with colleagues, space design, etc.).

Figure 5*:* The six shared values the founding team of faculty and staff identified in fall 2017 to lay the foundation for the kind of culture we desired. These values could also be described as character aspirations.

Vision and Mission of Wake Forest Engineering

Within the first six months together as a founding team, we began to articulate a vision and mission for Wake Forest Engineering. It was essential, as is the case for all ABET accredited engineering programs, for the new Wake Forest Engineering Department to align with the university vision and mission (below).

Our ***WFU Engineering Vision*** was to graduate engineering students who understood their responsibility to better humanity and to provide the best liberal arts engineering education. On our WFU Engineering website, we describe the vision of the WFU Engineer to be (a) leaders and agents of change, (b) active seekers and creators of knowledge, (c) empowered with the engineering fundamentals that is strengthened with the breadth of an exceptional liberal arts education, (d) adaptive experts that recognize the strengths and limits of his/her knowledge and team, (e) innovators by embracing inclusion, diversity, and equity, and (f) fearless in the face of complex problems. This vision should apply to both faculty and students and the founding chair talked about this often. Faculty modeling for students that kind of engineer we desired of them was essential and this concept was embraced by the faculty team. Our ***WFU Engineering Mission*** is to Educate the Whole Engineer with a commitment and responsibility to better humanity (Pro Humanitate).

By year three, we had articulated our program educational objectives (also needed for ABET and aligned with our mission to Educate the Whole Engineer) and informed by all our program constituents (i.e. students, faculty, external advisors). Our three program educational objectives (PEOs) became and remain the following and aligned with our vision and mission of the kind of WFU Engineer graduate we wanted. ***Figure 6*** shows how we mapped our PEOs to the seven ABET Student Outcomes. Ultimately, PEO 1 aligned with our goals for an interdisciplinary

approach to the engineering fundamentals, PEO 1 aligned to our goals for integrating professional knowledge, skills, and attitudes (KSAs) to engineering KSAs, and PEO 3 aligned with our goals to instill the virtue of responsibility for oneself and towards society.

PEO 1. Demonstrate versatility and adaptability in applying engineering fundamental knowledge, skills, and mindsets to diverse career trajectories within or beyond engineering. ***(INTERDISCIPLINARY APPROACH TO ENGINEERING FUNDAMENTALS)***

PEO 2. Integrate ethical decision making, effective communication, inclusive collaboration, and innovative thinking towards professional practice with and for diverse stakeholders. ***(INTEGRATION OF PROFESSIONAL KSAs TO ENGINEERING KSAs)***

PEO 3. Actively engage in lifelong learning for the betterment of one's personal and professional self with the ultimate goal of serving society and human flourishing. ***(RESPONSIBILITY TO SELF AND SOCIETY)***

Further, as can be seen from the excerpts below, WFU Engineering was intentional aligned and build around the Wake Forest University ***Institutional Mission and Vision***:

Excerpts from WFU Institutional Mission –

"Wake Forest is a distinctive university that combines a liberal arts core with graduate and professional schools and innovative research programs... It is a place where exceptional teaching, fundamental research and discovery, and the engagement of faculty and students in the classroom and the laboratory are paramount...The University sustains a vibrant residential community with a broad-based program of service and extracurricular activities... Central to its mission, the University believes in the development of the whole person – intellectual, moral, spiritual and physical...While national in scope, the university has been shaped by a culture that is distinctively North Carolinian. This history provides it with a sense of place and community responsibility. In extending its reach, the University has made a priority of international study and international understanding. Wake Forest seeks to be a place where a vibrant and diverse learning community weds knowledge, experiences and service that lift the human spirit."

Excerpts from WFU Institutional Vision –

"Wake Forest University aspires to: (1) Emphasize exceptional teaching, discovery, and student engagement within a dynamic academic community; (2) Integrate the intimacy of an undergraduate liberal arts college with the academic vitality of a research university; (3) Become a crossroads of discussion on the important national and international issues of our time; (4) Attract a diverse community of the brightest educators and students from throughout the country and the world; (5) Link intellectual curiosity, moral reflection and a commitment to service, shaping ethically informed leaders to serve humanity."

Program Education Objectives	Thematic Goal Mapped to the Student Outcomes
PEO 1 - Demonstrate versatility and adaptability in applying engineering fundamental knowledge, skills, and mindsets to diverse career trajectories within or beyond engineering.	**SO1** – Apply engineering and scientific fundamentals to tackle real-world engineering problems and non-engineering problems.
	SO2 - Design, prototype, and model solutions that meet human needs.
	SO6 – Collect and analyze data to make conclusions to inform decisions.
PEO 2 – Integrate ethical decision making, effective communication, inclusive collaboration, and innovative thinking towards professional practice with and for diverse stakeholders.	**SO2** – Use innovative thinking and tools to develop solutions that benefit and add value to diverse stakeholders.
	SO3 – Communicate effectively using diverse written, oral, and visual formats to technical and non-technical audiences.
	SO4 – Understand ethical and professional responsibilities to inform ethical decision making and implications to diverse stakeholders.
	SO5 – Work effectively in a team setting utilizing inclusive and equitable practices.
PEO 3 – Actively engage in lifelong learning for the betterment of one's personal and professional self with the ultimate goal of serving society and human flourishing.	**SO4** – Understand cultural context to inform decisions and adapt to diverse environments in order to support personal and societal growth.
	SO7 - Use diverse learning strategies to cultivate a lifelong learning mindset in achieving personal and professional goals.

Figure 6*:* The Wake Forest Engineering PEOs (Program Educational Objectives) mapped to the ABET Student Outcomes. From the Wake Forest Engineering ABET Self-Study Criterion 2 section prepared by Pierrakos.

Understanding our Distinct Identity

Along with our vision and mission, it was important to know who we are in the landscape of engineering education (***Figure 7***). Upon review of ABET accredited engineering programs, I identified the unique positionality of WFU Engineering and shared it with faculty, colleagues, students, parents, and many other internal and external constituents and stakeholders (e.g. Board of Trustees, advancement, admissions and recruitment events, parents, etc.). There are four characteristics that uniquely position WFU Engineering to understand its identity: (1) offering only one interdisciplinary *BS Engineering* degree, (2) having a *focus on undergraduate education* (no doctorate program), (3) integrating engineering education within *Liberal Arts Education*, and (4) being part of a *Research University* that sets the expectation to bring knowledge advancement to positive societal impact.

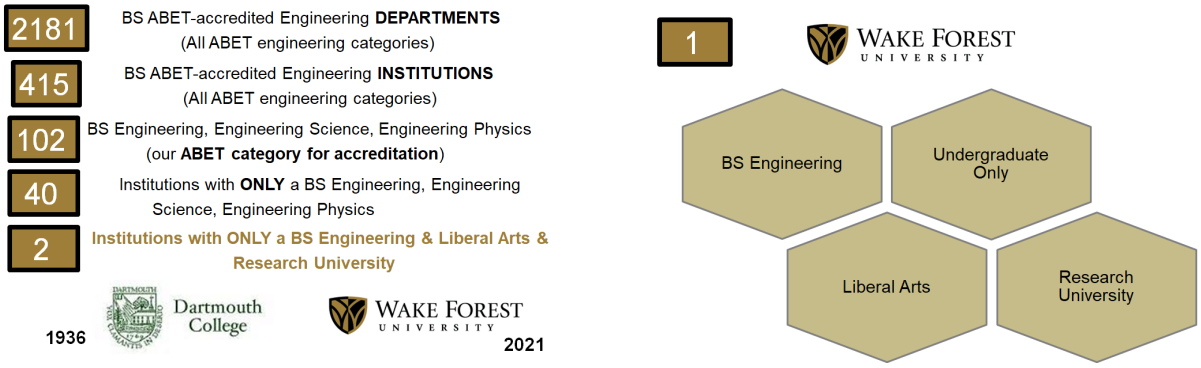

***Figure 7**:* Visual representations of WFU Engineering program identity and its uniqueness. From presentation slides prepared by Olga Pierrakos and presented to diverse stakeholders.

Vision for Pedagogy

Using a backward design process described previously, it became obvious to the founding team that a commitment had to be made for the first-year engineering experience to follow project-based learning pedagogy and in general student-centered pedagogies. The Founding Chair and one of the founding faculty had experience with project-based engineering courses and moved quickly in identifying stakeholders that could make the projects authentic. In the first year, the founding team co-designed and co-taught two engineering courses that culminated to (a) 5 unique projects (introducing both design and research thinking to understanding engineering problem solving, practice, thinking, and analysis), (b) one module "Engineering and Me" designed to connect historical, cultural, and personal values to the profession (and attempting to integrate knowledge beyond engineering and beyond what we traditionally see in engineering classrooms), and (c) embedded professional development workshops. We knew that our vision for the year one curriculum was to set a foundation for what would come over the next three years and to provide knowledge, skills, and attitudes so that our first-year students would have the confidence to start pursuing internships and other relevant engineering work experience. The successful first year curriculum ultimately included five unique projects, from design to research to client-based to community engagement, in support of internship-ready students at the end of year one led to a commitment early on for theory and practice to be part of every engineering class. **Experiential learning and use of student-centered pedagogies in every class was a striving goal.** ***Figure 8*** shows a visual representation of the various student-centered pedagogies the Wake Forest Engineering founding team discussed in supporting the learning in the new curriculum to be developed and delivered.

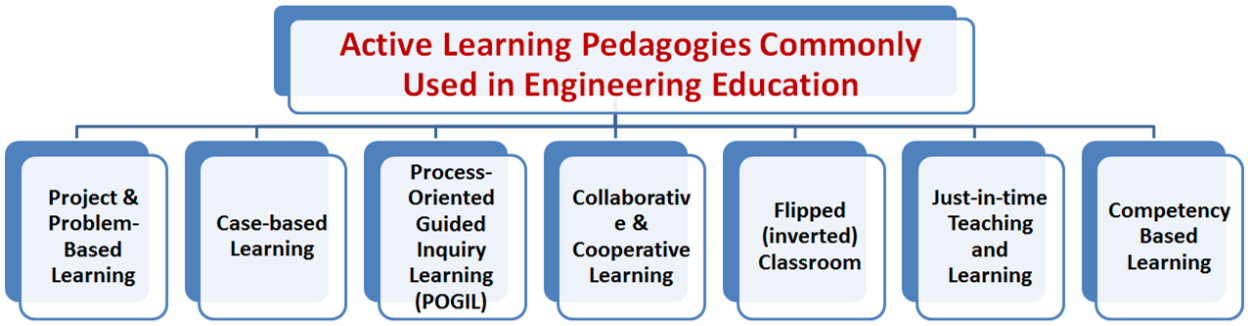

Figure 8*:* Visual representations of student-centered and active learning pedagogies the founding team discussed. From presentation slides prepared by Olga Pierrakos and presented during her interview as Founding Chair.

Vision for the Curriculum

Although an internal task force had drafted an engineering curriculum spring 2016 to get the new department approved in the College, the Founding Chair was allowed to start the curriculum design process from scratch to ensure ABET compliance and alignment with shared visioning. As a point of reference, ***Figure 9*** shows the originally proposed WFU BS Engineering curriculum, which showcases what most would describe as a traditional engineering curricular model. Eventually, as will be visible in upcoming sections of this paper, the WFU Engineering would reflect a model that is more interdisciplinary, integrated, and holistic.

Proposed WFU BS Engineering Curriculum (Spring 2016)
Math & Science 30 Credit Hours Calculus with Analytic Geometry I 4 / Calculus with Analytic Geometry II 4 Ordinary Differential Equations 4 / General Physics I 4 / Elective 4 / Elective 4 / Elective 3 / Elective 3 **Engineering 45 Credit Hours** Engineering Statistics & Experimental Design 3 / Engineering Computation 3 / Materials 4 Mechanical and Electrical Systems I 4 / Mechanical and Electrical Systems II 4 / Thermodynamics 3 / Senior Design I 1 / Senior Design II 1 / Engineering Elective 4 / Engineering Elective 3 / Engineering Elective 3 / Engineering Elective 3 Engineering Elective 3 / Engineering Elective 3

Figure 9*:* Visual representation of the originally conceived WFU Engineering curriculum prior that was presented to the College faculty to approve Engineering as a new department in the College (Spring 2016). From historical documents given to me.

Upon envisioning the WFU Engineer, we started to envision the WFU Engineering curricular structure and curricular requirements. ***Figure 10*** offers a glimpse of what we started to envision for our engineering curriculum (aka curricular requirements). There were clearly some ABET requirements, but most were our aspirations for what success would look like when complete. Figure 10 reflects the shared visioning curriculum requirements established by the 2017 founding engineering team.

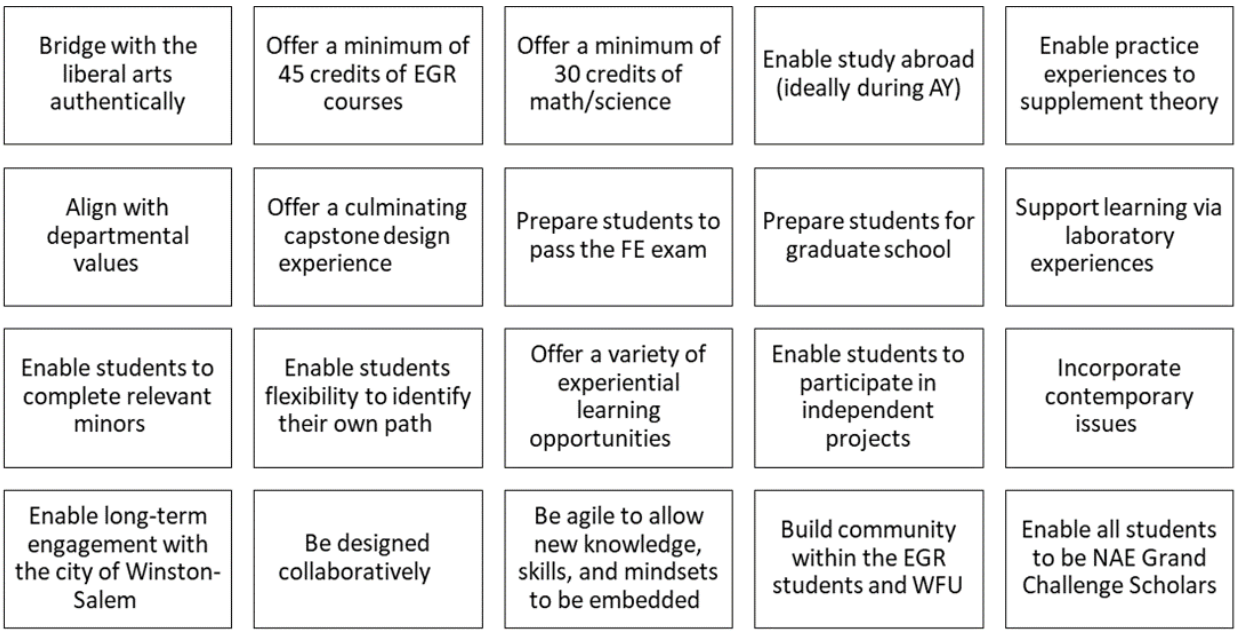

***Figure 10**:* Curricular vision for WFU Engineering. From presentation slides prepared by Olga Pierrakos and presented to diverse stakeholders.

The founding engineering team spent about ten meetings in Fall 2017 alone to discuss a vision, requirements, design features, course pre-requisites, content coverage and integration, pedagogy, and basics of assessment in building out our curriculum in line with the Undergraduate College norms as well as ABET requirements. The founding chair solicited insights not only from the founding faculty team, but also from the Division V (STEM) Chairs, the Dean's Office, the Office of Academic Advising, and most importantly engineering students. All founding faculty were encouraged to participate in such information gathering activities to make informed decisions about our curriculum in line with the relevant stakeholders we must serve. In fact, the founding chair institutionalized student entrance surveys and major declaration questionnaires. This provided a frequent and continuous process upon which to keep our pulse on the student's evolving needs and aspirations. Eventually, senior exit surveys were also added as part of the departmental continuous improvement assessment plan.

Vision for an Integrated Approach to Learning Outcomes

Wake Forest Engineering would offer one BS Engineering degree to be accredited under ABET's General Engineering category. This meant that engineering fundamentals would need to be authentically integrated across the curriculum and engineering disciplinary siloes would need to be broken down. We challenged the traditional boundaries we experienced as engineering students and reviewed FE exam topical areas to combine knowledge areas in efficient and effective ways. Traditional topics and typical stand-alone engineering courses like statics, dynamics, materials, and mechanics were combined to become one, integrated 4 credit hour course (6 contact hours in the class and lab) titled EGR 211 (Materials and Mechanics). Similarly, thermodynamics, fluid mechanics, and heat transfer, that are three typical stand-alone engineering courses, were combined to become one, integrated 4 credit hour course (6 contact hours of classroom and lab time) titled EGR 212 (Transport Phenomena). This integrated

approach not only enabled us to build natural connections across engineering fundamentals, but also enabled us to open other parts of the curriculum to fundamentals beyond the FE exam topical areas, which for the most part target ABET Student Outcome 1 knowledge. We needed to break the traditional disciplinary knowledge siloes, within engineering and beyond. As an example, having had the prior experience as a Founding Faculty at James Madison University Engineering, which prided itself in having an engineering design course "spine" across the four years, I also knew that engineering science courses should not be separated from engineering design courses. Engineering science courses tend to promote theoretical knowledge and tend to be taught with a mindset that engineering problems have one correct solution. In contrast, engineering design courses tend to promote applied knowledge and are taught with a mindset that engineering problems (design problems) have multiple paths to a solution and multiple appropriate solutions. The reality is that both mindsets (engineering science and engineering design) are essential to the competence of engineers. When isolated, though, and taught separately, it is a missed opportunity to showcase how authentic real-world engineering practice requires both mindsets. With this thinking and guidance, I ensured that the WFU Engineering curriculum did not isolate theoretical engineering knowledge (i.e. engineering science learning associated with ABET Student Outcome 1) from applied engineering knowledge (i.e. engineering design learning associated with ABET Student Outcome 2 and engineering experimentation learning associate with ABET Student Outcome 6). To achieve this authentic integration of fundamental engineering knowledge (e.g. ABET Student Outcomes 1, 2, and 6), I guided the WFU Engineering team to integrate the fundamentals. This same kind of mindset can be applied to the integration of the more professional and personal learning outcomes (ABET Student Outcomes 3, 4, 5, and 7).

To achieve the vision of the WFU Engineer and to deliver the integrated and interdisciplinary engineering curriculum we desired, I knew that we needed to hire a diverse team of engineering faculty that spans many engineering disciplinary areas. I also knew that we needed more than engineering faculty. Future publications will focus on these aspects of recruiting and hiring the founding WFU Engineering team.

IV. DEFINING GOALS TO TRANSFORM ENGINEERING EDUCATION AT WAKE FOREST ENGINEERING

We knew we wanted a transformative experience in building Wake Forest Engineering. We wanted it to be transformative for the students and their diverse post-graduation interests that we had been gathering, and transformative for the engineering faculty and their diverse scholarly interests. Our approach was not setting goals like "50% of students should be women" but instead our goals were articulated to reflect the kind of environment and experience we wanted for our students. The outcome and the results of our intentional process was transformative. Process was a key focus for me as the Founding Chair. The process had to be free of biases and informed by a diversity of perspectives, our students first and foremost. My role as the Founding Chair was to guide, coach, and find ways to assess the performance of the system, the experience, the curriculum, and each person contributing to the whole education of our students.

1. Building a Culture Aligned with our Shared Values.
2. Students Feeling Included and Empowered to Take Ownership of their Education.

3. Designing an Engineering Curriculum to Support the Diverse Engineering Interests of our Students and to meet ABET Accreditation Requirements.
4. Experiential Learning & Student-Centered Pedagogies in Every Engineering Course.
5. Integration of Knowledge Within and Beyond Engineering.
6. Integrate Ethics and Character in Every Engineering Course.
7. Enrich the Curricular Experience with High-Impact Co-Curricular Experiences.

Along with defining goals, I also knew that it was important to assess these goals and identify metrics of success. Such metrics evolved over time and will be a focus of future publications.

V. STRATEGIES USED TO TRANSFORM ENGINEERING EDUCATION AT WAKE FOREST ENGINEERING

In this section, I highlight the strategies I used as Founding Chair of Wake Forest Engineering to support the department in achieving our vision of a student experience that would enable us to achieve our goals. What is included herein is not all inclusive of all the strategies used but a sample of the strategies used to achieve our vision and our goals. It is these strategies that I believe are transferable to new and established engineering programs who desire to transform engineering education and transform the experience of our engineering students.

Goal 1: Building a Culture Aligned with our Shared Values.

If we were to live up to the shared values, we would need to embody them with every aspect of our work. Our shared values were not just included on our website (homepage), but became part of our hiring ads, hiring process, facilities planning efforts, reward structures, course evaluations, student awards, faculty and staff evaluation documents, etc. We used our values to brainstorm ways that we could design an interview site visit, in designing our spaces, in designing our classroom environment and classroom structures, in inviting students to give us feedback, etc. We would start department meetings reflecting on our values and brainstorming ways to embody them in every aspect of our operation and work together. ***Figure 11*** shows an excerpt from our faculty ads and the first paragraph outlining our values. In later sections of this ad, we also have a section that describes our unique identity and the vision of the kind of WFU Engineer graduate we desire. All to show how values and vision come together to help us identify the kind of faculty and staff team that we desired for Wake Forest Engineering. ***Figure 12*** further shows how we embedded in our standard course evaluation survey, which is administered with every WFU engineering course every semester, our departmental values and our desire to capture the extend to which students experienced a classroom culture that aligned with our values. If the classroom culture did not align with our values, we asked for feedback and ways that we could improve. Such responses were visible to the faculty instructors and me as Chair. This kind of culture setting example allowed for students to feel empowered to share with us what they were experiencing and to hold us (as faculty) accountable to make the necessary changes to improve the classroom culture. Certainly, the remainder of the course evaluation feedback provided more in-depth insights on specific aspects of a course – assignments, grading structures, project work, lectures, etc. – that would enable the faculty to take ownership of the classroom culture they were creating and to make the necessary improvements to ensure students felt empowered to take ownership of their learning. In time, we also instituted departmental student awards for our

graduating seniors that aligned with our departmental values to further promote and remind our engineering graduates of the responsibility they now had to continue creating cultures that aligned with important values that help reshape the cultures in professional engineering and non-engineering environments. That is at least the vision and hope I had for our graduates – that they would understand the responsibility they now had for bettering a better future for themselves and for others. I saw our graduates as engineering ambassadors to better organizations and humanity.

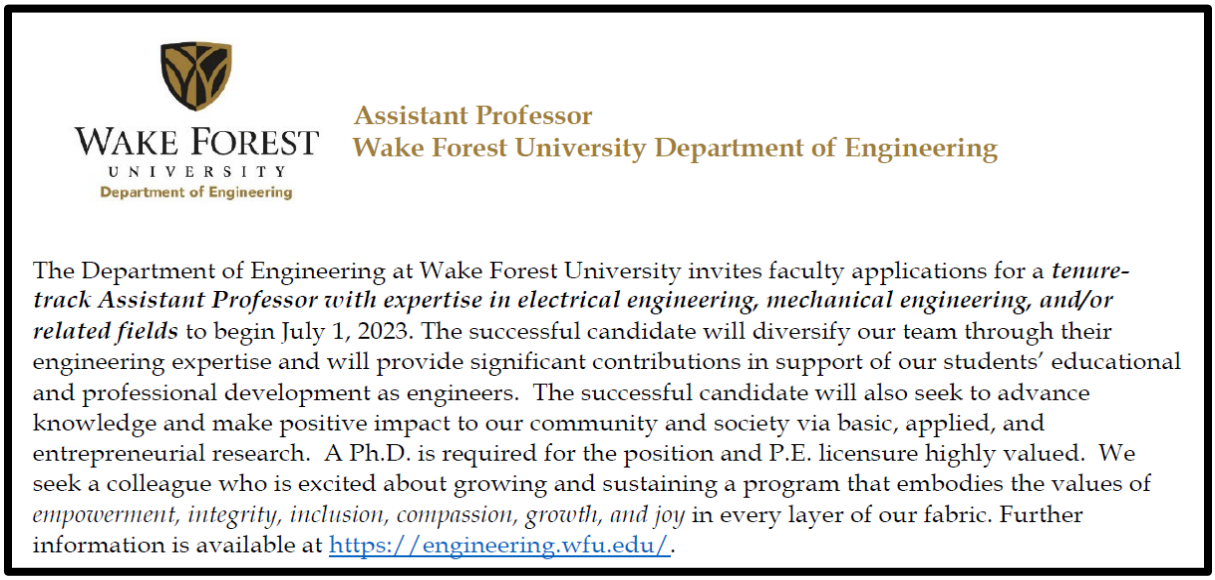

Figure 11*:* Some of the language in faculty ads that pointed upfront to our departmental values. The complete ads speaks to culture, vision, mission, and identity.

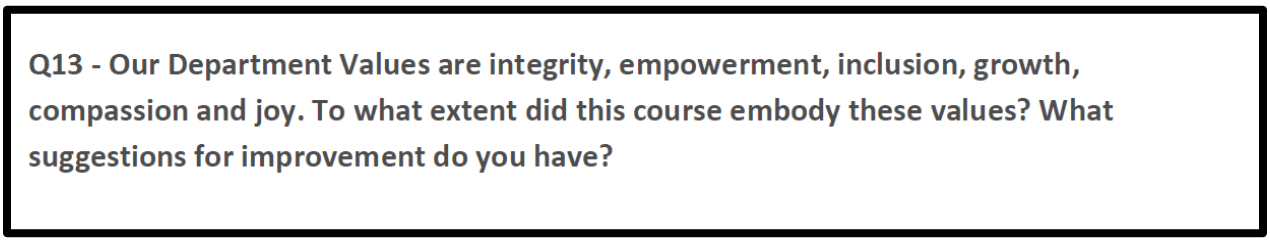

Figure 12*:* Open ended question with the course evaluation survey that reminds students of our department values.

In the early years of building Wake Forest Engineering, we discussed a lot what it means to be a high performing team and about the behaviors of high performing teams (as well as establishing a departmental culture aligned with high performance teams). Several departmental workshops took place over the founding years with a diversity of external speakers, experts, and scholars to directly and indirectly reflect on and discuss our values and our culture and our operations and how we engaged with each other and stakeholders (like our students). The pandemic and the disruptions to in person communication certainly introduced challenges for our team (as for many teams) and this was further exacerbated by top administrative personnel not modeling professional conduct that aligned with our department values nor healthy professional conduct. Assumptions started to be made and biases became visible. All this demonstrated the difficulty

of upholding a strong and healthy functioning departmental culture when the institutional culture did not reflect ethical leadership and healthy professional conduct.

Culture setting had to also take place in the classroom along with the department-level environments and activities. One way we supported a classroom environment that supported a professional environment that aligned with our values was inviting students to participate in defining a professional work environment. This happened for the first time in EGR 111, within our first course offering in fall 2017, where I invited the students during the first two weeks of the semester to define a professional work environment and how people should interact in this environment. A series of questions were asked of students (shown in ***Figure 13***) to describe the kind of work environment they wanted and their responses laid the foundation for what we wanted to see in the classroom environment. This kind of activity not only empowered students in the fact that they had a role to play in shaping the classroom culture, but it also provided the faculty team with the language that student used to define a professional work and classroom environment. These student responses would be used to reinforce the importance of a productive and healthy work and classroom environment for the years that followed. I personally used these same student responses in EGR 212, a sophomore level course in the curriculum, that I taught for the first time in fall 2018 and then again in capstone design (junior and senior year) to remind students of a professional work and classroom culture. I would complement their insights with published papers (typically from Harvard Business Review) on effective and innovative work environments. Thus, culture setting activities like this are not one and done. They must be reiterated often to establish the culture that we all desire.

Goal 2: Students Feeling Included and Empowered to Take Ownership of their Education.

As a first-generation college student, a first-generation engineer and PhD, an underrepresented minority (being a woman) in engineering (a white male dominated profession), and as naturalized citizen, I personally experienced and witnessed in both my education and professional work environments many situations of exclusion, inequitable access, unjust policies, bias, unwelcoming environments, marginalization, undermining, bullying, harassment, discrimination, and retaliation. As the Founding Chair of Wake Forest Engineering, I felt immense responsibility to create a classroom culture and a departmental culture that was inclusive and empowering. Due to my experiences, it is not a coincidence that my very first ever National Science Foundation (NSF) award was to study engineering identity development. I knew I could not do that work alone though and that is when I started formally collaborating with psychologists and social scientists. Such interdisciplinary collaborations transformed not only my research mindset, but also how I saw my role as an educator. Again, the mindset outlined in Figure 1. What most did not recognize in what I brought to the role of Founding Chair is over a decade of education research and engineering education research on:

(a) **Engineering student motivation** using theories like expectancy value theory, achievement goal orientation, self-determination theory (France et al., 2010; Pierrakos 2016; Pierrakos 2017; Williamson et al., 2016; McGrath et al., 2013; Panizo et al., 2015)
(b) **Engineering student identity development** (Pierrakos et al., 2009; Pierrakos et al., 2016; Curtis et al., 2017a; Curtis et al., 2017b; Pierrakos et al., 2010; Beam et al., 2009; Stoup and Pierrakos, 2016)

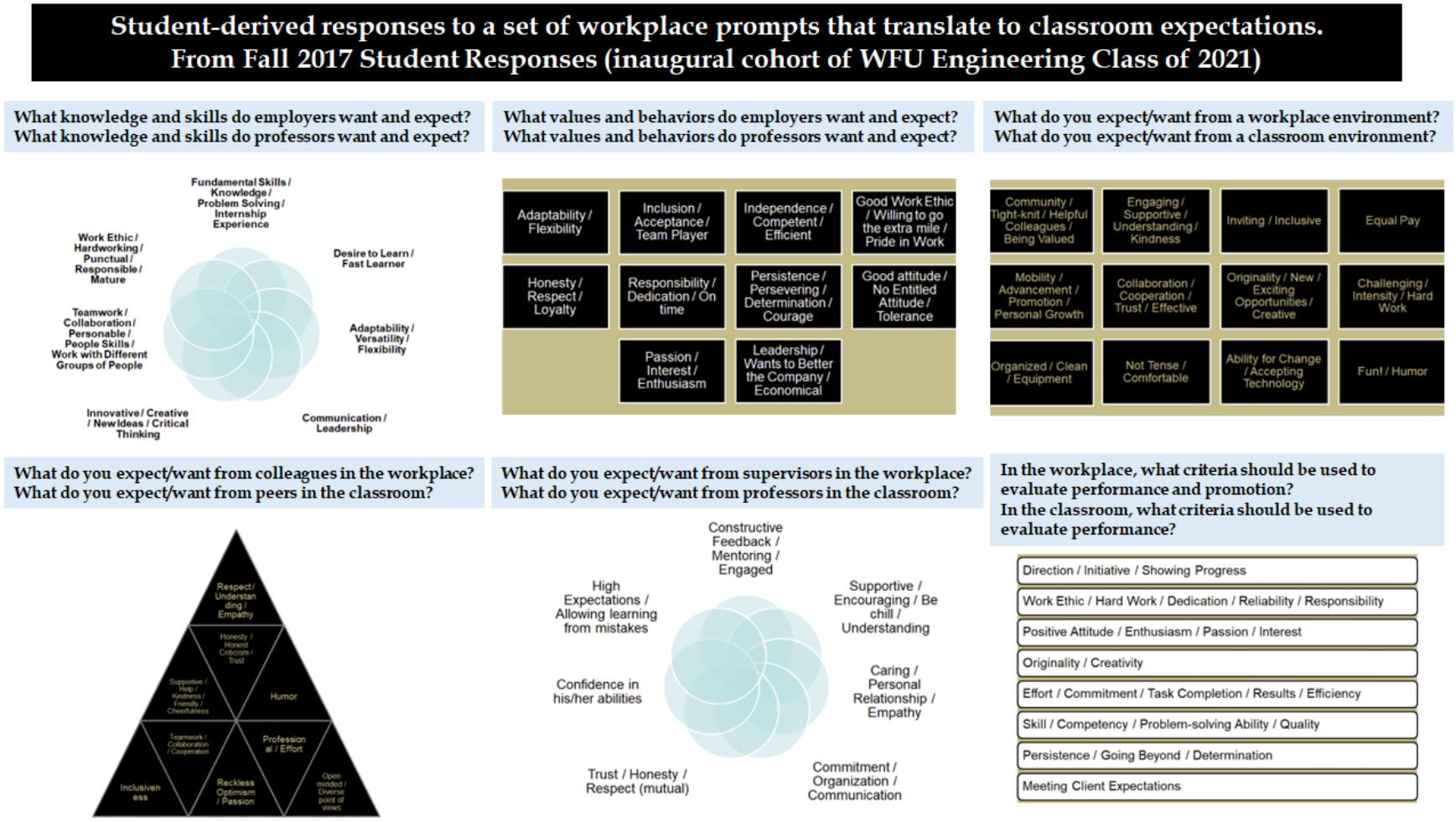

Figure 13: First-year Wake Forest engineering student responses (fall 2021, part of EGR 111) to prompts about workplace expectations and workplace interactions that can serve to also influence engineering classroom expectations. An activity in EGR 111 (fall 2021) to support classroom culture setting and to empower students to take ownership of their learning.

(c) **Engineering education pedagogy** focusing on project and problem based learning, flipped classrooms, service learning projects and community engagement (Pierrakos et a., 2016; El-adaway et al., 2015; Tucker et al., 2014; Pierrakos and Barrella 2014; Pierrakos et al., 2013; Nagel et al., 2011; Swan et al., 2011; Pierrakos et al., 2010a; Pierrakos et al., 2010b; Russell et al., 2010; Zilberberg et al., 2010; Watson et al., 2010; Pierrakos et al., 2008)
(d) **Cognition and learning** investigating adaptive expertise, cognitive flexibility, complex problem solving (Majdic et al., 2017; Barrella, Watson, and Pierrakos, 2017; Pierrakos, Anderson, and Welch, 2016; Pierrakos et al., 2016; Pierrakos and Barrella 2014; Pierrakos et al., 2013; Nagel et al. 2012; Zilberberg et al., 2010; Trenor and Pierrakos 2008)
(e) **Assessment of engineering student learning** (Pierrakos, Anderson, and Welch, 2016; Pierrakos, Anderson, Barrella, 2016; Pierrakos et al., 2013; Pierrakos and Watson, 2013; Pierrakos et al., 2012; Pappas, Pierrakos, and Nagel, 2011; Pierrakos et al., 2010; Russell et al., 2010; Pierrakos, Zilberberg, Anderson, 2010; Pierrakos, Borrego, and Lo, 2008a; Pierrakos, Borrego, Lo, 2008b; Pierrakos, Borrego, and Lo, 2007a; Pierrakos, Borrego, and Lo, 2007b).

I recognized that to achieve an inclusive, welcoming, and empowering classroom culture, it would start from the beginning, and it would be important to create such a culture from the beginning. This is why (although I did not have to teach my very first semester as the Founding Chair) I needed to teach with the founding engineering faculty team. I would need to model what I was expecting and what we knew we needed to do (based on the research being done in engineering education and STEM education). In the first ever Wake Forest Engineering class, EGR 111, I instituted the following that supported a culture of inclusion and empowerment: (1) student-centered pedagogies like project based learning and mastery-based learning, (2) student agency via personal and professional identity development learning experiences (e.g. personal value statement, professional value statement, independent development plan), (3) including students to offer feedback and insights to programmatic and curricular planning activities, (4) student culture setting activities (e.g. students defining in class the kind of professional environment they desired in the classroom and in our department including how student-to-student interactions and faculty-to-student interactions), (5) community building activities (e.g. lunches, student reflection opportunities, student newsletter, etc.), (6) course evaluation survey that included items about classroom culture and alignment with our departmental values (***Figure 12***), etc. I am proud that the founding Wake Forest Engineering faculty team continued to set a high bar of all these important aspects and continued to innovate with pedagogy, knowledge integration, assessment of learning, and inclusive classroom practices. Even beyond EGR 111, the first ever engineering class, I worked with the founding faculty team to institute the following within the first year to ensure we would continue these practices into the remaining 3 years of the curriculum: (1) continuously soliciting student feedback (formal, informal, direct, indirect) and being responsive to feedback that would lead to better and deeper learning, inclusion of all students, and empowering students to define their own path within our engineering curriculum and within their educational journey at Wake Forest University, (2) integrate knowledge of engineering practice by bringing theory and practice together continuously and modeling as best we could authentic and real-world engineering practice to the classroom, (3) bringing together high impact learning experiences not only to the curriculum but also thinking co-curricular experiences that would enrich the student journey (e.g. study abroad experiences that so many of our students wanted to pursue). This all meant that we had to understand our students and

become qualitative researchers in understanding their needs and their dreams and their desires. This also meant that we had a role to play in helping find their purpose within and beyond engineering. I modeled the importance of in class feedback sessions and inviting our students to shape our vision of Wake Forest Engineering and join us as partners to share the curriculum and their experiences. From **entrance surveys** (administered to incoming first year students in August) to **summer surveys** (administered to all returning students to understand their evolving needs and aspirations upon completing internships and reflecting on their past academic years) to **major declaration surveys** (administered to students who decided to major in engineering so that we could understand just-in-time what they aspired to do during their time at WFU and post-graduation, as well as what kind of technical elective courses they might be interested in as their understanding for engineering evolved) to **exit surveys** (administered to our soon-to-be graduating seniors so that they could help us reflect on the four-years, capture their post-graduation plans, and solicit feedback to continuously improve every aspect of the student experience). Having a pulse on our students was essential and their insights helped us shape the curriculum, shape the hiring of new faculty, shape strategic partnerships with other academic units, shape academic advising and career advising, etc.

Upon creating and modeling an inclusive engineering classroom within the first ever offering of EGR 111 (fall 2017) and achieving 80-85% retention (something I tracked for many classes), we needed to continue and sustain this culture and I intentionally used pedagogy as a tool to support inclusion and learning effectiveness. It was strategic on my part to assign new faculty to teaching in the first year so that they would see firsthand the approach we were taking. In fact, I assigned a lot of team-teaching during the first four years so that founding faculty who had experienced EGR 111 together would mentor new faculty hires and slowly I would transition faculty to teach in the remainder of the curriculum. This model paid off and enabled faculty who were adopting student-centered pedagogies (e.g. problem based learning, project based learning, flipped classrooms, mastery based learning environments, etc.) to mentor new faculty hires, most of which had very little experience with such student-centered learning pedagogies.

Goal 3: Designing an Engineering Curriculum to Support the Diverse Interests of our Students and to meet ABET Accreditation Requirements

Considering that the founding team arrived on site just six weeks before the arrival of the inaugural group of students, it became essential to start planning for the first engineering class – EGR 111 (Introduction to Engineering Thinking and Practice and eventually named Introduction to Engineering Design). This was not a trivial task for the Founding Chair because the expectations that would be set in this course would lay the foundation for the rest of the curriculum. The vision for this course was three-fold: (1) empower students to explore engineering without any prior knowledge (i.e. no prerequisites were set) and support engineering being seen as accessible to any interested student, (2) design a learning experience that would be representative of the kind of learning that would be part of the entire engineering curriculum, (3) help students to make an informed decision about majoring in engineering and becoming an engineer. A previous publication describes aspects of this first course (Kenny, Pierrakos, O'Connell, 2021). Thus, the vision for the four-year curriculum needed to start being conceptualized as this first class (EGR 111) would need to offer a foundational experience.

Upon setting an initial vision of the kind of curriculum we desired, we focused on developing the structure of the curriculum before developing the content that would go into this curriculum. I invited several education scholars to help us with curriculum design - Dr. Wendy Newstetter (Georgia Tech) and Dr. Greg Heileman (University of Arizona). Dr. Newstetter is a linguist and learning scientist who co-founded Biomedical Engineering at Georgia Tech and institutionalized problem-based learning in that curriculum. Wendy first visited us at the end of the fall 2017 semester (our first semester). She not only helped us reflect on the project-based learning approach we had implemented by meeting with our students and with us, but she also helped us plan for the second engineering course (EGR 112 - Introduction to Engineering Measurement and Analysis) that we also wanted to be project based. Wendy provided critical feedback and guidance to support the founding team and she visited us several more times as we were building the WFU Engineering curriculum. I eventually invited Dr. Newstetter to join the Wake Forest Engineering External Advisory Council and she still remains on this council.

Further, in the first year too, I invited Dr. Greg Heileman, an undergraduate Alumnus of WFU who became an electrical engineer and engineering education scholar. Greg had been doing research on curricular analytics and curricular complexity for years. He had been studying engineering curricula and science curricula to develop tools to assess curricular complexity (Heileman et al. 2017, Heileman et al. 2018). Greg visited with the WFU Engineering team in spring 2018 and presented on his work, which laid the foundation to us thinking about the structure of the WFU Engineering curriculum we were developing. Greg's research enabled us to think about pre-requisite courses and how we could "simplify" the curriculum so that students would be able to navigate it with ease. Greg was also invited to serve on the Wake Forest Engineering External Advisory Council and remains on this council today. Ultimately, and in time, being equipped to think holistically about the curricular structure, the founding engineering faculty team designed an engineering curriculum with a complexity score of 150 in contrast to a typical engineering curriculum that has a curricular complexity score of 300 plus. All this was just-in-time knowledge that the team needed because during Fall 2017, we polled our inaugural engineering students to discover that over 80% of them desired to pursue study abroad experiences during the academic year. This type of opportunity would be perceived as a disruption to curriculum design, but for us it became an opportunity to ensure flexibility and simplicity (without a loss to what we wanted students to learn).

The next phase of curricular planning was defining the credit structure. We desired not to do what we typically see across engineering curricula – all courses are pre-defined with little choice left to the students. From entrance survey responses and talking with our students, we knew that our students were coming to WFU Engineering with a desire to explore engineering even though they had particular areas of interest within engineering. We thus agreed on a curricular structure where 33 credits out of the 47 required engineering credits to be pre-defined and common knowledge - what became our core engineering curriculum (***Figure 8***). The remainder of the credits would come from students selecting areas of interest and slowly as the faculty team grew, with permanent hires, visiting faculty, and part-time faculty, our technical elective course offerings diversified (Figure 8). Students would also have choice in selecting their capstone project (part of EGR 314 and EGR 315 in Figure 8), thus students would have ***choice (and thus agency)*** with about 45% of the credits within the engineering. This kind of flexibility and choice is unheard of in typical engineering curricula.

Students were given several opportunities annually to provide feedback on the curriculum. The Engineering Faculty Advisor (Dr. Melissa Kenny) also had a strong pulse on what was working well and what could be improved as our students navigated the new curriculum. The major declaration questionnaire enabled us to take a pulse annually on student areas of interest, technical elective courses of interest, post-graduation plans, feedback on the curriculum, etc. By Fall 2019, I formed the inaugural WFU Engineering Student Advisory Council (SAC), comprised of 12 to 15 engineering students (about 2-3 students per academic year) that collectively represented the diversity of engineering interests and post-graduation plans we were seeing in the program. I also aimed to ensure that the SAC represented gender, racial, and ethnic diversity and this was intentional. The SAC met 3-4 times each semester with the Engineering Chair to provide feedback on all aspects of the student experience. Their feedback was reported back to the faculty team and their feedback led to new courses being developed, changes to pre-requisites, improvements to academic advising, partnerships to enhance career readiness and related activities within and beyond the curriculum, building strategic partnerships with other academic units, etc.

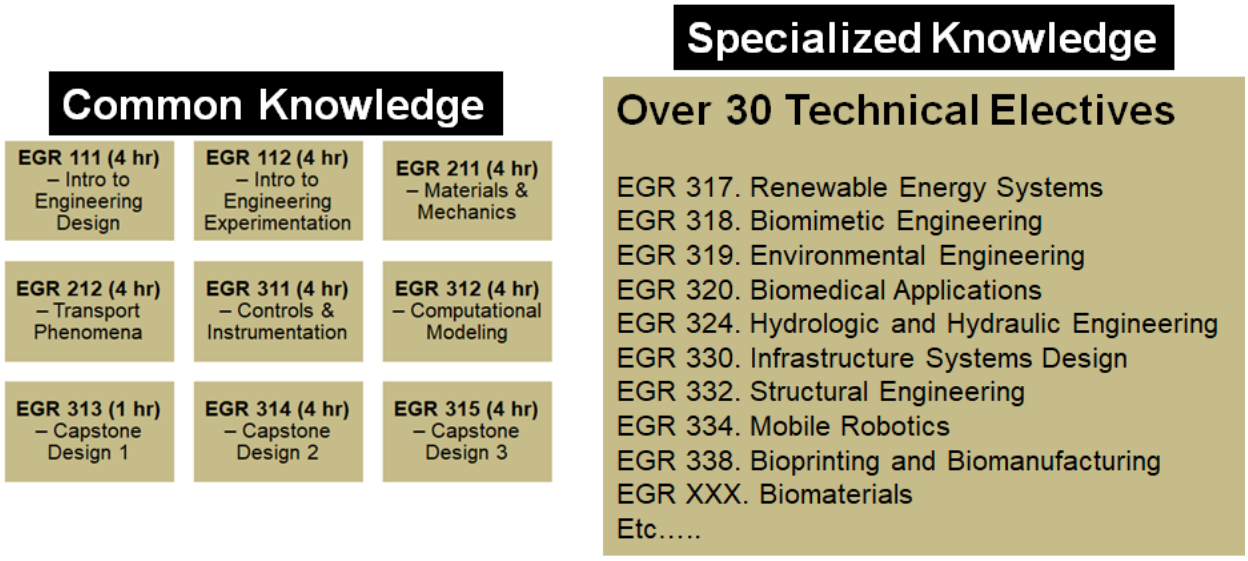

Figure 14*:* Visual Representation of the WFU Engineering Curriculum when about 55% of the curriculum is common knowledge and 45% is customizable and flexible.

Based on Student Advisory Council (SAC) feedback during fall 2019 and spring 2020, students started asking for the ability to pursue engineering concentrations by leveraging the technical elective offerings as this would also advantage them during internship searching and job searching post-graduation. Engineering concentrations would be an optional pathway for students that desired the ability to specialize a little but not a requirement for any student. I formed a faculty committee to assess the interests of the entire student body and to think through the processes, review existing course offerings, evaluate the areas of expertise of the faculty and ensure adequate staffing was in place to offer at least one technical elective each semester within a given concentration area, and draft the proposal that would go to the Committee of Academic Affairs and the Division 5 Chairs (all part of the internal College process). Ultimately a proposal

was submitted and was approved adhering to all the institutional processes of adding concentrations. While most of the engineering faculty supported engineering concentrations in accompanying the strong interest from students, there were a few that did not favor this direction. The five optional engineering concentrations became: (1) Biomedical Engineering, (2) Civil and Environmental Engineering, (3) Electrical and Computer Engineering, (4) Materials and Chemical Engineering, and (5) Mechanical Engineering. During the first year roll out of the engineering concentrations, about 60% of students pursued an engineering concentration and by year two of the roll out, this percentage was about 75%. The responsiveness to student feedback, faculty tracking student performance in courses, and strong advising allowed the WFU Engineering team to design a flexible, customizable curriculum. The following quote from a senior (from the senior exit survey) reflects what this flexible means to students:

"Being a WFU engineer means having the freedom to become the engineer that I want to be. The program has empowered me to explore my interests and pushed me to excel at them. It gets hard, but, if you like it, don't give up because it truly is a rewarding major. The program does a good job of letting you take the reins in your own engineering track, which is not common for most programs." – WFU Engineering Senior, 2022

Similarly to giving students flexibility within the allotted engineering credits of the WFU BS Engineering degree, students also have some flexibility within the 30 math and basic science credits. This empowerment has truly allowed students to define their own path, to make informed decisions about courses based on their interests and experiences (e.g. internships). Advising was essential to support the curricular agency we wanted for our students, and I empowered our first teaching assistant professor hire (Dr. Melissa Kenny, Engineering Student Advisor) to take ownership of advising in helping us empower our engineering students. Dr. Kenny gained a lot of insight from students and took initiative to continuously improve our advising practices, guiding the faculty team with advising, support changes in the curriculum, and ultimately launch the WFU Engineering Student Support Center, led by students for students with guidance from Dr. Kenny and support by me.

Goal 4: Experiential Learning (Theory and Practice Coming Together) in Every Engineering Course.

I expected theory and practice in every class and practice could being embodied in many ways - projects, laboratories, field work, interdisciplinary knowledge and collaborations, industry engagement, etc. In my exit meetings with faculty hires, I was explicit about bringing theory and practice together in every class and that we would not follow the traditional engineering education model - senior year projects as the place where theory comes to practice. While many engineering programs had already started to move to first-year, cornerstone projects as well, we knew that we would have to ensure that the middle two years brought theory and practice together as well. We have achieved this by promoting problem and project-based learning within the middle two years of the curriculum as well.

New faculty hires were strategically assigned to teach in the first-year courses so that they could experience project-based learning. By year two, as the team nearly doubled with the hiring of

three more faculty, it was important to continue sending the message of student-centered pedagogical innovation. Senior faculty gave presentations on student motivation, mastery-based learning, and flipped classroom experiences. The Founding Chair was strategic and intentional in joining the Kern Entrepreneurial Engineering Network (KEEN) by the end of year one (May 2018) and became the first North Carolina university to join KEEN and the first not yet ABET accredited. This strategic decision enabled WFU Engineering faculty access to immense faculty development opportunities and resources. This was essential for the young WFU Engineering team. Pedagogical experts from other universities were invited to visit WFU Engineering and spend time with the team. The engineering team had embraced student-centered pedagogies and this commitment to innovative pedagogy was strengthened by knowledge sharing together during departmental meetings, collective professional development activities, and being part of the KEEN network. Here are just ***some*** of the student-centered and active learning pedagogies we have used at WFU Engineering:

Project-based learning
Mastery-based Learning
Flipped Classroom Pedagogies
Problem-based Learning
Service Learning
Team-based Learning
Inquiry-based Learning
Case-based Learning
Virtue-based Learning

Just some of the projects across the curricular are described in the table below. Engineering faculty partnered with a diverse set of stakeholders to deliver these projects – clinicians, non-profit organizations, industry engineers, museums, campus facilities personnel, local government, colleagues across campus, etc. Figure 6 visually represents how the complexity of projects increased from year one to year four and scaffolding decreased. This was an intentional conceptualized that enables technical proficiency and professional development (teamwork, engagement with diverse stakeholders, management of project and team, documentation, presentations, etc.)

First Year	**Junior Year**
• Design and Construction of Cardboard Furniture for Disaster Relief • Analysis of Cervical Spine Immobilization During Pre-Hospital Patient Transport • Design of Water Treatment Technologies for National and International Communities • Analysis of Water Quality (Stormwater Runoff, Drinking Water, etc.) • Design and Use of a Sensor System for Aiding Campus Partners	• Design and build an Arduino-controlled autonomous vehicle • Circuit design and signal analysis to build an electrocardiograph (ECG) • System modeling and simulation of real-world controls systems (cruise control, biodynamic systems, aircraft pitch, motor speed, etc.) • Design and analysis of integrated circuits to build a functioning metronome • Computational algorithm modeling Katherine Johnson's numerical approach to determine burnout position of John Glenn's Friendship 7 capsule
Second year	
• Reverse Engineering of Hair Dryers for Energy Analysis and Innovative Redesign • Structural analysis to WFU's Reynolda House (100 year-old historic home)	

• Design and Loading Analysis of a Suspension Bridge at Wake Downtown • Analysis of Real-world Thermal-fluid Systems (Renewable Technologies, Electromechanical Systems, Human Powered Systems, etc.) • Cradle to Cradle Life Cycle Analysis of Diverse Materials • Structural analysis of hanging partition support beams (Engineering Renovations turned into a curricular project)	• Computational modeling and optimization of diverse engineering applications (soft tissue deformation, chemical mixing, economic optimization of a chemical plant, etc. • Design of alternative engineering solutions to minimize human life impact due to Covid19 **Senior Year** Diverse set of Capstone Design Projects (yearlong)

Figure 15*:* Tabular representation of just some of the projects embedded across the WFU Engineering curriculum. By instituting project-based learning in the first year, we opened the door to a project-based learning engineering curriculum. Projects in nearly every engineering class across all four years of the curriculum.

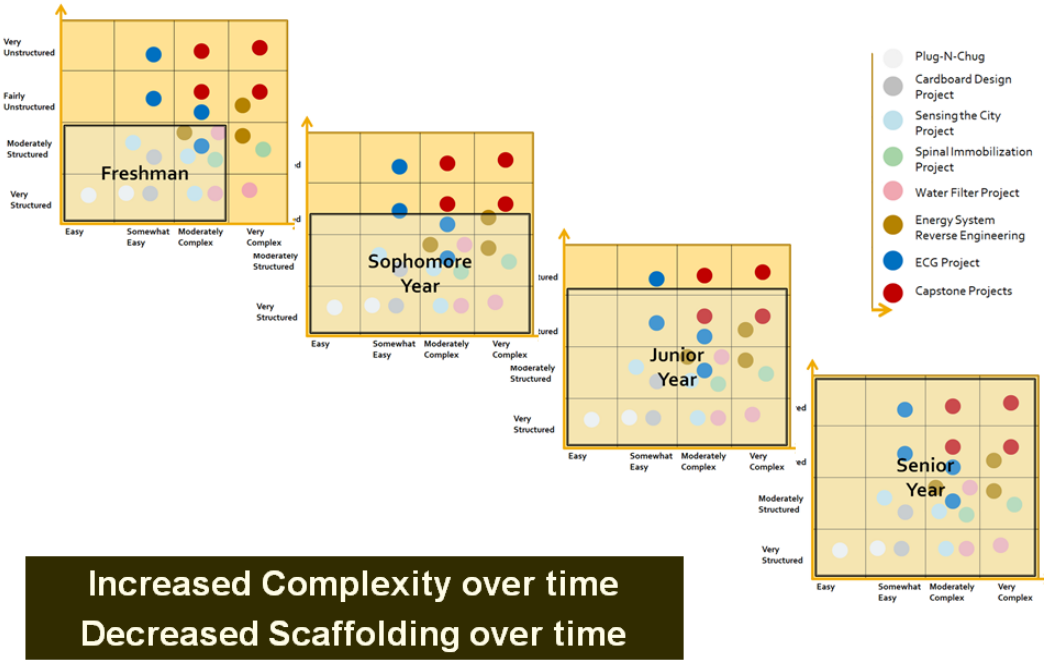

Figure 16*:* Visual representation showing the vision of projects across the curriculum. Increased complexity over time and decreased scaffolding over time. From presentation slides by Pierrakos presenting to stakeholders.

Goal 5: Integration of Knowledge Within and Beyond Engineering.

For Wake Forest Engineering to be approved as a BS Engineering degree within the College of Arts and Sciences (aka College) structure, a curriculum structure had to be drafted by an internal WFU faculty group in the fall 2016. Upon being appointed as Founding Chair in January 2017, I

asked the then Dean about deviating from this originally conceived curricular structure and the answer was yes. Because only two course titles were formally on the books, we had the ability to reimagine the WFU Engineering curriculum from scratch. As was described previously (visioning section), I wanted to see interdisciplinary, integrated engineering learning. ***Figure 17*** serves as a tabular representation of the Wake Forest Engineering curriculum. While the math and basic science courses are fairly traditional in scope (the only one we were able to influence was the integrated linear algebra and differential equation course), the engineering curriculum represents an integrated approach to the engineering fundamentals. What would be stand alone courses in most engineering curricula like statics, dynamics, materials, and mechanics became EGR 211 – Materials and Mechanics. Similarly, what would be stand along courses like fluid mechanics, thermodynamics, and heat transfer in most engineering curricula would become EGR 212 – Transport Phenomena. FE Exam topical areas were integrated together to bring the WFU Engineering curriculum together. This kind of curriculum provided engineering students incredible flexibility compared to traditional engineering curricula. Graduates of our program have choice in selecting their technical elective courses. (https://bulletin.wfu.edu/undergraduate/departments-programs/engineering/bs-engineering/)

Actual WFU ABET Accredited BS Engineering Curriculum (Fall 2022)
Math & Science 30 Credit Hours Calculus with Analytic Geometry I 4 / Calculus with Analytic Geometry II 4 Multivariable Calculus 4 / Linear Algebra and Differential Equations 4 / General Physics I with Lab 4 / General Chemistry I with Lab 4 / Elective 3 / Elective 3 **Engineering 47 Credit Hours** Intro to Engineering Design 4 / Intro to Engineering Experimentation 4 / Materials and Mechanics 4 / Transport Phenomena 4 / Control Systems and Instrumentation 4 / Computational Modeling in Engineering 4 / Capstone Design I 1 / Capstone Design II 4 / Capstone Design III 4 / Engineering Elective 2 / Engineering Elective 2 / Engineering Elective 2 / Engineering Elective 2 / Engineering Elective 2

Figure 17*:* Tabular representation of the WFU Engineering Curriculum when about 55% of the curriculum is common knowledge and 45% is customizable and flexible.

Shared curriculum visioning continued into years two and three. Part of this visioning, upon determining the curricular structure described previously, was creating a vision for the content we wanted to be covered within our courses. As detailed previously, the faculty team already made a commitment to student-centered pedagogies and this commitment was expected of the many visiting and part-time faculty that needed to be hired to support the new department and curriculum. All new faculty (full-time, part-time, visiting), in fact, underwent an onboarding session to communicate the WFU Engineering vision, mission, and pedagogical expectations. In time, expectations around student outcomes learning assessment would be included as well.

In determining the shared content areas of learning that we wanted to include in our curriculum, time was of the essence, considering the department underwent four rounds of build-out renovations on top of all the curriculum planning, hiring 4-6 new people every year, the delivery of the curriculum, and the expectation for research productivity. It was an intense time even before the pandemic hit. I decided to creatively leverage all the faculty candidate campus visits

in a way to both enable the candidate to see the collaborative spirit behind curriculum design, but also to give the WFU Engineering team time to continue making progress with content we wanted to integrate across our curriculum. Figure 9 below shows a wordle of the kinds of topical learning areas we wanted to see in our curriculum. This was in alignment to the requirements described previously and our commitment to delivering a liberal-arts engineering degree. Afterall, our team saw "Engineering as a Modern Liberal Art." Once again, Dr. Anita McCauley was called in to facilitate these curricular sessions during candidate on campus visits. We offered faculty candidates choice to select from a select set of topics (e.g. ethical reasoning, cultural awareness, entrepreneurial mindset, etc.) that the WFU Engineering faculty team had already identified to be important to our curriculum.

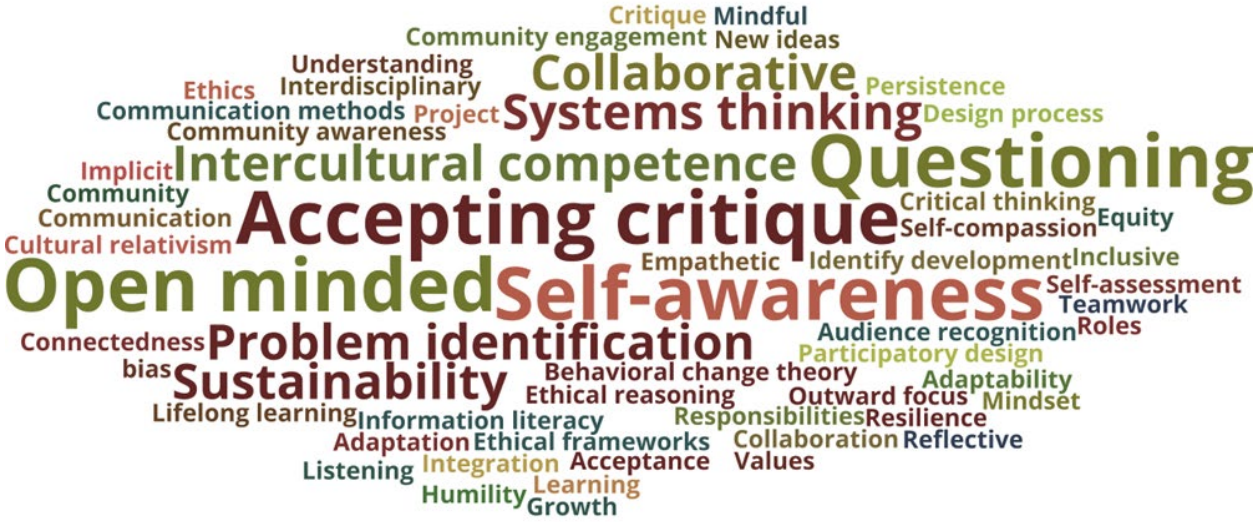

Figure 18*:* Topical learning competencies that were desired for the WFU Engineering courses.

Intentional design of our engineering curriculum required a strategic focus and mapping to ensure effective and efficient coverage of key content, plus alignment with ABET Student Outcomes (SOs) that are required for our graduates to attain by the time they graduate from our program. The first thing I guided the team with is to see the ABET SOs as two general categories all linked to Educating the Whole Engineer. ABET SOs 1, 2, and 6 were categorized as the ***Engineering Fundamentals*** reflecting technical knowledge areas, while ABET SOs 3, 4, 5, and 7 were categorized as ***Personal and Professional Development*** reflecting knowledge that support professional practice (Figure 10).

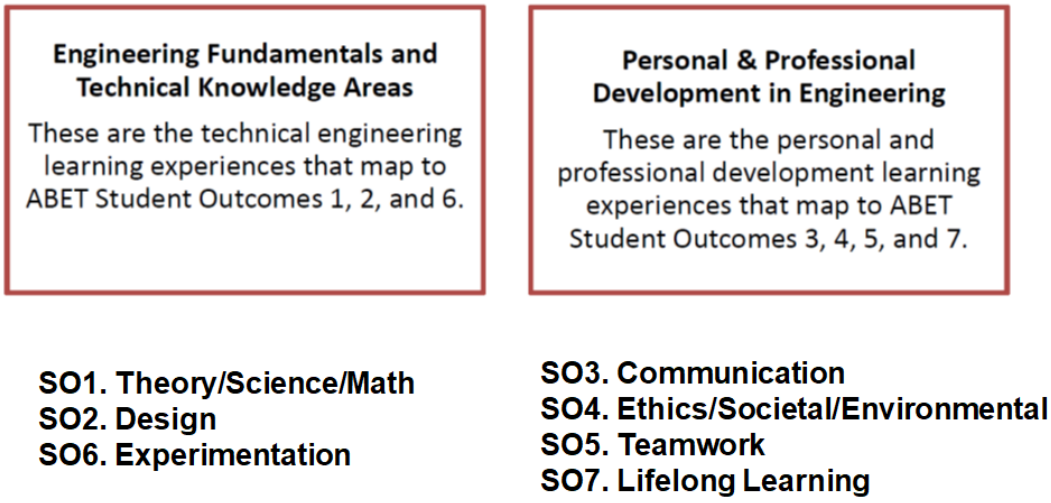

Figure 19: Categorizing the ABET Student Outcomes into two general categories - (1) Engineering Fundamentals and (2) Personal & Professional Development.

Engineering Fundamental Knowledge (mapping primarily to SOs 1, 2, and 6) – this category of learning outcomes describes the more engineering-specific outcomes that include both theory and practice of areas covering mathematical thinking and modeling, scientific thinking and reasoning, engineering science fundamentals, engineering design fundamentals, systems modeling, sustainable design, instrumentation skills, experimental design, data analysis, analytical methods, etc. Many (but not all) of the engineering fundamentals are also topical areas that are covered in the Fundamentals of Engineering (FE) Exam, which was a requirement for graduation for our graduates up until spring 2022. The FE Exam is a minimum set of topical areas that serve to guide the design of our curriculum, so there are many more KSAs (knowledge, skills, and attitudes) that drive our curriculum.

Personal and Professional Knowledge (mapping primarily to SOs 3, 4, 5, and 7) – this category of learning outcomes describe personal and professional development knowledge, skills, and attitudes (both theory and practice) pertinent to professional practice and include written, oral, and graphical communications, modern communication methods and tools, interpersonal communication, cross-cultural communication, cultural reasoning, ethical reasoning, character education, moral and social reasoning, leadership development, project and team management, leveraging diversity of teams and perspectives, continuous independent development, entrepreneurial mindset, business acumen, policy education, etc. Many of the topics identified in Figure 9 connect to personal and professional development. See Figure 11.

Personal and Professional Development in Engineering	
ABET Student Outcome	Curricular Threads
SO3: an ability to communicate effectively with a range of audiences.	Written Communication
	Oral Communication
	Visual Communication
SO4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	Ethical Reasoning and Decision Making
	Cultural Awareness & Societal Impacts in Engineering Professional Practice
	Professionalism in Engineering Practice
SO5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Team Organization & Leadership
	Team Performance Evaluation
	Project Management
SO7: an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	Professional Engineering Identity Development
	Self-Directed Learning
	Mindsets and Attitudes for Lifelong Learning

Figure 20: Representation and mapping of the Personal and Professional Development target learning areas for WFU Engineering.

Together and integrated, **engineering fundamentals plus personal and professional knowledge**, enable us to achieve the vision of the WFU Liberal Arts Engineer and to achieve the vision of our curriculum designed to Educate the Whole Engineer. All these knowledge areas are traditionally taught in silos, yet we believe that authentic integration can be achieved in a contextualized means, thus the focus on delivering a curriculum that is problem-based, project-based, application-based to enable technical knowledge and skills to come together with the personal and professional development facets. Problem and project-based learning offered us a fertile ground to do so much in integrating knowledge.

So that we could be effective and efficient in achieving our curricular goals, we needed to be intentional and focused. We had to be strategic in achieving the ABET Student Outcomes in a developmental way. Thus, in discussion with the faculty, we set the following target goals for each course:

Course Design Goal 1: Each engineering course should aim to focus about 70-75% of the content/experiences on Engineering Fundamentals (ABET Student Outcomes cluster of 1, 2, and 6) and about 25-30% of the content/experiences on Personal & Professional Knowledge (ABET Student Outcome cluster of 3, 4, 5, and 7). This 75/25 breakdown is not a fixed target, but a flexible goal to help with focus.

Course Design Goal 2: Each engineering course should map to some of the topical areas of the Fundamentals of Engineering Exam. This will also help achieve Course Design Goal 1 and explicitly mapping to ABET Student Outcomes 1, 2, and 6. The topical areas of the FE Exam can help to guide our mapping. FE Exam topical area mapping was done annually during years 3 and 4 to ensure our students could be successful in taking and passing the FE Exam. For those that took the exam seriously, the pass rate was high.

Course Design Goal 3: Each engineering course should build off knowledge, skills, and attitudes from the pre-requisite courses (engineering, math, and basic sciences) in order to establish strong connections and the developmental nature of our curriculum design efforts.

During years 3 and 4 of building WFU Engineering, we did considerable mapping to developmentally advance our students' learning across each ABET SOs with the support of an assessment fellow (Dr. Jessica Koehler) we spend an immense amount of time mapping course learning outcomes to ABET Student Outcomes to performance indicators to assessment rubrics.

To embody the vision we had for the WFU Engineering curriculum, we knew that we would need support from colleagues across the university and also practicing engineers. We targeted inviting at least 1-2 external speakers to join every class to offer context to the technical learning happening in the course. At times, these speakers help build contextual connections with a project embedded in the class or with a specific learning outcome. Ultimately, we intentionally wanted to humanize engineering and bring colleagues that could speak to the human elements of the technical work. I invited humanists and social scientists to join department events where discussions of the curriculum were happening and this was done to identify and spark important connections that could be made between technical content and human experiences that would inform the engineering learning. Here are a *few* such examples of interdisciplinary teaching where we intentionally invited colleagues to our engineering classes:

(1) EGR 111 (Intro to Eng. Thinking & Practice) – "What is Engineering?" Module was co-developed between Dr. Melissa Kenny (Engineering) and Dr. Monique O'Connell (History). This included guest lectures and active learning activities by Dr. O'Connell to explore the history of engineering and guest lectures by Dr. Pierrakos to explore the history of engineering education in the US and other global contexts. This work was published in ASEE proceedings (Kenny, Pierrakos, O'Connell, 2021).
(2) EGR 313 (Capstone I) – Dr. Pierrakos and Dr. Friede (anthropologist) worked collaboratively to develop the "Self-Discovery" module in the class and support engineering design challenges with a humanistic lens to problem solving.
(3) EGR 324 (Hydrology and Hydraulic Engineering) – Dr. Friede (anthropologist), as part of the Mellon Grant, designed and delivered a "stakeholder analysis" module.
(4) EGR 314/315 (Capstone II and III) – Dr. Jesse Pappas (social psychologist) co-taught the capstone design course sequence with engineering faculty for three years. He supported team effectiveness and prosocial learning activities across 30+ capstone project teams (Pappas and Pierrakos, 2022).
(5) EGR 211 (Mechanics and Materials) – Dr. Stan Meiburg (Sustainability & Policy expert) was invited by Dr. Boatman to connect policy and sustainability in the context of environmental justice and impact.

The following is a set of topical learning areas integrated across the curriculum that further reflect an intentional integration of liberal arts with engineering practice and part of the personal and professional development.

Personal Values & Engineering
Independent Development Plans
History & Culture of Engineering
Aesthetics of Engineering Systems
Engineering Decisions & Policy
Environmental Impacts & Sustainability
Community Engagement (Real Users/Needs)
Diverse Stakeholder Feedback
Social Justice & Engineering Design
Teamwork as a Performance Virtue
Organizational Structures & Performance
Ethics / Character Education and Virtues
Connection cards b/w eng. & LAs classes
Outreach and engineering awareness
Cycle of innovation & exemplars
Project and Team Management
Goal-setting & Action Plans

In nearly every engineering classroom, we have also engaged with practicing engineers and brought their unique perspectives into the classroom as well. Their industry and global perspectives have enriched the classroom experience and helped connect topics that students would traditionally see in siloed ways.

Goal 6: Integrate Ethics and Character in Every Engineering Course.

Lastly, when we think about the vision to Educate the Whole Engineer, ethics and morality in the context of engineering practice was essential. We were blessed to receive Kern Family Foundation KEEN funding in 2018 to integrate character education across the engineering curriculum. Knowledge sharing in this area of learning was established by partnering with Michael Lamb and the WFU Program for Leadership and Character. Past publications offer greater background into this aspect of our curricular work (Koehler et al., 2023; Koehler et al., 2020; Pierrakos et al., 2019; Pierrakos et al., 2021; Gross et al., 2021). Herein, ***Figure 21*** showcases the vision of a virtuous engineer as well as how we connect virtues to professional engineering practice, in this case the virtues pertinent to teamwork and collaboration.

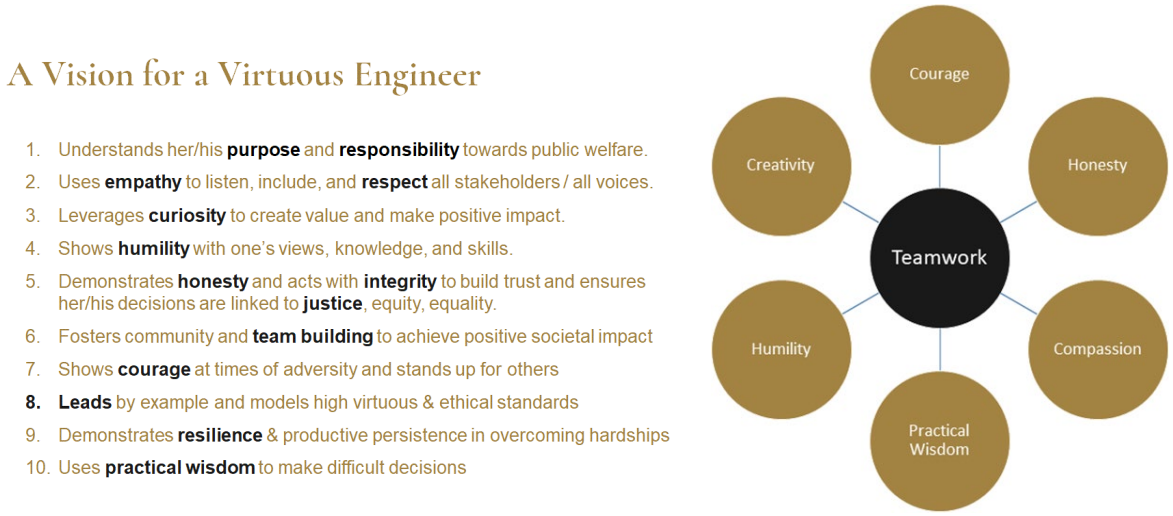

Figure 21*:* A descriptive vision of a Virtuous Engineer (left) and virtues connected to the professional practice of teamwork (right).

Goal 7: Integration of Curricular and Co-Curricular Student Experience Activities

Beyond the engineering curriculum, a successful student experience includes other aspects – academic advising, internships, co-curricular and extra-curricular learning experiences, etc.

Students joined WFU Engineering with broad and diverse interests across engineering applications and beyond engineering. Although students do not formally declare a major until their sophomore year, typically spring semester during Major Declaration Week in February or upon having completed 40 credits, most of our engineering students begin taking engineering classes during their first year. Each August, incoming students who enroll in EGR 111 (now titled Introduction to Engineering Design) and/or EGR 112 (now titled Introduction to Engineering Experimentation) and also continuing students (sophomores, juniors, and seniors) are sent an annual "start of the academic year" engineering survey. Our goals with such a survey are to: (1) gain insight into students' areas of engineering interest, (2) gain insights into summer work experiences (i.e. internships, research, service experiences), (3) identify ways that the program can meet students' professional goals. From this survey, we learned early on that students were interested in: (a) biomedical engineering applications (about 30%), (b) environmental and civil engineering applications (about 15%), (c) computer and electrical engineering (including computer science) applications (about 15%), (d) mechanical and materials applications (about 15%), and (e) the remainder having interests across other engineering applications (e.g. systems engineering, aerospace engineering, neuroengineering, chemical engineering, etc.). All in all, our students came to us with multiple interests across engineering applications and we made intentional decisions to reimagine the traditional engineering curriculum and traditional engineering student experience. In our core curriculum courses, we knew we needed to offer diverse engineering applications (e.g. biomedical engineering, environmental engineering, mechanical engineering, civil engineering, etc.) and I promoted that for the team but also strategically created an environment for that to happen using a team-teaching model. As an example, I assigned a newly hired environmental engineering faculty and newly hired electrical engineering faculty to teach with me (a mechanical and biomedical engineer and course lead) one of our sophomore-level core courses - EGR 212 (Transport Phenomena) - that brought together fluid mechanics, thermodynamics, and heat transfer using conservation principles (mass, energy, momentum) to teach together. Another example, I assigned a newly hired biomedical engineering faculty (with mechanics background) to co-develop and co-teach with a materials engineering faculty (course lead) one of our sophomore-level core courses - EGR 211 (Materials and Mechanics). As another example, I assigned an electrical/computer engineering faculty member to co-develop and co-teach with a biomedical engineering faculty (electrophysiology research expertise) our junior-level core course - EGR 311 (Controls and Instrumentation). My hope in bringing together interdisciplinary engineering faculty teams to co-develop and co-teach our core engineering courses was to achieve the vision we desired of a cross-disciplinary engineer. If students could see engineering faculty from diverse disciplinary backgrounds teaching together and supporting the engineering fundamentals, we would be modeling for them what we expected of them. To break the disciplinary silos that exist in engineering education and offer them a different perspective in seeing how the engineering fundamentals are applied across a diverse set of disciplinary applications.

Advising was and remains a critical element to our and any engineering degree, and also essential in ensuring we positioned ourselves well for ABET accreditation. The WFU Engineering student experience involved formal and informal advising opportunities. Initially, during the first three years of Wake Forest Engineering, we were required to adopt the College advising model where first year students are assigned a lower division advisor, typically outside of their area of study. This meant that the formal advisors for engineering students were faculty (e.g. English, Philosophy, Math, Art, Psychology, Chemistry, Communications, etc.) with little to no experience in engineering. Ultimately, this model led to many challenges after a mock ABET visit at the end of year three that validated the flaws of the model that I had been advocating to fix, we adopted a new model where Engineering faculty were formally advising most of our first-year engineering students. Across both advising models, our faculty engineering team participated with formal engineering student advising (one-on-one advising), cohort style advising (during engineering class time to ensure as the curriculum was developing, students were abreast of all the upcoming changes so they could plan accordingly), plus lots of just-in-time and informal advising (during office hours, hallway conversations, etc.). Considering that an undergraduate, professional degree program was housed within a College that did not have adequate support for professional degree undergraduates (most of whom planned to go to industry and most of whom ended up in industry), the Wake Forest Engineering faculty team had to take on more responsibility to fill the gaps. Some creative strategies we implemented were several Career Readiness assignments across the curriculum: (a) an Independent Development Plan (IDP) to support personal and professional growth within EGR 111 (the IDP required students to lay a 4-year curricular map and prepare a resume), (b) students creating a LinkedIn profile, writing a cover letter for an internship that interested them or undergraduate research opportunity that interested them, and then ultimately applying for that internship (industry or research) (in EGR 112), (c) networking and interviewing engineers who are currently doing something that interests them, (d) practicing interviewing with staff front he Office of Personal and Career Development (OPCD), (e) attending local or regional job fairs, (f) seeking professional development opportunities that support their career goals (within capstone design), etc. The point being is that we had to think strategically and creatively about getting our engineering students the support they needed to explore their career aspirations, their professional purpose, and their personal goals. Wake Forest Engineering brought uniquely positionality by merging liberal arts education with professional education in every aspect of the student experience (e.g. learning, academic advising, career preparation).

IV. DISCUSSION

When one dives deep to understand the building of WFU Engineering, something I continue to reflect on immensely, there are important themes that emerge and these themes have the potential to be transferable to other engineering programs, departments, and colleges/schools (established and new).

(1) **Bridging Engineering Education Research and Engineering Education Practice** - We had a unique opportunity to launch a brand-new engineering program and let go of all the preconceived notions of engineering education. I often talked about this as striking a balance between TRADITION and INNOVATION. We wanted to keep the best parts of tradition

and innovate where we knew we could do better. As an example, we knew that designing an engineering curriculum to prepare students for passing the Fundamentals of Engineering (FE) exam would be an important tradition to uphold (even though all of us knew and know that the FE exam is not the only measure and certainly not an ideal measure of defining what a good engineer should know). Yet, the FE exam served as an important tradition that we could innovate within. In contrast, we could innovate with our curricular structure, the ways we packed engineering knowledge, the ways we integrate engineering fundamentals and the many other areas of holistic education (e.g. ethics, teamwork, professionalism, communication), our pedagogical approaches, the ways that theory and practice came together in each engineering class, etc. What some of the WFU engineering faculty knew was emerging areas of engineering education research, and as chair and an engineering education researcher, I needed to make that knowledge visible to all members of the team.

(1) **A Focus on Culture** – Our shared vision, values, and identity shaped the way we built WFU Engineering. We needed to know who we are to become who we wanted and who we needed to be to achieve our vision and our goals. Knowing what made us distinct was and is an important part of our identity and our distinctness continues to define us. Further, rethinking the traditional engineering culture was significant and constantly a work in progress. Upholding our shared values and embodying them in every aspect of our work was essential. This was not easy to do and yet this was an intentional focus of my role as Founding Chair. We did really well focusing on culture the first four years. It became really hard though by year five because we were now deep into the pandemic, deep into an extreme and intense workload to get ready for ABET accreditation, and deep in faculty being laser focused on their research so that they could succeed with promotions and tenure. The institutional culture (or at least the culture the then Dean was creating) was a bit different than the culture we were creating and over time, starting in year three, I began to witness cultural conflict in the handling of many situations (a future paper). What exacerbated things even more and more challenges arose during the pandemic. The institutional leaders put in place controls (budget, curriculum, staffing, new approval processes) that stifled the culture of innovation we had created. Policies were being imposed that did not fully meet the needs of all departments and all programs, most certainly an externally accredited professional degree like Engineering. The culture of other parts of the university in contrast to the culture within Engineering were stark and many saw this. Many colleagues across the university could already begin to see how the culture Engineering was creating was more inclusive, more innovative, and more empowering. Conflict mismanagement and control started to threaten the culture we had launched in Engineering, and we were not the only department and program impacted. The future will ultimately reveal the long-term costs. I stepped down after 6 years as Founding Chair in December 2022 and a new internal Chair was overwhelmed with the responsibilities that he stepped down after six months. Now, Wake Forest Engineering has an Interim Chair from Chemistry. Upholding our shared department values and culture thus continues to be a long-term challenge.

(2) **Shared Visioning** – Considering that the founding WFU Engineering team arrived on site only six weeks before the arrival of the inaugural group of students – with no website, no 4-year curriculum, no furniture, no equipment, no operating budget – it is absolutely essential for shared vision and program planning to take place. While most brand-new engineering

programs typically have 2-3 years of planning, the WFU Engineering faculty team had six weeks. The first three years were a constant process of visioning, implementation, visioning, implementation. Building the airplane as it was flying. The shared visioning work involved a diverse set of stakeholders and resources. The visioning work laid a foundation for the curriculum, pedagogies, the attributes for our graduates, essential strategic partnerships, hiring, facility build outs, etc. Intentionality! Shared visioning needed to be grounded though on what we already know from research, practice, and the diverse experiences of our constituents and stakeholders. Inviting subject matter experts and diverse scholars to our shared visioning was essential. I truly believe that visioning should be happening not only at the beginning of program development but throughout all phases of program development and my leadership style as the Founding Chair of Wake Forest Engineering embodied this mindset. Visioning is an iterative process that should be guided by the stakeholders that will most impacted by the change.

(3) **Staying Focused and Being Responsive to the Needs of our Engineering Students** – In the same way that a good engineer engages with the users of the system they are designing, it was absolutely essential that our WFU Engineering students would help us co-create many aspects of the engineering curriculum and engineering student experience. They were partners with us and their feedback informed the curriculum, our pedagogical models, co-curricular experiences, advising (academic and career), etc. Assessing student needs and feedback took place with surveys, questionnaires, class discussions, focus groups, forming a Student Advisory Council, advising sessions, etc. Being responsive to the feedback and communicating with students was part of the success story. Wake Forest Engineering would not be what it is today without the feedback they provided us along the way. Particularly the first three graduating cohorts. Our responsiveness to their feedback and open communication built a trusted partnership between faculty, staff, and students. Student engagement in any change effort is a must!

(4) **Breaking the Silos within Engineering and Beyond Engineering** – Not only because we were building a BS Engineering degree that intentionality needed to be interdisciplinary, but also because the WFU Engineering faculty team brought together (intentionally with our hiring) over 12 engineering disciplines to the curriculum, it was essential that we bridged the engineering disciplinary siloes and bridged engineering (as a modern liberal art, as we saw it) with the traditional liberal art areas (e.g. humanities, literature, social science, etc.). The team needed to get comfortable with disciplinary diversity and for students to see that was powerful. Integration was a fundamental value. As seen in how the WFU Engineering curriculum was envisioned and developed, it is clear that integration was a driving value so that students could see engineering learning and engineering practice from a holistic viewpoint rather than a siloed viewpoint. Integration of diverse knowledge (engineering and beyond) is authentically preparing students for professional and engineering practice. Interdisciplinary education is a must (Hitt, Banzaert, Pierrakos 2023).

(5) **Inclusion of Diverse Perspectives to Minimize Bias in Decision Making** – To minimize bias in decision making, I was intentional in inviting and including a diverse set of stakeholders (including the users, aka the students) to the process of building WFU Engineering. Faculty of course were active and engaged participants in all visioning and

decisions, they were not the only stakeholder though. Colleagues from across the university and beyond the university were solicited for feedback, expertise, and to challenge all our biased mindsets. My fellow College Chairs were important in this as well as they provided institutional knowledge and disciplinary differences. External scholars enriched our knowledge and challenged us with their diverse viewpoints. Industry and professional engineers were part of the process. Faculty candidates participating in the many searches we ran were invited to reflect on their own engineering education journey and help us identify opportunities for rethinking and reimagining engineering education. ABET as the accrediting body needed to be part of the decision making early on and there were many moments of tension between me (as Founding Chair) and a small subset of the engineering faculty who did not understand ABET. They were willing to take ununderstood risks towards compliance and I needed to ensure that we were innovating within the boundaries of accreditation. Innovation was still possible in midst of ABET despite misconceptions of many in engineering education. I made decisions as Chair attempting to minimize the inherent biases I had and informed by a diverse set of stakeholders and constituents. This is a place where I believe higher education needs to transform. Diverse viewpoints need to be leveraged when decisions are made, and students need to be part of those decisions. I empowered students to have a voice and to have influence, as did the faculty and external constituents. ***Ethical leadership and ethical decision making is a must.***

(6) **Agility & Innovation** – The agility and capacity of the engineering team to tackle all that came our way during startup mode continues to be remarkable achievement. Instead of large committees, a lot of the work was done comprised of small 2-3 member teams or one key champion that would prototype a policy or procedure or idea. Operating as small teams (e.g. planning specific courses, developing our engineering concentration proposal, tacking the ABET self-study, etc.) or having one key champion (e.g. study abroad advising, undergraduate research coordinator, etc.), we were able to propel department goals and ideas forward quickly and find flaws quickly too. We achieved all this with transparency and immense team buy-in. Our August 2018 retreat was facilitated by an Agile Coach (Jim York) who taught us a customizable framework (Scrum) to help us work as a team on both the procedural and complex challenges ahead of us. He came back to visit in January 2019 for a self-diagnostic session in helping us refine our processes and identify areas of improvement. This investment of time has revealed ways of effectively and efficiently working together. For a couple of years, prior to the pandemic, I had instituted in departmental meetings what I called “stand-ups” where all members of the team (faculty and staff, permanent and visiting, full-time and part-time, and me as Chair) would stand-up and write on whiteboards the major activities they were involved in since our last meeting and to share what is working well and what is not (maybe areas where they need help and support). If someone wanted to learn more about a particular activity, they could “star” the activity so that more sharing could take place. This kind of agile activity helped us build community and make our work visible, including the things that were hindering progress. While it could be time consuming, this activity was well-received by the team but it needed to scale back do to an immense workload on all. While it was not easy for all to adopt agile practices, operationally it helped us survive and thrive in the start-up environment we had (and which was further perplexed in midst of the pandemic and in midst of extreme build and accreditation work). A previous publication (Pierrakos and York, 2023) speaks to the

impacts of agile as a framework on matters of curriculum and co-curricular experiences. With an agile mindset, faculty were inspired to prototype ideas and pilot them and knowledge share with the team.

(7) **Educating the Whole Engineer Holistically** – As was made visible in this paper, integration was essential in all aspects of building WFU Engineering. Integration of engineering knowledge, integration of bridging engineering with professional knowledge, integration of engineering and liberal arts, integration of academic and career advising, integration of curricular and co-curricular learning experiences, integration of personal identity development and professional identity development, integration of ethics and moral development, integration of space design and learning, integration of faculty hiring and curriculum development, integration of culture and departmental operation. It truly took a holistic lens to understand our purpose, our identity, our approach to education to be able to step back and see that all the pieces connect and impact the student experience. Educating the Whole Engineer was more than integrated learning, it was intentionality around every experience that students had and the faculty/staff understanding their role and their purpose to making impact that would position our graduates as ambassadors and change agents within any path that they selected in their professional journey. Engineering at Wake Forest University has become a catalyst for positive change and demonstrated that students desire an authentic integration of liberal arts education with professional education in every aspect of the student experience (e.g. learning, academic advising, career preparation). Engineering as a degree offers an important positionality to help us transform higher education.

When we think about metrics of success, and outcomes of the inclusive culture and innovation we implemented, here are some:

(1) Curricular and Academic Innovation - We knew we had to innovate in building the WFU Engineering curriculum and our students were partners with us as we thought about the curricular structure and designed learning experiences that would enable us to achieve our vision.

a. **Over 75% of our BS Engineering graduates pursue minors and/or a second major (when national averages do not even come close to such diversity of knowledge that engineering students pursue).** This is an outcome we achieved by intentionally changing the model of academic advising. Considering how stretched hin (in terms of workload) the engineering faculty were in developing and teaching new courses, advising was falling behind (especially because the advising model in the College of Arts and Sciences was to assign a non-major faculty advisor to students prior to declaring the major, which typically happened spring of sophomore year). To ensure our engineering students were getting the appropriate academic and career advising they needed, we had to innovate. We instituted, with me leading the charge the first year and eventually finding other faculty champions (Dr. Kenny) to make the model even better, 4-year curricular mapping and independent development plans in the first year. This allowed us to encourage students upfront to think strategically about second majors our engineering students are pursuing include (in no particular order): (1) Biology, (2) Politics and International Affairs, (3) Computer

Science, and (4) Studio Art. Minors our engineering students are pursuing include (in no particular order nor degree of frequency): (1) Spanish, (2) Mathematics, (3) Economics, (4) Biology, (5) Russian, (6) Computer Science, (7) Chemistry, (8) Environmental Science, (9) Chinese Language & Culture, (10) Art History, (11) Statistics, (12) German, (13) Writing, (14) Psychology, (15) Entrepreneurship, (16) Theatre, (17) Anthropology.

b. **Over 50% of our BS Engineering graduates pursue undergraduate research (when national averages are about 10%).** Undergraduate research experiences are something we could not do by ourselves. We did not have enough research labs to support the number of engineering students who wanted to pursue research. Thus, I invited a newly hired assistant professor (Dr. Kyana Young), who was passionate about research experiences to build confidence in students and broaden students' understanding of engineering practice, to serve as our inaugural undergraduate research coordinator. Together, we identified and recruited over 20 research labs from across the university who wanted engineering undergraduates. Dr. Young then developed a process to match engineering students with research labs and offered guidance in setting expectations on both ends and developed various models of credit (e.g. paid research internships, course credit research internships that could count towards the major if appropriate requirements were met). Most of the research labs we recruited were from the School of Medicine (e.g. impact biomechanics, bioinformatics, cancer research, precision medicine, public policy, etc.). These experiences were powerful as they showcased to engineering students the diverse ways and the diverse knowledge that an engineer needs to tackle interdisciplinary problems.

c. **Over 50% of our engineering graduates pursue study abroad (when national averages in engineering are about 10%).** About 50% of our engineering students have participated in study abroad experiences during their sophomore or junior year. Study abroad locations have included Chile, Australia, Italy, Denmark, Spain, Germany, England, etc.

d. **Over 70% of our engineering students pursue internships in line with national norms and over 65% of you pursue one of the optional engineering concentrations in order to support post-graduation career goals**.

e. ABET highlighted as a program strength the diversity of experiences our students pursued.

(2) Pedagogical Innovation - Experiential education (the bridging of theory and practice) has guided us from day one. Theory and practice come together in every engineering classroom. This is innovation in learning that surpasses what we typically see in engineering education. Our BS Engineering graduates experience over 15 engineering projects across the curriculum, culminating with the year-long capstone design project. Authentic projects with real stakeholders. We invite colleagues across the university and across the community to join us in the engineering classroom. These colleagues provide context and expertise that

complements engineering learning. We partner annually with over 50 industry and community partners to bring real world projects and real-world practice to the engineering classroom.

(3) Diversity of Student Body - As a result of the welcoming and inclusive culture we have achieved, ABET highlighted as a program strength the diversity of our student body.

(a) About 40-42% of the WFU engineering students annually are women (when national averages in engineering are 15-20%). We expected 15% women in the inaugural cohort of students, but recruited 40% women, a percentage we have sustained due to inclusive excellence.

(b) To date, about 20% of the WFU engineering students bring racial and ethnic diversity to our community (when national averages in engineering are about 5%). We are one the most diverse departments at WFU, let alone engineering education.

(4) Diversity of Faculty Body - To build a diverse student body, we knew we would need a diverse faculty body. Our faculty and staff team represents over 12 engineering disciplines of knowledge and this strengthens our program and betters you as the next generation of engineers.

a. 60% of the permanent WFU engineering faculty are women (when national averages in engineering are 10%) and proud that our faculty also bring racial and ethnic diversity.

b. All this is another ABET identified program strength and the result of intentionally using best practices (research grounded that minimize inherent biases in hiring committees) with regards to hiring.

(5) National Impact to Society by our Graduates – Our students come from all over the US states and from other countries too. Our first two graduating classes (2021 and 2022) have entered all industries of engineering and are already getting promotions that showcase their distinct education. Post graduation, 70% of our graduates pursue diverse opportunities in industry and 30% of our graduates pursue diverse opportunities in graduate school (across all disciplines of engineering) or professional schools (business, law, medicine). About 20% of our graduates remain in North Carolina post-graduation to work across various industries and this points to the state and regional impact that our program is making. Our Alumni successes continue to amaze us each year and we are thrilled to be graduating our fourth graduating class this May 2024. 90% of graduates have job placements by the time of graduation and multiple offers to choose from. This is success!

(6) Faculty Becoming Scholars of Teaching and Learning - Last but not least, a strategic focus in building Wake Forest Engineering was bringing engineering education scholars to demonstrate to the founding engineering faculty the value of being a scholar of engineering education. As Founding Chair, I also modeled this for the faculty. I demonstrated how educational research, learning science theories, social psychology perspectives and knowledge pays off in how we make change in engineering education. We developed faculty reward structures where diversity of scholarship was valued. We leveraged Boyer's domains of scholarship - discovery, application, integration, and teaching and learning – as a way to frame the diversity of scholarship that we valued and would reward. I am proud that over 70% of the

WFU Engineering faculty have published engineering education scholarship. This was an intentional commitment that will pay off in the long run. This is not to say that WFU Engineering faculty were not successful with basic research, they absolutely were. WFU Engineering became in 2022, the second highest ranked unit in regard to external funding and this external funding was focused on basic engineering research, applied engineering research, and teaching and learning scholarship.

V. CONCLUSION

Although this paper offers one glimpse into the strategic, inclusive, and innovative strategies I used to build and transform a brand-new engineering program as Founding Chair, this paper still remains a small glimpse into all the important facets of building Wake Forest Engineering. The specific focus of this paper is on curriculum, culture, pedagogy, and the student experience. My hope in sharing this paper from the lens of being the Founding Chair of Wake Forest Engineering is to point to both the successes and challenges that exist for engineering education leaders working to transform engineering education and more broadly higher education.

Despite brand new engineering programs being often dismissed as being irrelevant to established engineering programs, whose cultures, curricula, structures, and operations are set, I do hope that all engineering educators can learn from the journey of building Wake Forest Engineering. There are many strategies that are transferable and relevant to brand new and established engineering education programs. There is an opportunity for us as a community to rethink and reimagine everything that we do in support of a thriving student community, faculty and staff community, as well as society as a whole. Engineers play a critical role in bettering humanity. As such, engineering educators also play a critical role in bettering higher education, which is stuck behind and productive progress extremely slow. The responsibility I feel is to share openly and professionally both the successes and challenges of building Wake Forest Engineering. This will be the first of many publications to tell the story.

The successes of building Wake Forest Engineering were many, the challenges just as many too. Sustainability remains my biggest concern regarding what happens with Wake Forest Engineering.

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