



An Iterative Process to Assess and Optimize Diversity Programming

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Background

Many engineering colleges are dedicated to creating an inclusive and diverse student population. These colleges can offer a variety of engineering-focused outreach, recruitment and retention programs to attract and retain underrepresented students for populations that include multicultural, women, low-income and first generation college attendee students. With often limited resources, it is advantageous to understand the effect of a diversity initiative and be able to make changes that can enhance the program's effectiveness as well as save funds, staff time or other resources. Such a decision may also allow a program to implement another different or coordinated action that can lead to better outcomes as related to their desired diversity goals.

Approaches to building a slate of programs to address diversifying goals on multiple fronts greatly vary. Decisions about which K-12 activities to offer range from whether to host small to large size events, the design of an activity with respect to the appeal for younger, high school, minority and/or women students and whether to host it on campus or at a local school. Creating and executing retention initiatives to support students once on campus may involve determining the amount of scholarship support necessary, teaching strategies to help students build an academic community and maintaining pathways to involve more diverse students in research. An institution's diversity slate may include individual projects resulting from faculty grants that create a one-time outreach or research experience, the outreach efforts implemented by a student section of the Society of Women Engineers or National Society of Black Engineers, or each year bringing to campus hundreds of ninth graders for hands-on activities or high school seniors to explore the various engineering majors. Some institutions have diversity organizations whose major emphasis is reaching students through the types of activities described above. A key issue, then, is how an institution or a diversity organization can balance the resources needed to reach multiple audiences while maintaining the ability to demonstrate quality and effectiveness.

K-12 Programs: To activate interest in engineering, many institutions want to engage and develop an understanding of engineering among K-12, pre-college underrepresented students, who may not have role models or sufficient access to resources to develop this knowledge. For middle school girls, effective one-day experiences range from Girl Scout Badge Days¹⁻³. Girls Exploring Science, Technology, Engineering and Math sponsored by SWE^{4,5}, and AAUW's Expanding Your Horizons⁶. The resources required to execute these types of activities is often shared by multiple entities: parents or schools who can provide transport, institutions who provide the space and in-kind staff costs, professional organizations and industry volunteers.

Longer term, pre-engineering programs may be more effective at engaging girls and boys^{7, 8}. Math Engineering Science Achievement (MESA) gives engineering experiences to students through yearlong coursework or afterschool activities, including competitions that many students enjoy⁹. Examples of other longer term activities include one which emphasizes the human impact of engineering for highly diverse middle and high school students¹⁰; a middle school renewable energy outreach camp¹¹; and middle school engineering design projects taught in science classes¹². A biomechanical project focusing on creatively designing a prototype tool for exploring endometriosis that was implemented in a high school setting showed overrepresentation of enrolled minority and female students¹³. This project was conducted with NSF GK12 engineering fellows who taught each week in middle and high school classrooms. The range of assessment responses to these types of activities is generally positive, and the assessments themselves often are linked to school learning outcomes.

Recruitment Activities: Many institutions focus on recruitment events and proactive admissions practices that enable them to show off their college and disciplines. Recruitment events are favored because they can provide information to a large number of high school students at once. Moreover, the faculty time commitment is minimal and the cost is usually reasonable, making such events sustainable¹⁴. By the end of the admissions season, the institutions can quickly ascertain the yield to the next-year's class from the recruitment event. Institutions are also examining ways to proactively attract underrepresented students and reduce structural barriers to apply for admission and subsequent engineering enrollment¹⁵. Alongside recruitment and admissions are strategies for awarding scholarships that can help underrepresented students meet their financial needs^{16, 17}.

Retention Initiatives: Colleges also offer programs that build student engagement with the engineering college and each other. Students who attend an on-campus, summer bridge program have been shown to have greater success and persistence in part due to the ability to form a cohort and gain familiarity with campus resources¹⁸⁻²⁰. Elements such as study centers, course clustering, tutoring and structured study groups that foster collaborative learning have been found to promote student success for underrepresented students²¹⁻²³. Students who also engaged in student societies, research, employment, meeting with faculty and other activities within their colleges of engineering have been found to show higher persistence due to a sense of belonging in engineering^{24, 25}.

Alternative Paths into Engineering: Some institutions conduct programs to address the needs of transfer students²⁶, dual degree students²⁷, pre-engineering majors²⁸ and other preparatory programs to build capacity in engineering²⁹⁻³¹. Assessment results indicate persistence of students in these programs to be on par with traditionally admitted engineering students, though factors exist that can impact persistence²⁶.

Assessment Overview

The primary goal for assessing a program is to collect information to determine its effectiveness. This means that the program itself met certain measures such as attendance of people from certain demographics or content gains of participants. However, when assessing diversity initiatives, assessment can also encompass how well the program directly contributed to building student numbers, improving student performance or retention, or fostering an inclusive climate. For K-12 programs, often the intent is to improve the impression and understanding of engineering. Typical assessments include Likert-style feedback questions regarding interest, the appreciation of engineering activities, and the likelihood of pursuing an engineering career. The assessment feedback for these activities most often demonstrates that many participants did increase their interest in engineering. The catch is that it is difficult to determine long-lasting effects from one-day activities, especially over the many years that may transpire before students attend college. Institutions may instead prioritize the offering of recruitment events to gain the attention of underrepresented high school students so that they will apply and/or attend. Consequently, understanding the yield of students from such events can guide the implementation of subsequent programs. Information for college retention programs gained from assessments try to correlate student performance and persistence to a specific intervention often can help to justify the activity. Assessment of tutoring or collaborative study programs will then work to build attendance numbers and increased performance outcomes. Assessment of more social programs such as student societies, volunteering for outreach and other community-building programs will examine numbers and persistence of those participating.

The types of assessments that can be applied rigorously to gain knowledge about an engineering educational intervention include a variety of quantitative and qualitative assessments³². The Assessing Women and Men in Engineering (AWE) program provides validated assessment tools that can help programs analyze effectiveness and compare against other results³³. Information about satisfaction and identity formation can be gained by the use of the instruments from the Academic Pathways of People Learning Engineering Survey (APPLES) study³⁴. Further information is gained by using qualitative techniques such as interviews and observations³⁵.

Workflow Process Diagrams

Most engineering disciplines use flow charting to illustrate the idea of a process that progresses from one state or condition to another. In engineering colleges it is common to use the concept to chart the courses that students need to take to graduate, often linked to certain terms of the college career. The concept of a general workflow process has its origins in manufacturing, when flow charting enabled engineers to follow the measured or monitored variables. It now is also applied to business processes when complex activities or plans involve decision-making, infrastructure and human tasks³⁶.

Using flow chart software, a detailed profile can illuminate the scale, scope and decisions of an organization's diversity actions³⁷. A simple workflow process is typically linear, without much branching into other process avenues. As shown in Figure 1, a basic, general workflow process diagram shows an action or intervention designed to meet stated goals and which follows an implementation and assessment plan. A decision to discontinue or make other decisions is also enabled.

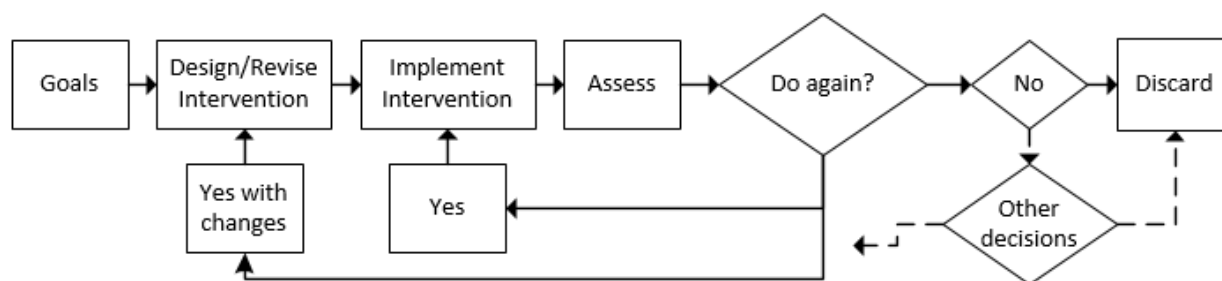


Figure 1. General workflow diagram showing the iterative design-implementation-assessment process for programmatic interventions.

More complex diagrams often designate points where information is needed and used in the process. Sometimes it shows more alternatives as well. A revised, general workflow process diagram containing examples of information to be added for K-12 or recruitment activities is shown in Figure 2. After the intervention is implemented, a full assessment should lead to a determination of the effectiveness of the program. It determines participation and demographics, successful components, areas for improvement, staffing, costs and other logistical and resource information. This information then supports the staff to have a critical look at how well the program met the stated goals. The critical point is the decision arising from the assessment that leads to implementing the intervention again, revising, or stopping. Notice that a key diversity issue is assessing whether participants are likely to enroll in engineering (for K-12 activities) or persist (for college retention activities); this information is derived as part of the assessment process.

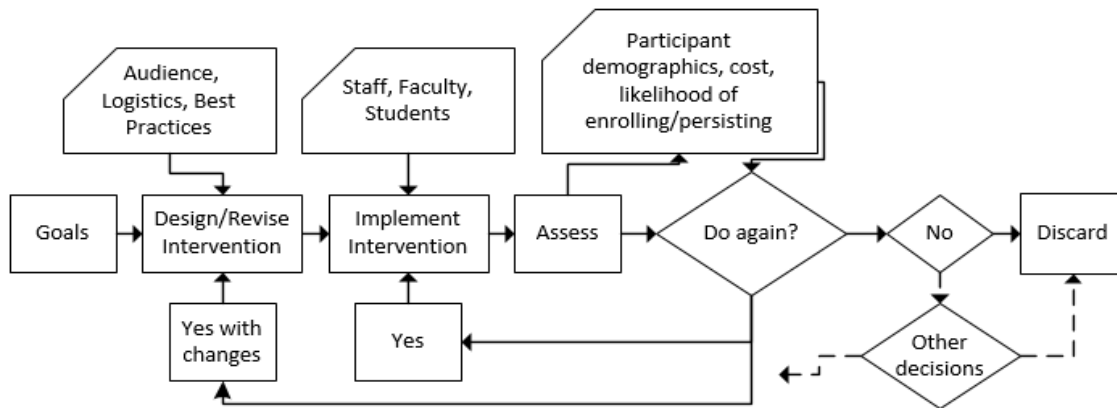


Figure 2. General workflow process diagram showing informational points of input for interventions that have participants, staff requirements and other logistics.

Much like an iterative research or engineering design loop, a thorough assessment and implementation process will reveal information useful to determine the value to an institution’s slate of activities and to its diversity goals. In this context, the “problems” include the overarching objectives or goals such as increasing the number and representation of diverse students in the college, creating an inclusive climate, and increasing the likelihood of diverse students graduating from engineering. Prior to designing an intervention, an “information gathering” process incorporates a review of the literature can reveal best practices and research results. It can also help to discuss with colleagues at other institutions to learn from their successes and solicit their suggestions for improvement. An institutions prior experience and results also factor into the gathered information. These literature, research and other results then are pieces of the collected information used to develop programs and initiatives that are optimally created to meet the stated objectives. It also includes logistical information to enable the implementation to be carried out. This logistical information determines the size of the initiative, including the available funds, room logistics and staffing (students, faculty and college/campus and staff) that are needed. Then, the initiative is “designed” and “implemented.” After the initiative is implemented, an “assessment” provides information that can be used to optimize or revise the details before the “iteration” step, which is the next implementation of the activity.

The BOLD Center Diversity Initiatives

At a large western university, a unified diversity program called the BOLD (Broadening Opportunities through Leadership and Diversity) Center has hosted numerous programs that are similar in nature to their collegiate counterparts. When the BOLD Center first started³⁸, a small slate of activities led to simple decisions around revising or choosing between a few programs. As in Figure 1, each program could be evaluated on its own merits because the logistics and

outcomes were simple. For example, a discover engineering day was held each year with few changes from year to year, due to repeatable logistics, including staff and faculty who had organized and run the program many times.

With growth in the college population and a broadened mission, a primary difference in its current approach is that BOLD hosts many programs for each type of diversity initiative. For the K-12 audience, at least six Girl Scout Badge Days each year are held, and over 300 students participate. Also, a summer camp for high school students reaches 30-50 diverse students. Annual recruitment activities include a large “discover engineering day” event with more than 600 attendees, and four to five smaller, on-campus events for women and minority students with about 100-120 participants each. BOLD representatives also meet 60-70 students in three or four one-on-one interview days set up to choose 30-45 students for its capacity-building, alternative pathway program, the Engineering GoldShirt Program. Retention initiatives include a study center used by 300-400 students each semester; drop-in tutoring that in the most recent fall semester was used by nearly 400 students who visited a total of ~1600 times; a scholarship program for more than 450 diverse students; weekly community-building and professional development meetings attended by 20-40 students each time; and other initiatives such as an industry nights and tours, student societies housed in the study center and guided by BOLD staff, and presentations and participation in other college, campus and community diversity events. In spite of this full slate of activities, the BOLD Center staff wonders how to handle additional activities to push forward the college’s diversity goals.

The ability to take on more initiatives is often a strategic objective, especially in an era of growth and desire for greater diversity in engineering colleges. Expanding offerings can be warranted when, for example, a recruitment event designed for 100 targeted participants has a waiting list each time it is offered. It may be that additional funds are available that enable the development of a broader scholarship program, but a scholarship expansion decision can take away from offering the additional recruitment event. The ability to expand also depends on the availability of sufficient staff, students, faculty, time and space. None of these issues alone is complex, but they all need to be considered together.

Information Collection: BOLD uses workflow process diagrams to bring together the pieces of information about its diversity initiatives. In the K-12 area, a workflow process diagram, shown in Figure 3, illustrates the breadth of its programs. For each of the initiatives, the diagram shows that each one’s assessment should identify facts that support the primary diversity objective, namely that students who attend will be more inclined to apply to the college. The current set of K-12 initiatives attempts to reach multiple audiences with different formats. Numerous events offer one-day visits to campus (Girl Scout Badge Days for K-8, Discover Engineering Days for 9-12, and Transfer Student Day for community college students). Others send students and staff into the community or schools (ACT Prep and SWE visits for 9-12, after-school clubs for 3-8). A weeklong STEM camp for 9th–11th grade students provides an extended hands-on experience

with engineering activities. A scholarship program that factors in attendance at one or more of our events supports diverse 12th grade students who apply to the college. After each implementation, a thorough assessment process determines the value to the main objective of building a diverse student body in our college.

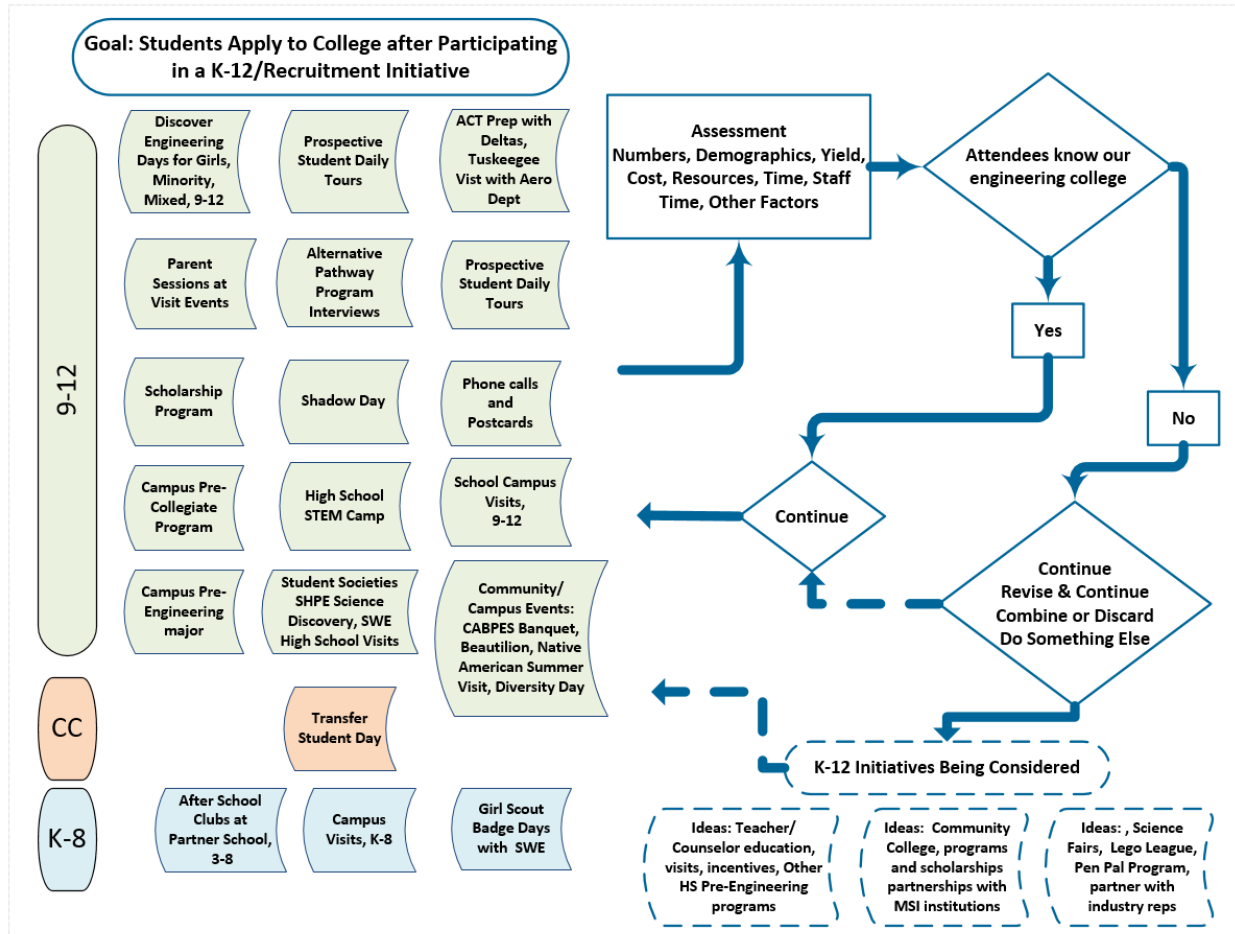


Figure 3. Workflow process diagram for BOLD's K-12 initiatives.

Figure 4 shows the initiatives supporting student performance and retention. A combination of academic and social (community-building) initiatives, including a specified number of required activities, is required for BOLD's participation scholarship recipients. For instance, on the academic side all scholarship recipients are required to enroll in a first-year projects course, but it is optional, yet marketed broadly, to enroll in the pass/fail course that features a collaborative approach for learning calculus. Likewise, on the social initiatives side, a certain number of attendances at the weekly Power Hours will count as community building or professional development activities for the scholarship recipients. Of note are the volunteer hours required of the scholarship recipients. Their volunteerism provides important student staffing required for BOLD's K-12 events. The assessment of these initiatives as a whole enables BOLD to determine whether to add, eliminate or change activities in subsequent offerings.

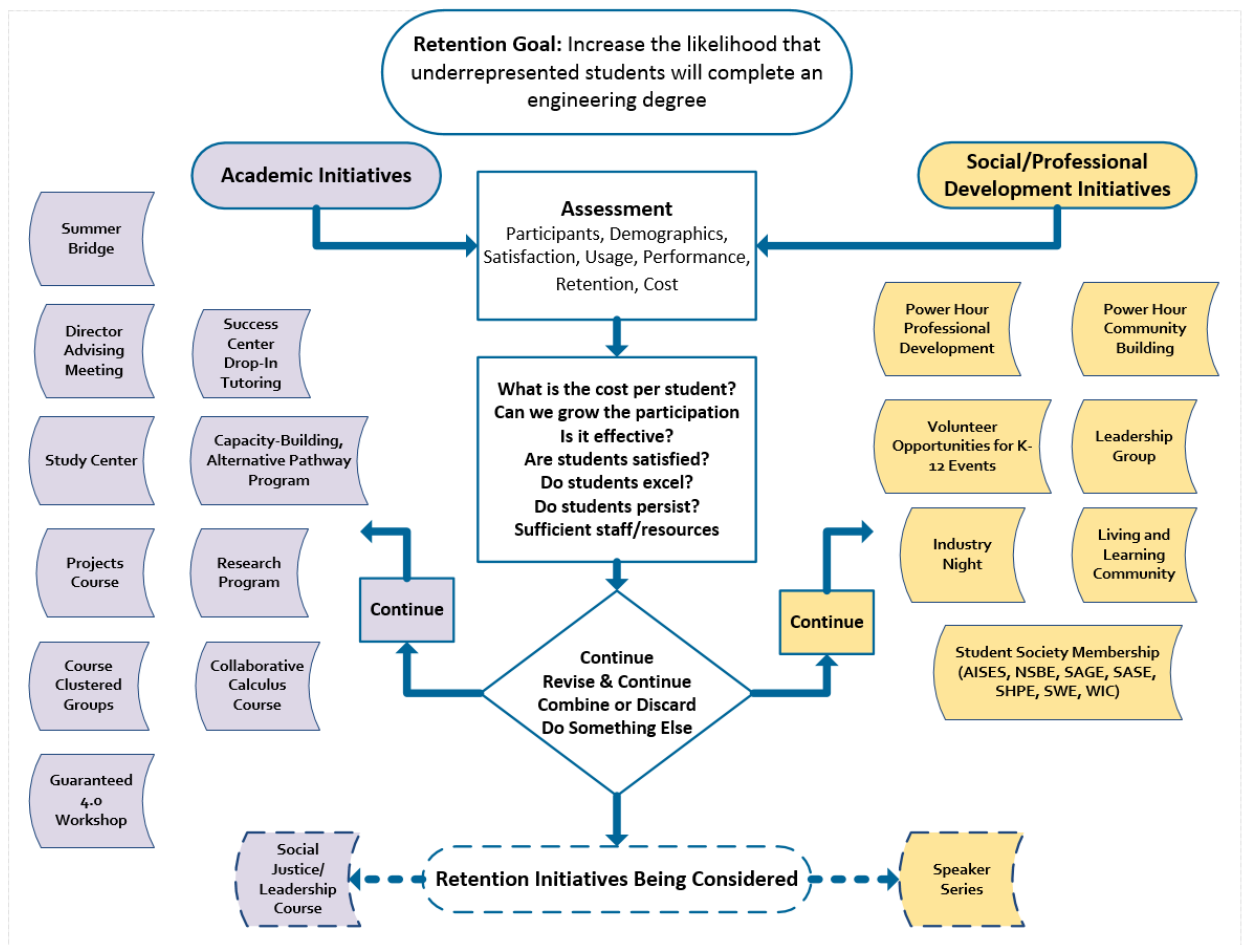


Figure 4. Workflow process diagram illustrating BOLD initiatives to support the retention of students underrepresented in engineering.

Goals Process Drives Implementation: A detailed logic model can incorporate the specific goals to be addressed so that an intervention can be formulated with tactics that are easily assessed. It is a clear way for all involved to see that the goals are linked to the results. An example shown in Table 2 is the logic model for an intervention called Summer Bridge, a residential experience that occurs a few weeks prior to the start of the fall term. A group of between 24-40 students is chosen from applications with an eye toward those underrepresented in engineering and with lower predicted college performance. Academic and social components promote group interactions; other activities help instill confidence and comfort in the students choice of engineering. The expected outcomes of Summer Bridge include demonstrating the formation of a community, getting a taste of life on campus and to build a knowledge of engineering and other campus resources. Because it is a time, cost and resource intensive endeavor, being detailed about the goals and expected outcomes helps to determine the program’s effectiveness.

Table 1. Summer Bridge Logic Model

Goals	Objectives	Design Plan	Outcomes
1. Create community	1a. Run team-building workshop 1b. Incorporate slate of non-academic activities 1c. Create residence life experience	1a. Challenge course 1st day 1b. Introduce to campus and college resources 1c. Residence advisors lead activities 1d. Develop community core values	1a. Students form friendships 1b. Students choose to enroll in the same course sections
2. Prepare students to succeed in the engineering curriculum	2a. Assess students' academic skills pre- & post- 2b. Expose students to authentic course content 2c. Offer facilitated group study experiences 2d. Provide office hours as a course resource	2a. Math & Physics workshops Track progress in these courses through Fall & Spring 2b. Math and Physics workshops will cover freshman topics Two engineering design courses - taught like existing courses with Design Expo and Final Presentations Humanities reading and writing assignment 2c. Collaborative group work in Math and Physics, Math Orals and HW sessions 2d. Office hours and HW hours scheduled Instructor assessment for each	2a. Students perform at or above the class average for midterms and the course 2b. Students have semester and yearlong cumulative grade point averages at or above that for the entire first-year class
3. Expose students to campus life and resources	3a. Meet with student society members (NSBE, SHPE, SWE, AISES) 3b. Help students get registered for fall classes 3c. Learn to use the study center as a 2nd home 3d. Gain knowledge about campus facilities	3a. Schedule dinner & game night with NSBE, SHPE, SWE and AISES reps 3b. Conduct a course registration workshop, distribute example course schedules, and hold registration morning in the study center 3c. Schedule HW and activities in study center 3d. Scavenger hunt, Rec Center, Bowling, Shakespeare Festival	3a. Students demonstrate comfort with the campus 3b. Students learn program and college staff names 3c. Students use the study center resources
4. Instill satisfaction in students' choice of major	4a. Demonstrate that engineering is fun and exciting (Projects) 4b. Connect engineering with students' personal values 4c. Introduce students to faculty in their potential majors	4a. Engineering humanitarian aid projects 4b. Conduct Spatial Visualization modules to boost self-efficacy in an engineering skill area 4c. Mentors talk about their own majors and process of choosing	4a. Students can state which majors they are choosing between 4b. Students identify engineering skills they enjoy or have learned 4c. Student can explain the societal value of their engineering projects

A Comprehensive Implementation Process: While strategy is developed by the team for an initiative, an event coordinator has primary responsibility to ensure that the logistical details including rooms, food, volunteers, agendas, registration, set-up and clean-up are accomplished. Another important factor in BOLD’s ability to conduct numerous events is the prevalent supply of student volunteers, from the scholarship recipients and others, who are interested in supporting the next generation of engineering students. Consequently, the staff creates agendas to inform this often large group of individuals of the details from start to finish of each initiative. For instance, for Summer Bridge an hour-by-hour schedule is created with names and responsibilities designated.

Detailed Assessment Process: A thorough assessment enables our institution to expand in a controlled manner. For instance, it is illustrative to follow how the K-12 slate of activities has developed over time. BOLD conducts numerous recruiting initiatives that contribute to the college’s diversity goals. In the past, BOLD hosted several large, inclusive recruiting events for both prospective and admitted students. Only a small diverse population would attend these events. In the past five years, the recruiting strategy has been changed to include primarily targeted recruiting events such as events for only girls or underrepresented minority students. Only one large, fully-inclusive recruiting event is hosted in each the fall and spring semesters, while 6-8 of the targeted recruiting events are held throughout the academic year.

A thorough analysis of each event is conducted to determine the cost per enrolled student as shown in Table 2.

Table 2. Data Analysis of Girls’ Recruitment Event

Student attendees	Seniors	Seniors who applied	Seniors who were admitted	Seniors who confirmed	Females	URM	Cost per student	Cost per enrolled student
154	75 49%	55 73%	45 82%	24 53%	154 100%	10 6%	\$19.48	\$125.00

Through this analysis it was determined that there was a very low return on investment for students younger than 11th grade, specifically that a low yield of younger students was seen in the admissions rosters in subsequent years. The highest return on investment is for senior students. The recruitment strategy was modified once this was realized, and 12th grade seniors were invited to the event, with 11th grade juniors being able to attend on a space available basis. The decision to not allow younger students to attend these events has been controversial with

both parents and others in the engineering higher education community. Many believe that BOLD *should* be offering recruiting events for younger students, but the analysis and assessment shows that based on the historic return on investment, the limited resources are best spent on recruiting events for seniors.

The Summer Bridge program has focused on inviting students so that it includes higher representation of women and underrepresented minorities, as shown in Table 3. Each year the diversity of Summer Bridge participants has been greater than for the entering first-year class of engineering students, meeting the overall diversity goal. Because housing and dining are the largest, and fairly fixed, components of the overall cost, the primary method to reduce the cost impact has been to reduce the duration. Also, efforts to reduce other costs since 2009 have been made. Consequently, increasing the number of participants while reducing the duration of the program resulted in much lower overall costs and better affordability for BOLD. A key objective moving forward will be to continue to increase participation.

Table 3. Summer Bridge Program Information

Cohort	Number of Weeks	Number of Participants	% F	% URM	Cost per Student
2009	4-5	21	29	62	\$3,930
2010	2	27	54	25	\$1,600
2011	2	41	61	46	\$1,580
2012	2	39	62	26	\$1,520
2013	1	29	41	62	\$1,190
2014	1	23	38	58	*TBD

In general, each of the initiatives is evaluated at the time of implementation and some are also reassessed longitudinally depending on their length and desired outcomes. As an exemplar, the length and goals of the Summer Bridge program detailed in Table 1 allow the use of student pre- and post-surveys. To measure the outcomes of goal 1 and 3, to create community and expose students to campus life and resources, students are asked before and after the program about the number and quality of friendships and relationships they have with various types of people in the campus community. They are also asked about the knowledge of various campus resources. For goal 4, instilling satisfaction in students' choice of major, we use a subset of the questions in the APPLES instrument³⁴. Comparing the pre- and post-survey results demonstrate changes in student perceptions and knowledge. Various Summer Bridge goals are also evaluated after the program has completed, comparing the student performance of program attendees to their non-attending peers.

While Summer Bridge is a good example of an initiative with pre- and post-assessments, some initiatives do not allow for, or require, this level of assessment. Particularly, one-day K-12 or recruiting events are evaluated using different metrics and tools. Some initiatives only include a

quick follow-up questionnaire to assess attendee perceived effectiveness. Another source of assessment for these relatively short events includes retrospective feedback from students who subsequently enrolled in the institution. While this produces information only from matriculates, it is helpful to know how much the event influenced their decision to enroll. In one such survey we asked which events and other factors, including college branded recruiting materials, were most influential in their decision to attend our engineering college^(reference removed for blind review).

For all initiatives usage numbers with detailed demographics illustrate if the desired audiences have been reached. If not, new strategies are included in the next offering to address the previous shortfalls. Performance indicators are tracked over time, and higher level analyses are used to understand the impact, if any, of high school background, standardized test scores, and placement exams. Costs are tracked to determine areas to reduce or eliminate, or if extra expenditures are warranted. These analyses help BOLD to implement changes, including eliminating ineffective programs and practices.

Optimizing Strategies to Meet Diversity and Program Goals: In developing a slate of activities that addresses audiences at the K-12 and college level, BOLD delineates the goals and designs activities to best meet each audience's needs. The K-12 audience needs to be exposed to engineering, making it familiar to them, and making them feel empowered to become an engineer. Seniors in high school need information about the engineering school, including evidence that they will be welcomed and supported. Current engineering students need initiatives that help them with academics while meeting social and professional needs. Consequently, it is important to have sufficient staff to develop the correct programs for the variety of institutional diversity goals. BOLD has several staff members to tackle the myriad activities and give each one the attention it needs for implementation and during the assessment process.

For each initiative, it helps to have a set of overall strategies that provides guidance when working to optimize. BOLD works to maximize the number of participants and develop effective tactics to convince students of the value of engineering and/or our college. While large programs present logistical challenges, they often have the lowest time commitment and cost per student ratios, making them affordable and effective. Programs that run longer than the single day events must be evaluated, both looking at the event itself and the long term outcomes (recruitment, retention, graduation) for the participants. BOLD uses survey feedback and best-practice guidelines from the research literature to optimize the activities, working to incorporate creative scenarios for hands-on activities with which students can relate³⁹. For instance, a summer bridge activity using small vehicle prototypes was made more inclusive by using an open-ended search-and-rescue backdrop with which all students could relate.

Conclusions

Like many other engineering colleges, BOLD has limited resources but aims to make a large impact with diversity-related goals. Because of this, it is essential to assess each and every program to determine if it should be continued, what changes should be made, and if the program is helping to achieve diversity objectives. It can be easy to get into an anecdotal feedback loop where it may seem like a program is making a difference. Using an ill-informed approach can result in an institution repeatedly implementing an ineffective or overly expensive programs that consumes resources. Until a thorough data assessment is completed, it is nearly impossible to determine if a program should be continued or discontinued.

While BOLD has developed an approach that allows it to implement myriad activities, each institution must determine its own approach. Evidence exists that faculty efforts can create interesting and meaningful programs; also, student societies can contribute with their outreach efforts. The limitations with either of these approaches are the availability of time to dedicate to these activities and the longevity of, and ultimate effectiveness of, an initiative. As a whole we propose that it makes sense to address diversity goals with a more unified approach on multiple, interrelated fronts. Our experience shows that a dedicated diversity program that continually assesses their programs in a systematic engineering design process way using workflow processes, logic models, and metrics tied to program goals, can provide leadership and contribute significant results to its college.

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