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Continuous Improvement from Foundation to Accreditation: Challenges in Creating an Engineering Program at a Small Liberal Arts College

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Abstract: Although most engineering degree programs have historically been offered by large universities, there is a growing trend of smaller colleges instituting engineering degree options for their students. These programs offer many advantages to students, including closer relationships with engineering faculty, unique educational approaches embodied by the college mission, and the ability to participate in extracurriculars such as varsity sports. However, founding and growing an engineering program at a small school also presents numerous unique challenges. Some of these challenges stem from an initial lack of dedicated resources – program funding, lab and classroom space, equipment, software, etc. New programs must also build awareness and connections with the local community, industry, and government to attract students, offer meaningful learning experiences, and build job placement pipelines. In addition, they must ensure they conform with and enhance the educational mission of the colleges they are part of. While this can impose limiting curricular constraints, it can also be seen as an opportunity to develop a unique educational product. In 2013, Saint Vincent College (a small college with a strong liberal arts and sciences focus) initiated a four-year bachelor's degree in engineering science after several years of planning. In the decade since that time, the program has evolved in response to numerous challenges, while expanding in scope and breadth of opportunities afforded to its students, culminating in successful ABET accreditation in 2023. This paper aims to highlight the challenges that were faced in this process (especially those that are unique to smaller institutions) and discuss how these challenges were addressed. The paper focuses on three distinct phases of the program's development: conceptualization, implementation, and accreditation, highlighting challenges that are directly tied to those phases, along with challenges that are threaded throughout the entire development. It concludes with key takeaways and lessons learned, which the authors hope will benefit similar programs as they develop.

Introduction

By its very nature, the landscape of higher education is constantly shifting as new fields develop and others stagnate. Institutions of learning must be constantly vigilant of these changes and develop new educational programs in response to the needs of the populations from which they draw students. Even liberal arts colleges, whose educational foundations are rooted in traditional notions of scholarship must ensure that their educational product will appeal to the needs of the modern student.

Saint Vincent College (SVC) is one such college. SVC is a small, Catholic, liberal arts and sciences college located in rural western Pennsylvania, enrolling approximately 1400 undergraduate and 200 graduate students. Since its founding in 1846, the college has sought to make its high-quality well-rounded education accessible to all, with first-generation students comprising approximately 40% of the student body. In response to changing college-age demographics of the region, SVC sought to found a new engineering degree starting in the early 2010s. Doing so was no easy task, and the program went through several changes in the early years. Despite these challenges and setbacks, the degree was successfully accredited by ABET in 2023. In this paper, we seek to tell the story of Saint Vincent Engineering throughout this process. The number of engineering programs at small and/or liberal arts colleges has continued to grow and is expected to keep growing as these institutions seek new programs to help maintain enrollment numbers in the face of shifting demographics and to serve their constituencies. We begin with a short overview of engineering and liberal arts institutions. After that, we will discuss the growth of the program in three distinct phases: conceptualization and planning, implementation and early years, and the path to ABET accreditation. Finally, we will offer advice and insight that we hope will be valuable to other new engineering programs as they develop.

Background

Traditionally, engineering has been perceived as a focused and professionally oriented degree program and as such has historically been offered by schools whose mission is similarly aligned, including engineering colleges within large public and private universities as well as polytechnic institutions. Engineering has not, however, been broadly embraced by liberal arts institutions, often being seen as being overly career-focused and not sufficiently broad in its educational approach. Liberal arts institutions also tend to be much smaller in size, which can make it challenging to furnish an engineering program with the specialized facilities and equipment it requires. Furthermore, liberal arts institutions typically have comparatively larger core curricula, which can make it challenging to design a robust engineering curriculum that is completable in four years.

A few small engineering colleges exist (e.g. Harvey Mudd, Rose-Hulman, and Olin College) whose enrollment ranges from a few hundred to a couple thousand students. However, given that these institutions consist almost completely of engineering students, they are more akin to standalone versions of the engineering schools that normally fall under the umbrella of a larger university when it comes to size and mission.

Some liberal arts colleges (typically highly selective institutions such as Swarthmore College[1]) have long embraced engineering, offering full bachelor's degrees. Another common strategy is to partner with universities to offer hybrid degree programs where the student starts their education at the liberal arts school and completes it at the university. While specific details of these programs vary, a common model is for the student to take three years of foundational coursework at the liberal arts school and two years of focused engineering courses at the university, receiving bachelor's degrees from each institution. These programs are generally referred to as 3+2 programs.[2]

However, as competition for students becomes more intense, many more colleges are seeking to add engineering to attract students who might not otherwise consider a liberal arts education.[3], [4], [5], [6] While instituting any new degree program is challenging, founding an engineering program at a small liberal arts college presents some unique challenges:

- Defining the program's mission to be in concert with that of the institution
  - Overcoming resistance to engineering as having a place in the liberal arts
  - Using institutional values to formulate the departmental mission.
- Determining the type of degree that best fits the institution and local industry needs.
- Procuring funding and space for a resource-intensive program on a small campus
- Constructing the curriculum to simultaneously satisfy ABET and institutional core curricular requirements.

While none of these challenges are insurmountable, they do require careful planning and a unified vision for engineering from the college board of directors and president down to the faculty and students. In the rest of this paper, we will recount the development of Engineering at SVC, paying special attention to the decisions that were made to address the above challenges and whether those decisions were ultimately successful.

Conceptualization

As of the late 2000s, Saint Vincent College had for decades provided a very successful 3+2 program where students completed their math, science, a few engineering courses, and core curriculum in three years and then spent the last two years taking engineering courses at affiliated schools. After completing their engineering courses, the students would transfer credit back to get a BA in Mathematics/Engineering from SVC and a bachelor's degree in a specific engineering field from the partner institution. While the program was successful, there were many times that students and alumni expressed interest in SVC starting its own engineering program so that they would not have to leave the college at the end of three years. Students expressed a desire to continue their studies at SVC because the institution was smaller with a tight-knit community of students and faculty and because students in athletics or extra-curricular activities could continue with these activities in their senior year.

In response, the faculty surveyed students who were in the 3+2 program at the time to ask them if they would remain at SVC if the college offered a four-year engineering degree. Of the 50 students in the program, 39 responses were received. Approximately 19% of the students responded that they would change their major to the new degree and 57% responded that they would consider doing so. Of the respondents, 39% were in their 1st year in the program, 22% were in their second year, and 39% were in their 3rd year.

Based on this positive interest from students, a committee of faculty who taught in math and sciences was convened to develop the program. Because of the institution's historical strengths in the sciences, the committee recommended that the institution offer a B. S. in Engineering Science, which was subject to the same ABET criteria as B.S. programs in Engineering and Engineering Physics.[7] It was also believed that the program named Engineering Science would be better accepted at a liberal arts institution where a degree such as engineering might be viewed by some as a strictly vocational major. The intent of the degree to equip students with a broad and general engineering background also reflected key principles of the liberal arts approach.

The faculty committee developing the proposal for the new B.S. in Engineering Science worked with a few fundamental principles:

1. They would develop a successful four-year engineering program which would build upon the long-standing and well-known 3+2 engineering program.
2. The curriculum would be developed to align, as much as possible, with ABET criteria for Engineering Science. This would position the program to apply for ABET accreditation in the future.
3. The new general engineering program would offer engineering specializations to provide depth in specific engineering disciplines. These specializations would build on existing strengths in the sciences.
4. The existing 3+2 program would continue to be offered in parallel to the new BS in Engineering Science. It was anticipated that the 3+2 program would serve students who desired an engineering degree in an area not covered by the engineering specializations.
5. It was not possible for the new engineering program to fully meet all ABET criteria at the time of its inception. Specifically, institutional support for additional engineering faculty and new space for engineering labs were needed before an application for ABET accreditation could be prepared.

To determine if a B.S. in Engineering Science would offer meaningful career pathways for students, area industry was surveyed. One question of importance was: "Would your company consider hiring an engineer with a degree in Engineering Science if this candidate had completed courses in mathematics (including calculus and differential equations), science (including chemistry and physics), core liberal arts requirements (literature, philosophy, theology, language, etc.) as well as basic engineering courses in thermodynamics, engineering design, computational methods, and materials engineering?" All companies responded positively to this question.

Additionally, several members of the school's Advisory Council and of the College's Board of Directors were graduates of the 3+2 Engineering program and were strong advocates of the new engineering program. As a result, the proposal for the new program was strongly endorsed by the College administration and by the College Board of Directors. The proposal for the B.S. in Engineering Science program progressed successfully through the faculty approval process and was approved as a new degree offering by the College Board of Directors in June 2013.

The new program grew quickly following its approval. Because the BS in Engineering Science program was built upon the existing 3+2 program, many courses in the program's curriculum were already being taught. While there was no time for a full recruiting cycle for Fall 2013, two first-time freshmen joined with three students formerly enrolled in the 3+2 program to begin study in the new major that fall.

During the program's first year, a search commenced for another engineering faculty member, and recruiting took place for the first full incoming first-year class. The search was successful with the hiring of a junior faculty member with a broad and interdisciplinary engineering background. The first full recruiting class in Fall 2014 brought 35 first-year engineers to campus, roughly half of whom matriculated into the new Engineering Science program. In contrast, during the previous five years of the 3+2 program, the first-year classes ranged from 15 to 22 students. Thus, the new program successfully attracted new students without affecting the 3+2 enrollment.

The program proposal included an initial budget for the program and planned increments over the first four years of the program. The realization of the envisioned budget occurred more slowly than anticipated in the proposal. Some reasons contributing to this were the lack of laboratory facilities for which purchases could be made and the economic conditions at the start of the program. As faculty were hired and new facilities were constructed the budget did increase in support of the program.

One aspect of the budget that was available from program inception was support for faculty development. Before the Engineering Science program was created, the College had an endowed chair in engineering who taught in the 3+2 program, and this faculty member was a driver in the program's development. This endowed position included support for faculty travel/development. As new faculty were added to the program, the Department's travel budget allotment from the school grew and the dean further supported the program by ensuring that program faculty have been able to attend national conferences (including ASEE and disciplinary conferences) each year through department and school funds. This was encouraged to assist the faculty in building their professional networks, in keeping up with best practices developing in undergraduate engineering, and to attend presentations by ABET staff and officers.

Implementation

It is one thing to have a well-conceived plan for a new degree program. It is quite another thing to successfully carry out that plan. The arrival of the first cohort of Engineering Science students to campus was a key milestone that shifted the nature of the challenges towards the logistical and operational, while not losing sight of the eventual goal of ABET accreditation.

The biggest limitation of the new program was space. Engineering is a hands-on discipline full of lab- and project-based courses that require dedicated lab space, appropriate lab equipment, a workshop with appropriate fabrication tools, computer labs with engineering software, student project "dirty floor" space, and faculty and staff office space. When the program launched in 2013, the only dedicated space for Engineering was two faculty offices. An introductory design lab was held in a Physical and Chemical Sciences non-majors laboratory space, which offered little in the way of fabrication tools or storage space for design projects. A MATLAB programming course was held in a general computing lab on which the software had been installed. This setup met basic instructional needs but presented challenges in keeping the software updated and allowing students after-hours access when the lab was closed. The lab also did not allow for easy incorporation of engineering project hardware such as sensors and microcontrollers. The existing science facilities included a Machine Shop that was developed, used, and overseen by the Physics Department, although this space did not include modern fabrication tools such as 3D printers and laser cutters. As a small college, it was not felt that there was a need to build a duplicate machine shop for engineering. The Physics program graciously allowed Engineering to utilize its machine shop for project fabrication. However, this only occurred after many conversations to develop initial protocols and policies to encompass the faculty and students from both departments. The machine shop had existed for decades within the Physics Department, and this was a significant change to how it would be used, organized, and maintained. This space also served as the initial location for the new Materials Engineering lab, though it was clear that this small, shared room could not serve this role for long.

As the first year of the program progressed and into the 2^{nd} year, discussions were had with the college administration regarding the need to develop "dirty-floor space" for the program. During this period, other existing spaces on campus were reviewed for possible use but nothing was found. Ultimately, the solution to the lack of dedicated engineering space was simple (but not easy): construct a new building. However, building a new space on campus requires institutional support and a funding source. The College President and College Advancement office began raising funds to design and build an addition to the existing science center. These efforts culminated in the construction in 2017 of a joint Engineering and Biomedical Sciences Hall, which included a dedicated engineering laboratory, an engineering computation lab, a modern teaching classroom, three faculty offices, and two "project labs" intended to provide workspace for Engineering and Integrated Science design, research, and capstone projects. However, shortly after construction was completed, Saint Vincent College initiated a program in Nursing, and the two project labs were re-designated for nursing clinical labs. Thus, space remains a concern, although the college is currently planning a new building for Nursing with plans to revert the nursing labs back to space for Engineering.

Another major challenge was staffing the program with the right number of qualified faculty to teach the curriculum. By the Fall of 2014, the program had two faculty, members: a program director with decades of industry experience before moving to higher ed, and a recent PhD hired into their first full-time faculty role. Although the standard teaching load at SVC is 24 credits (~8 courses per year), both program chairs and pre-tenure faculty qualify for a 3-credit (1-course) reduction, adding extra pressure on being able to teach a full curriculum. The following solutions were used to make things work initially:

- Faculty members teaching courses outside of their engineering disciplines (e.g. a chemical engineer teaching Statics and Dynamics).
- Cross-listing a Circuits course in both Physics and Engineering, taught by physics faculty.
- Creation of a combined Engineering and Computing Ethics course, taught by a faculty member with a doctorate in Computer Science and Engineering.
- Although the MATLAB programming course was designed by an Engineering faculty member, it was soon handed off to a Computer Science faculty member to allow the Engineering faculty to teach other engineering courses.
- Use of adjunct professors to teach CAD and Control Systems courses.
- Chemical Engineering, Environmental Engineering, and Computer Engineering concentrations relied heavily on courses offered by related science departments.

While these solutions helped get the program off the ground, it was clear that they were not sustainable or accreditable, and attention soon turned towards growing the number of faculty members. From the earliest days of the engineering program, a common topic of discussion was how many faculty were needed before beginning the formal process to pursue ABET accreditation. In most conversations, the discussion came back to three or four with the concern that three might be too tight. In an environment where enrollments at liberal arts colleges are generally dropping, this expansion required significant support from the college administration. The first stage of faculty expansion was the hiring of a new program director in 2017 to lead the program through ABET accreditation (and because the then-current director wished to retire in a couple of years). This resulted in the successful hiring of an ideal candidate with extensive administrative and ABET leadership experience at a similar institution.

Next, a search was held for a fourth faculty member in 2018. The program advertised for a mechanical engineer with a mechatronics specialization to complement the existing curriculum while also addressing a current lack of expertise. Unfortunately, this search attracted few applications and ultimately did not result in a hire. The search was repeated in 2019 and expanded to include two hires in anticipation of the imminent retirement of the previous director. This time, a wide net was cast seeking candidates from all disciplines of engineering, and the response was much better in terms of both the number and quality of applicants. Still, hiring for these positions proved challenging for the following reasons:

- The college's rural location was seen as a drawback for many applicants, and the offered salary was perceived as too low for candidates accustomed to higher cost-of-living areas.
- The prospect of joining a relatively new and as-yet unaccredited program compared poorly with candidates who received offers from more established programs.
- Candidates who have spent their entire educational career in engineering programs often misunderstand the nature of an institution grounded in the liberal arts.
- Disconnect between the candidate's proposed research plan and the limited funding available at a small institution.

Despite the challenges above and the onset of the COVID pandemic while the search was ongoing, the two positions were filled with well-qualified candidates who clearly understood the unique mission of engineering education at a small liberal arts college, bringing the department to four full-time engineering faculty. This was viewed as the critical number of faculty required for the program to be ABET-accreditable and set the plan to become accredited firmly in motion.

Accreditation

It was expected by the Saint Vincent administration that the new Engineering program would seek ABET accreditation. From the outset, the curriculum of the new four-year Engineering Science program was designed to support the ABET student outcomes. As noted earlier, the program was initially unable to meet all the ABET criteria for accreditation because of the small faculty size and the lack of dedicated engineering space. The hiring of three new Engineering faculty members and the construction of new space for the Engineering program removed these impediments. There remained some challenges to overcome, however, before the program was ready for a formal accreditation review, as discussed below.

The new Engineering program awarded a degree in Engineering Science. While the ABET criteria are the same for programs with the names of "Engineering," "Engineering Science," and "Engineering Physics," prospective students and their families perceived an Engineering Science degree to be different than an Engineering degree and put more value on an Engineering degree. As a result, the College Admissions department encountered difficulty marketing and recruiting for the new program effectively. In 2019, the Engineering Science program faculty voted to rebrand the program as Engineering, removing "Science" from the program name. This change was positively received by the Admissions Department and by prospective students and their families. The initial motivation for naming the program Engineering Science – to acknowledge the contribution of the sciences to the liberal arts and to build on the long-standing strengths and recognition of the science programs at SVC – was no longer a concern due to the immediate success of the new program.

The faculty took a critical look at the program curriculum following the change in the program name. As discussed earlier, the Engineering Science program relied heavily on courses taught by faculty in other math and science programs. With the hiring of a new program director and additional engineering faculty, the program was able to assume the teaching of the engineering courses which allowed for a significant revision in the engineering curriculum. The revised curriculum was designed to support the student attainment of the ABET Student Outcomes (SOs) and was informed by benchmarking the engineering science program against general engineering programs at similar institutions. In particular, the former engineering science curriculum offered few laboratory classes, little depth in a student's selected engineering specialization, and only one significant team-based engineering experience. The current engineering curriculum addresses these deficiencies; the two engineering programs are compared in Table 1. Student teams participate in projects that are threaded throughout the curriculum, hands-on work has been integrated into many classes, and the engineering concentrations require 15 hours of additional coursework. The capstone course was also significantly reimagined. Previously, senior students would conduct individual, research-focused projects (modeled after similar experiences in the natural science departments at the college). The new capstone course offered team-based design-focused projects, along with some basic project management and job search instruction. This aligned more closely with ABET requirements and opened a pathway to industry-sponsored capstone projects. The faculty were confident that with these changes students would be able to attain the ABET SOs by the time of graduation.

One of the most difficult parts of the curriculum revision was satisfying ABET requirements for engineering hours given the large general education core of the College and the budget and space constraints of the program. General education cores with significant credit hour requirements are a strength of liberal arts institutions but present challenges for designing curricula for programs with significant credit hour requirements. This meant that we had to be intentional about what we included in the required engineering core – required by all engineering students – and in the engineering concentrations. The budget and space constraints forced the engineering faculty to think outside the box when designing the curriculum, creatively using shared laboratory spaces and designing meaningful lab work around small, portable devices.[8]

Engineering Science Curriculum		Current Engineering Curriculum	
Required Engineering Core	**Credit Hours**	**Required Engineering Core**	**Credit Hours**
ENGR 100: Intro. to Engineering	2	ENGR 100: Intro. to Engineering	2
ENGR 115 Intro. to Engineering Computation, or CS 110 C++ Programming I	3	ENGR 115 Intro. to Engineering Computation	3
ENGR 220 Engineering and Computing Ethics	3	ENGR 220 Engineering and Computing Ethics	2
		ENGR 222 Engineering Graphics and Design	**3**
ENGR 223 Statics	3	ENGR 223 Statics	3
ENGR 226 Materials Engineering	3	ENGR 226 Materials Engineering	3
ENGR 228 Materials Engineering Lab	1	ENGR 228 Materials Engineering Lab	1
ENGR 240 Engineering Design & Lab	4	ENGR 240 Engineering Design & Lab	4
PHYS 261 Intro. to Electrical Circuits	**3**	**ENGR 215 Intro. To Circuits and Measurement**	**3**
PHYS 263 Intro to Electrical Circuits Lab	**1**		
ENGR 266 Control Theory	**3**	**ENGR 366 Automatic Control Systems**	**3**
ENGR 310 Engineering Thermodynamics	3	ENGR 310 Engineering Thermodynamics	3
ENGR 313 Engineering Seminar	**1**	**ENGR 315 Junior Engineering Lab**	**1**
ENGR 425 Eng Project Management	**3**		
ENGR 440 Capstone Design I	2	ENGR 440 Capstone Design I	2
ENGR 441 Capstone Design II	2	ENGR 441 Capstone Design II	2
Engineering Electives (3)	**9**	**Engineering Electives (5)**	**15**
Total Engineering Credits	**46**	**Total Engineering Credits**	**50**
MA 111 Analytical Calculus I	4	MA 111 Analytical Calculus I	4
MA 113 Analytical Calculus II	4	MA 113 Analytical Calculus II	4
MA 211 Analytical Calculus III	4	MA 211 Analytical Calculus III	4
MA 212 Differential Equations	4	MA 212 Differential Equations	4
MA 311 Probability and Statistics	3	MA 311 Probability and Statistics	3
CH 101 General Chemistry I	3	CH 101 General Chemistry I	3
CH 103 General Chemistry I Lab	1	CH 103 General Chemistry I Lab	1
CH 102 General Chemistry II	**3**	**Technical Elective**	3
CH 104 General Chemistry II Lab	**1**		
PH 111 General Physics I	3	PH 111 General Physics I	3
PH 113 General Physics I Lab	1	PH 113 General Physics I Lab	1
PH 112 General Physics II	3	PH 112 General Physics II	3
PH 114 General Physics II Lab	1	PH 114 General Physics II Lab	1
Total Math/Science Credits	**35**	**Total Math/Science Credits**	**34**
Additional College Core Credits	**49**	**Additional College Core Credits**	**45**
Total Credits	**130**	**Total Credits**	**129**

Table 1: Comparison of Engineering Science and Engineering degrees. Note that around the same time as the degree changes, the college changed its core requirements, allowing the number of engineering credits to expand slightly. Courses listed in bold represent significant changes between the two curricula.

These changes meant that the engineering program could prepare to seek initial ABET accreditation. Preparing for ABET accreditation at a small liberal arts institution presents several challenges. The faculty generally carry larger course loads and there tend to be fewer institutional resources available for administrative support. The administrative overhead associated with ABET accreditation – including collecting data, meeting with various constituencies, and assessing and evaluating student outcomes – can significantly strain the engineering programs at these institutions. It is difficult for most faculty to devote significant time to accreditation activities and we do not have access to administrative assistants who can support these activities. We recognized that streamlining and standardizing as many accreditation tasks as possible was essential to successfully obtain accreditation for the engineering program and to maintain accreditation in the coming years.

Starting in the Fall 2020 semester, the faculty embarked on a two-year effort to prepare for the ABET Readiness Review and subsequent Self-Study. First, the program's mission statement and Program Educational Objectives were revised to better reflect the College's mission statement, the program curriculum, and the constituents served by the program. The previous mission statement had been general and undistinctive, whereas the revised version helped define the specific vision and unique approach of Engineering at SVC. Second, the continuous improvement processes necessary to attain and maintain ABET accreditation were updated and formalized. Specifically,

- The faculty developed a set of performance indices (PIs) and rubrics to assess and evaluate each SO. As an example, the performance indices and rubric for SO 1 (an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics) are given in the Appendix.
- The faculty developed standard formats for the SO assessment memos and reporting of assessment data. Faculty teaching the courses used for SO assessment evaluate student work products and are responsible for archiving the assessment memos, data, and student work products.
- Input gathered from other constituents, including current engineering students, alumni, employers, and engineering faculty, is documented in annual program reports.
- All issues or concerns that affect how well the program meets the accreditation criteria are tracked in a continuous improvement log. This log documents the issue or concern, the action taken by the faculty to address the issue or concern, and evidence that the issue or concern is resolved.

Microsoft Teams was used as a central repository for all documents and data related to accreditation. This provided all engineering faculty access to all assessment data, including longitudinal assessment of SO attainment, the annual alumni survey report, the annual senior survey report, minutes from student focus group meetings, and annual program assessment reports.

One year later, the program submitted the Readiness Review to ABET in September 2021. In late 2021, ABET notified the program that the Readiness Review showed it was ready for a complete review. The ABET self-study was submitted in June 2021. The program was evaluated by an ABET evaluation team in late Fall 2022, and in 2023 the college received notification that the BS in Engineering program was successfully accredited.

Reflections and Looking Forward

The approach to developing an accredited Engineering degree at Saint Vincent College was deliberate and not rushed. Care was taken at each step of the process to ensure that the changes being made were in alignment with the college mission and existing campus resources. The evolution of the program occurred over the course of a decade, which allowed Engineering to be shaped into a degree that best fit the specific needs of students, the broader college community, and local industry. It is worth noting that other institutions have taken a more action-biased approach, rolling out new facilities, hiring many faculty at once, and seeking ABET accreditation as quickly as possible. While there are advantages to this approach (such as faster enrollment growth), the more measured approach taken by SVC was seen as a better fit for our institution, as it allowed Engineering to grow sustainably and become integrated and accepted into the liberal arts college mission.

However, achieving ABET accreditation has not stopped the evolution of the program. A key goal moving forward is to further increase awareness of the program among the local community – especially among prospective students and industry partners. As the number of engineering alumni grows, we hope to build an active and engaged alumni network to facilitate student mentoring, pathways to internship and job placements, and sponsorship of student capstone and research projects. We also anticipate a boost in program enrollment following successful ABET accreditation, which opens the pathway to the hiring of additional faculty and further expansion of engineering labs and project space. This would allow us to expand the types of concentrations we offer (civil engineering is commonly sought by prospective students, and not currently offered) as well as to consider offering additional degree options.

Lessons Learned

Here we offer advice to institutions considering the development of an engineering degree – especially those at small liberal arts colleges.

- Designing a degree that encompasses the mission of the institution while also meeting the needs of prospective students and local industry is key. Also, having the flexibility to update the degree as these needs come into clearer focus and to enhance the strengths that emerge as the program matures.
- Even if ABET accreditation is not immediately viable, it should be a goal from the outset of the program, and this should guide strategic decisions and hiring practices. The school dean's experience with the Computing Accreditation Commission of ABET helped ensure this vision was present from the outset, but having a program chair with extensive ABET knowledge to lead the accreditation endeavor was critical.
- Ample opportunity for faculty development is critical. Three of the four current faculty began as junior faculty with little prior experience as full-time college faculty.

Institutional support allowing faculty to travel regularly to ASEE conferences as a non-presenting attendee has greatly improved their teaching, fostered new ideas for labs and projects, and allowed these faculty to become familiar with ABET assessment and the accreditation process.

- A particular challenge has been building awareness of the Engineering program among the local community and industry. Even now, local engineering companies are often surprised to learn that the college offers engineering. However, once a relationship is established, these companies have proven to be valuable partners who provide internships and job opportunities while enhancing student learning with guest lectures and field trips. These companies have identified location as a negative factor in recruiting and retaining engineering talent and are happy to have a local Engineering program from which they can hire.
- Many liberal arts colleges have a significant focus on community and service. This can be leveraged into developing meaningful projects for introductory design or senior capstone courses. For example, students have engaged with the Saint Vincent community in the following ways:
    - Analysis of heat transfer in a maple sap evaporator run by a campus community member.[9]
    - Design of assistive technology for students in a vocational program for developmentally disabled individuals that is run by the college.
    - Analysis and design of projects to improve the environmental sustainability of the campus, focusing on food waste management.
    - Design, construction, and testing of laboratory apparatuses for the Engineering and Biology programs, for educational and research purposes.

Conclusions

Based on our experience, it is clear that engineering programs can thrive at a small liberal arts institution. The liberal arts foundation complements the engineering education in a way that helps students attain the SOs at the time of graduation. Additionally, engineering programs can be successfully implemented with significant budget and space constraints. As an added benefit, these constraints force engineering faculty to think outside the box when designing the curriculum, creatively using shared laboratory spaces, designing meaningful lab work around small, portable devices, and utilizing opportunities within the college community to develop student projects. Furthermore, the implementation of a new engineering program need not occur all at once; a gradual and measured approach has proven valuable in developing a sustainable program that fits well within the college's identity.

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Appendix: Performance Indicators and Rubric for Student Outcome 1

Student Outcome 1: An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

The term *principles* refers to relevant principles of engineering, science, or mathematics

Performance Indicators	**Exceeds Expectations** 3	**Meets Expectations** 2	**Developing** 1	**Unsatisfactory** 0
1-1: Identifies problem	Demonstrates the ability to identify all relevant engineering, science, and mathematics principles using the given contextual factors and problem statement.	Demonstrates the ability to identify most of the relevant engineering, science, and mathematics principles using the given contextual factors and problem statement.	Demonstrates a limited ability in identifying relevant engineering, science, and mathematics principles using the given contextual factors and problem.	Does not identify relevant engineering, science, and mathematics principles for the given problem.
1-2: Formulates problem **Includes identifying the key engineering, science, and/or mathematical principles necessary to solve the problem**	Correctly formulates the engineering problem using the given information and all relevant engineering, science, and mathematics principles	Formulates the complex engineering problem using the given information and all relevant engineering, science, and mathematics principles but minor errors performed in the process.	Formulates the complex engineering problem using the given information and relevant engineering, science, and mathematics principles, but major errors performed in the process.	Does not formulate the complex engineering problem using the given information and the relevant engineering, science, and engineering principles
1-3: Solves problem	Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem. Calculations are also presented elegantly (clearly, concisely, etc.)	Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem.	Calculations attempted are either unsuccessful or represent only a portion of the calculations required to comprehensively solve the problem.	Does not implement the solution methodology to solve the problem.
1-4: Evaluates solution *May include a review of logic/ reasoning, comparison with expectation based on principles or other methods of obtaining similar results, review of relevant assumptions, or examination of feasibility of solution*	Evaluation of solution is deep and elegant, with thorough and insightful explanations	Evaluation of solution is adequate with minimal errors, and includes basic engineering reasoning such as order of magnitude evaluations or confirmation of the direction of trends	Evaluation of solution is brief and provides only a surface-level explanation. Evaluation may be incorrect.	Does not evaluate the solution