Stakeholder-Informed Review of a First-Year Engineering Program

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Stakeholder-Informed Review of a First-Year Engineering Program

Introduction

The Department of Engineering Education (DEE) at Virginia Tech manages the General Engineering Program (GE), which serves first-year students enrolled in the College of Engineering (COE) at the same institution. Anecdotal evidence suggested that there was an inconsistent understanding across the college regarding the GE program's student outcomes. For example, during the 2023/24 academic year, faculty members from two disciplines inquired about the level of programming covered in GE courses after students reported having no recollection of any prior programming instruction.

In addition, university- and college-level initiatives have recently been put into place to increase student retention, decrease time to graduation by reducing curricular redundancies and barriers, and increase alignment and intentionality within degree curricula. As DEE began an effort to update the GE learning outcomes, it was clear that, in order to address the college and university goals, there was a pressing need to engage with our program's external stakeholders—particularly the degree-granting departments in the college—to ensure strong alignment between updated GE learning outcomes and the curricular plans of the other engineering departments.

In response to the identified communication gap, DEE hosted a four-hour forum near the end of the Spring 2024 semester with representatives from all degree-granting departments within the COE. The forum focused on the purpose and aims of the GE program and its alignment with the expectations and needs of the degree-granting engineering departments. The Department Head (DH) of DEE tasked the Undergraduate Committee (UGC) with designing, organizing, and facilitating the forum with attendees from all engineering departments and representatives from the COE. The primary goal of the forum was to foster open and ongoing dialogue between the GE program and external stakeholders from the college's degree-granting departments. The goal of this dialogue was to identify opportunities and barriers to better align the outcomes of the GE program with the expectations and needs of the engineering departments.

We detail in this paper key decisions made in designing the forum and the scholarship that was drawn upon throughout the forum design. We also describe the implementation and facilitation of the event, providing a comprehensive overview of the process used to facilitate dialogue and capture outcomes. In addition, we include in this paper the outcomes of the forum at various stages, from initial planning to post-event evaluation and reflection, offering insights into the forum's effectiveness and areas for future improvement. Ultimately, the findings from this work can serve as a framework for conducting stakeholder-informed reviews of First-Year Engineering (FYE) programs at other institutions, fostering collaboration and enhancing curricular alignment across engineering education.

Theoretical Underpinnings

The purpose and design of this forum were motivated by the need for change in the context of college engineering education. Specifically, the change we sought was improving alignment between our general engineering program outcomes and the 14 degree-granting engineering

programs students are eligible to enter after completing our general engineering course sequence and other change-of-major requirements. We find this change to not only be necessary, but crucial to student success considering the landscape of engineering higher education in the United States has been shifting rapidly, particularly within the past decade. How we educate undergraduate engineering students has been significantly impacted by factors like the COVID-19 pandemic, ongoing efforts to broaden participation in engineering, increasing the affordability and accessibility of a college education in engineering and computer science fields, and the appearance of broadly accessible generative AI technologies.

To design this forum, our team leaned on theories of change [1], and explored how theories of change have been described in literature in the context of STEM higher education [2]. Reinholz and Andrews define a theory of change in STEM higher education as "A particular approach for making underlying assumptions in a change project explicit, and using the desired outcomes of the project as a mechanism to guide project planning, implementation, and evaluation" [2, p. 2]. By this definition, the forum detailed in this paper as well as its outcomes are the first stages of our programs' theory of change. Reinholz and Andrews draw from the Aspen Institute Roundtable on Community Change to describe what they call the anatomy, or fundamental composition, of a theory of change [1], [3]. They state that a theory of change starts with a deep understanding of the context within which the change effort will occur in, then an implementation of "backwards mapping" that begins with identifying the desired end results and identifying short and long-term outcomes needed to achieve those results, and then clearly articulating intentional interventions which will help achieve those outcomes. Many of our forum design decisions align with the theory of change anatomy discussed by [2].

Reinholz and Andrews also emphasized the importance of integrating *change theory*—or evidence-based/research-backed frameworks for change—in the design of a theory of change to improve the likelihood of successful and sustainable change [2]. Due to the large size and complexity of our general engineering program and the many stakeholders it serves (14 degree-granting engineering programs), we were drawn to Van Tulder & Keen's "Capturing Collaborative Challenges: Designing Complexity‐Sensitive Theories of Change for Cross‐Sector Partnerships" [4]. While their work is published and framed through a business lens, their evidence-based recommendations for creating and maintaining partnerships across different sectors (areas of focus or interest) that can handle addressing complex systems-level change were helpful in planning how to best engage with our external stakeholders while designing and beginning to implement our program's theory of change. Van Tulder & Keen recommend when creating partnerships for complex problem solving strategies such as: identifying the scope and trends of the problem with partners, engaging in stakeholder analysis in which opportunities for collaborations or conflicts of interest are identified, identifying and challenging assumptions that may exist, continuous and transparent sharing of goals and challenges with partners, and the design of reflective approaches, and many more [4]. The intentionality with which we engaged with stakeholders before and throughout the forum mirrored these recommendations as we collaborated across engineering disciplinary boundaries. These are described in more detail in the Forum Design section of the paper.

Background Context

General Engineering Program

The Department of Engineering Education at Virginia Tech is home to all General Engineering (GE) students and our Foundations of Engineering courses. Foundations of Engineering is a two-course, four-credit sequence that spans the first two semesters. Both courses aim to help students develop transferable engineering skills—such as structured problem-solving, teamwork, communication, and the use of software tools. The first course introduces students to multiple engineering disciplines through class activities and short projects, while the second features a semester-long project designed to foster engineering design principles through practical application.

At Virginia Tech, all first-year undergraduate students admitted to the College of Engineering are admitted as General Engineering students. General Engineering is a non-degree program in which first-year GE students complete a specific set of requirements, known as change of major requirements, before being able to declare a degree-granting engineering major within the COE. These requirements for change of major include completing a common set of first-year courses (Foundations of Engineering, Calculus, and English), obtaining a minimum of a 2.0 overall GPA, and completing at least 12 GPA hours. Every year, DEE receives over 2,300 newly admitted General Engineering students and the time they spend within GE gives them an opportunity to explore their engineering disciplinary options prior to declaring a degree-granting engineering major. In their application for admission, engineering students inform the university the engineering major they are interested in pursuing. Historical institutional data shows that typically 40-50% of first-year Engineering students at Virginia Tech change their intended major during the period between their admission to the university and their transition from General Engineering to a degree-granting program [5].

The DEE is also home to an undergraduate advising unit. The GE Advising Team is composed of 10 undergraduate advisors who each have a student advising caseload of around 320 undergraduate General Engineering students. The GE advising team are crucial members of the department that foster and facilitate student success by providing support to students through many modalities such as individual advising appointments, email, appointment campaigns, advising newsletters and communication, workshops, and events. The advising practices of the GE advising unit are informed by the needs of students; research in the field; university, college, and departmental level policies and priorities; and the needs of all engineering degree-granting programs. GE advisors help prepare students for entry into their major and serve the interests of degree-granting departments through:

- Helping students develop key college success skills and awareness of campus resources/offices
- Communicating university, college, and departmental deadlines, events, and opportunities to our student population
- Assisting students in exploring various engineering majors and career opportunities, as well as comparing their major of interest to other similar engineering majors
- Developing academic plans of study which map out their course and degree requirements through graduation

- Assisting with a student's transition from high school to college and helping students build academic self-efficacy to assume more responsibility for their undergraduate education prior to entering a major

Application of Theory of Change: Forum Design

Forum Participants

The COE at Virginia Tech comprises 12 major-granting departments that collectively offer 14 degree programs and 33 engineering majors. Reinholz and Andrews recommend that any theory of change should begin with developing a working understanding of the context within which change is occurring [2]. It was immediately apparent that the context of our change goal of improving alignment between the GE program course outcomes with the degree-granting programs our students enter was a complex system that involved many different "sectors" as Van Tulder & Keen define them [4]. For the purpose of this paper, we consider these "sectors" to be the 12 major-granting departments. Following Van Tulder & Keen's recommendation of creating a stakeholder map, we noted that not only were there a large number of departments to collaborate across, but in each department an even more complex breakdown should be considered, as administrators, faculty members, and advisors within those departments are all stakeholders of the GE program outcomes. To ensure the total number of attendees remained manageable and allowed for meaningful conversations, each department was invited to select two representatives to the forum. It was initially suggested that these representatives include an undergraduate administrative faculty member as well as an instructional faculty member teaching undergraduate courses. However, upon further reflection, it was clear that academic advisors within these departments should also be invited. Departments were given flexibility in choosing their representatives, which resulted in a diverse group of forum attendees that included advisors, assistant department heads, and faculty across all ranks invested in undergraduate teaching. Additionally, a few representatives from the COE were invited, for a total of nearly 30 potential guests.

Several personnel from the hosting DEE department participated in the forum including instructional faculty, academic advisors, the Department Head, the Assistant Department Head for Undergraduate Programs (ADH), and the Academic Programs Coordinator. This group was intentionally composed to include multiple pairs of instructional faculty and academic advisors to enable concurrent discussions, and enough staff to provide logistical and procedural support. The Department Head and the incoming Assistant Department Head for Undergraduate Programs also attended in a more observational capacity, circulating around the venue to support the discussions and offer insights where needed.

Forum Objectives

In following Reinholz and Andrews's anatomy of a theory of change, we began "backwards mapping" by envisioning an ideal end result (a COE-wide shared knowledge of the GE program outcomes and alignment between the GE program outcomes and degree-granting program needs) and then translating the charge laid upon the UGC by the DH into short and long-term outcomes needed to achieve this result. After ensuring the DH's needs and expectations were accurately interpreted, the UGC members discussed the desire for the forum to establish a collaborative

partnership, as recommended by Van Tulder & Keen [4]. With this in mind, the UGC established three specific outcomes for the forum:

1. Communicate the goals and implementation of the General Engineering (GE) program. (short-term)
2. Brainstorm ideas to foster collaboration and alignment between the GE program and the curricula of other departments. (short-term)
3. Establish a foundation for ongoing dialogue and collaboration. (long-term)

Prior to the forum, a pre-forum survey was distributed to the leadership of each department to send to their invited forum attendees. The survey's purpose was to collect information on participants' interest levels, ideas or assumptions about our program, and questions or concerns about aspects of the GE program's course outcomes. Van Tulder & Keen encourage involving multiple stakeholders from across sectors to intentionally identify assumptions and/or conflicts of interest as an important part of complex systems-level change [4]. Since these were likely to surface through dialog within the forum anyway, knowing them early and up-front can improve communication and outcomes. The results of this pre-forum survey will be discussed in the Forum Implementation and Outcomes section of this paper.

Forum Agenda & Structure

With the forum being intentionally designed to communicate a tone of partnership and collaboration across COE departments and disciplines, it was made a priority to host an in-person event that accommodated the schedules of attendees. With these constraints and objectives in mind, and considering the expected number of attendees, the UGC designed a four-hour forum featuring three key portions: contrasting attendees' perceptions with facts about the GE program (60 minutes), facilitating multiple multidisciplinary roundtable discussions (120 minutes), and concluding with major takeaways and actionable ideas for ongoing collaboration (30 minutes). A 30-minute lunch preceded the forum to give attendees and facilitators an opportunity to meet and interact informally, fostering a sense of comfort and ease for the subsequent discussions. Additionally, a catered cocktail hour followed the forum, to provide opportunities for additional debriefing, discussion, and relationship building.

While the forum aimed to prompt participants to freely express their thoughts about the GE program courses and outcomes, the UGC designed a structure within which discussions remained focused and relevant, and intentionally anchored conversations around the GE learning outcomes. Based on the number of learning outcomes and the time allocated for this portion, the UGC organized discussions around six guiding topics, each one to be discussed within 15 minute rotating table discussions:

1. Engineering design skills (e.g., problem scoping and solving, data analysis, decision making)
2. Engineering tools (e.g., programming, CAD, prototyping)
3. Holistic issues (e.g., stakeholders, ethics in engineering)
4. Teamwork (e.g., equitable teaming, conflict resolution)
5. Communication (e.g., reports, presentations, citations)
6. Academic success (e.g., major choice, transitions to college and majors, self-regulation)

To maximize coverage of content within the limited timeframe, the committee planned on concurrent roundtables for the discussion of each guiding topic, ensuring participants had time to focus on and discuss each GE outcome in depth. With over 30 attendees expected and 12 departments represented, the committee decided to organize participants into six roundtables, each seating five or six attendees. Figure 1 shows an example of how attendees at each roundtable were intentionally selected to maximize the diversity of "sectors" (engineering departments) and stakeholders (roles within a department) represented.

This purposeful arrangement was motivated by Van Tulder & Keen's discussion of initiating partnerships, as they note the importance of an open discussion and sharing between partners through voicing uncertainty or disagreement when analyzing complex problems.
They note that in particularly complex contexts, considering more stakeholders will "help identify opportunities for collaboration (win–win) or identify conflicting interests or prisoner's dilemmas that need to be overcome to unlock positive change" [4, p. 326]. The diverse table assignments not only sought to encourage multifaceted discussions, but also aimed to make participants aware of the often competing expectations of various major-granting departments regarding the GE program. This approach was expected to result in more realistic and feasible suggestions, aligned with the challenge of addressing the needs of diverse stakeholders.

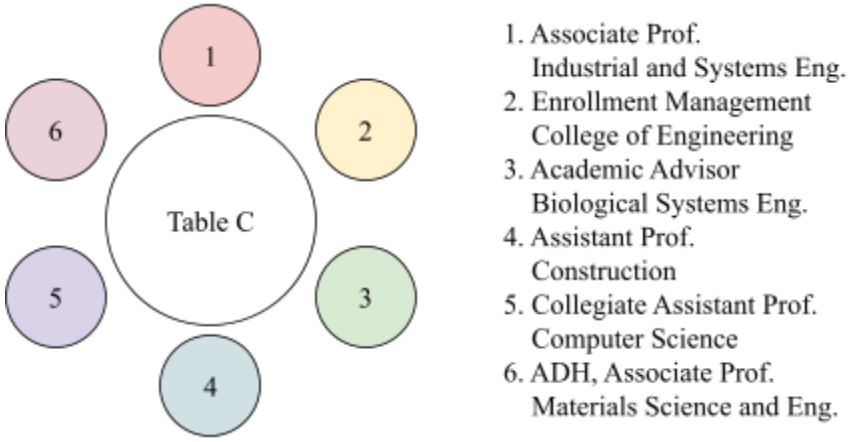

Figure 1. Example of the composition of one roundtable.

Forum Implementation

The forum was implemented in three distinct phases. The first phase involved two different iterations of collecting attendees' perceptions, assumptions, and concerns related to the GE program - one iteration through the pre-forum survey, and second live at the start of the forum. We addressed the participants' incoming perceptions and assumptions by preparing and delivering a presentation on the purpose and scope of the GE program to ensure a common understanding of what Van Tulder & Keen call the "intended change" [4]. The second phase were the roundtable discussions, and the third phase was a debrief and brainstorming of actionable next steps for partnership and collaboration at the forum's conclusion. This section is organized by each of those phases.While this section does report on the outcomes of the forum and the contributions of the participants, Virginia Tech's Human Research Protection Program determined this study is not research involving human subjects as defined by HHS and FDA regulations, therefore not requiring further review and approval by the institution's IRB.

Phase 1: Gathering of Attendee Perceptions and Program Presentation

This phase focused on gathering attendees' expectations and existing views of the GE program and a subsequent presentation outlining the GE program's purpose and scope. Attendees' existing views were first collected via a pre-forum survey sent to the participants identified by the departments. The pre-forum survey, sent out by the host DH, requested invitees' reactions to the six guiding topics listed in the previous section.

Based on responses received from 18 invitees, the UGC observed a positive reaction to the forum and most of the proposed discussion topics. However, several invitees expressed the need to emphasize "Major Choice" as a crucial aspect of the GE program. Many invitees identified "Academic Success" as an aspect previously unrecognized, yet acknowledged its importance. On the other hand "Teamwork" and "Communication" did not receive many comments. In addition, some invitees identified "Holistic Issues" as a potentially ambiguous concept that required further elaboration. Based on this initial feedback from the pre-forum survey, the UGC decided to update the topics for the roundtable discussions by splitting Major Choice from Academic Success, giving Major Choice its own category, and merging Teamwork and Communication under one category, as follows:

1. Engineering Design Skills (DEE 1)
2. Engineering Tools (DEE 2)
3. Holistic Issues (DEE 3)
4. Teamwork and Communication (DEE 4)
5. Major Choice (DEE 5)
6. Academic Success (DEE 6)

On the day of the forum, right after the lunch, the DEE ADH began by asking attendees to share their views on the role of GE via an anonymous online poll, aiming to gauge their assumptions about or preconceptions of the program. Figure 2 presents a simplified word cloud of the responses, manually curated to group similar concepts expressed in different ways. Notable comments from individual participants are quoted verbatim and presented in quotation marks.

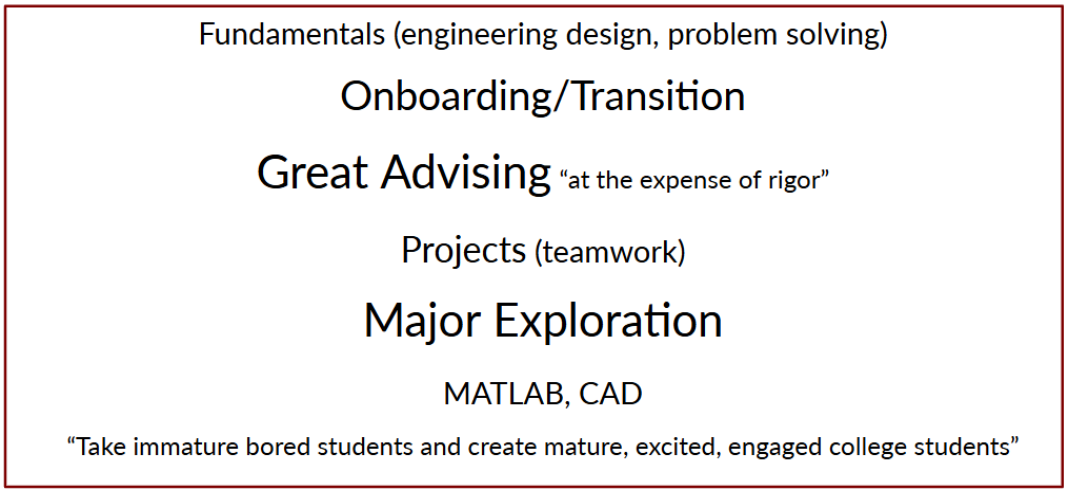

Figure 2. Word cloud of preexisting notions of the GE program.

The ADH reasserted the outcomes of the GE program and demonstrated their alignment with course learning outcomes. The ADH then provided examples to demystify some of the inaccurate preconceptions revealed in the poll data.

Phase 2: Roundtable Discussions

During this part of the forum, six pairs of DEE representatives, each pair consisting of an academic advisor and an instructor, respectively, led the discussion on one of the topics listed above at a table. After a 15-minute discussion, the DEE pairs stood up and moved to the next table to bring their respective topic there, repeating the process. Six rounds of this rotation ensured that all tables had the opportunity to discuss all six topics. Figure 3 illustrates the starting configuration of the roundtable discussions and the topics (outcomes) led by each DEE pair.

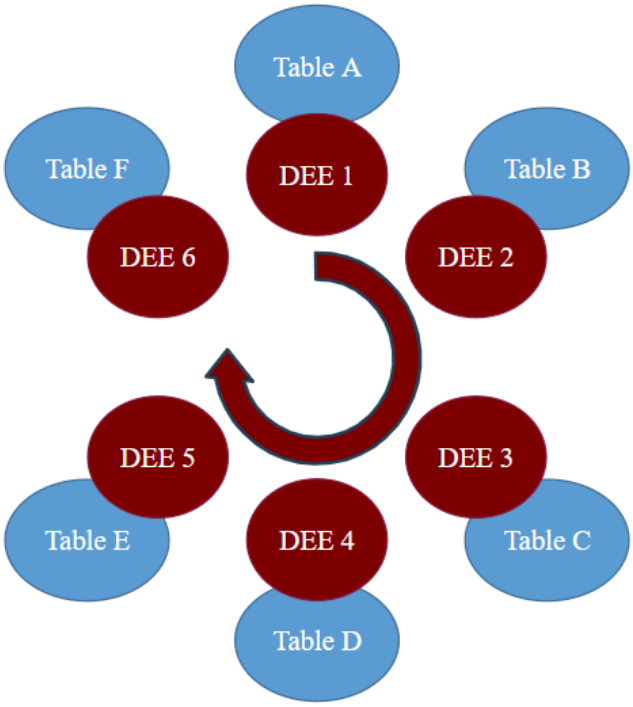

Figure 3. Starting configuration of the rotating roundtable discussions.

The DEE pairs briefly introduced each topic including the relevant program, student, and course learning outcomes. Then, they used a template document to facilitate the roundtable discussions and organize data collection during each rotation for subsequent analysis (see Appendix A). The prompts guiding both discussion and note-taking were the following: 1) What are your impressions of or immediate responses to this topic? 2) What gaps do you see in relation to this outcome? 3) How is this outcome important to your department or major? 4) How/where is this outcome incorporated into your major? 5) How can we as programs align with each other?

Summary sheets for these topics can be made available upon request. After the forum, the filled-out templates were discussed during a meeting of the UGC, with participation of the six faculty members who lead the topics. Table 1 presents examples of salient issues identified by each DEE pair after the roundtable discussions. The complete summarized results of this preliminary analysis and discussion are included in Appendix B.

Table 1. Examples of salient issues from each roundtable discussion.

Engineering Design	The design process taught in GE aligns well with other department's approach, but the topics don't (i.e., discipline-specific topics are not well balanced).
Engineering Tools	Departments value coding instruction regardless of the language, but there are mixed preferences (e.g., MATLAB, Python, MS Excel).
Holistic Issues	Most departments discuss ethics at different points within their programs, including sophomore seminar, class projects throughout, and capstone projects.
Teamwork & Communication	Many students continue to struggle with team conflict and visual communication long after their first year.
Major Exploration	Departments consider that increased exposure to disciplines could be achieved through class projects in GE tailored to specific majors.
Academic Success	Participants commended the opportunity to expose more students to academic success concepts and practices in class than through advising.

Phase 3: Wrap-Up and Closing

The forum concluded with a wrap-up session, offering attendees the opportunity to share their feedback on the event and discuss expectations to move forward. This feedback was captured by UGC members and integrated into the rest of the information collected from the forum and presented in the next section. A UGC member was tasked with compiling this information into a report for the DH. Then, the DH worked with this UGC member to finalize the analysis and craft a final version of the report to be shared to all departments in the COE. Figure 4 presents a complete timeline of the forum, including preparation and post-forum milestones.

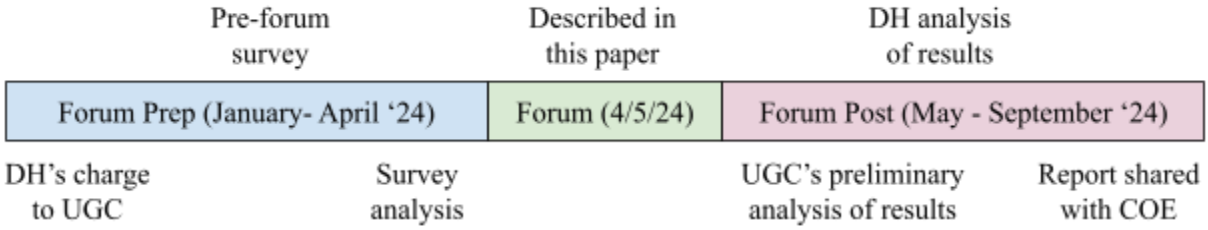

Figure 4. Timeline of the forum.

Forum Outcomes & Forum Design Takeaways

This section presents outcomes from the forum 1) as they relate to what the participants of the forum brought forward as stakeholders and partners in our theory of change to increase the alignment between the GE program and the COE departments and 2) as they relate the the lessons the DEE Department and UGC forum designers learned for future forums as a means of partnership and collaboration with COE departments.

Major Exploration vs. Enrollment

Several major-granting departments expressed concerns about enrollment trends and offered recommendations that their majors be better promoted within first-year classroom content (e.g., videos) and activities (e.g., design projects). The open dialogue and discussion of the forum allowed this concern of some COE departments to be brought forward and served as an example of what Van Tulder & Keen refer to as a "critical condition" or a risk for a successful partnership and theory of change [4]. These risks to a successful theory of change can be potential changes in the context or environment and/or dynamics within the partnership. Because the partnerships this forum sought to develop were not just between the DEE department and each of the 12 COE departments individually, but rather a common partnership across all COE departments, the topic of GE engineering students' major selection has implications for each departments' enrollment and therefore creates what can be considered a dilemma or conflict of interest between partners.

Given the administrative and financial implications of enrollment in each department, GE students' major exploration and selection was an important concern and discussion topic of interest for forum attendees as indicated on the pre-forum survey and conversations at the "Major Exploration" round table. These concerns expressed by forum attendees align with Van Tulder & Keen's observations that dialog about intended change often leads to the assumptions about partnerships and outcomes surfacing. In this case, there appear to have been assumptions made about the influence that the GE program has on students' major exploration and selection that were able to be brought forward and productively discussed in the forum. While classroom exposure to multiple engineering majors undoubtedly plays a role in the decision-making process for many students. It must be considered among other influential factors, many of which are beyond instructor control [5]. These factors include conversations with academic advisors, faculty, alumni, and other students; discussions with family and friends; experiences in other coursework, clubs, or major-sponsored events students take and attend; preconceptions about job fields students absorbed prior to to college; and job market conditions like salary and demand to name a few.

To help communicate these complexities and dispel initial assumptions, the major exploration roundtable discussion at this forum was prefaced with a quick discussion of the major and career exploration process as it is generally understood in the practice of academic and career advisors. This process includes three different phases: explore, test, launch. In the explore phase, students gather information about a major through a variety of ways that include classroom content, online content, events and seminars, clubs and organizations, peer discussions, academic advising, and more. Students can also test majors they are exploring through options like joining disciplinary specific organizations, networking with alumni and professors, attending departmental events, job shadowing, and project-based design work. The final launch phase occurs when a student makes their major selection, and this can still be affected by various factors already discussed. Prefacing this forum's roundtable with a discussion of the major exploration process not only helped attendees learn about the diverse ways through which students gather information to make a major selection, it also changed the nature of the discussion which allowed for a more collaborative conversation around the problems of major exploration.

From our perspective in the GE program, the suggestions provided by stakeholders within the major exploration roundtable are worth exploring to diversify the scope of GE activities and increase the exposure to more majors among our student population. However, the impact of exposure to different majors in first-year courses on major selection requires further investigation. As observed by DEE advisors and instructors, and supported by data from the COE's Enrollment Management office, GE students largely fall into two roughly equally sized groups: students who remain dedicated to their original Engineering major of interest they indicated upon admission and students who select a different major than what they originally indicated by the conclusion of the first-year program. While the latter group may benefit from more major exploration, it must be carefully balanced with the need to ensure that the first-year engineering experience remains useful and engaging for students who are already confident in the major they have selected.

Increased Representation of Disciplines

From the selection of topics for class design projects, to the use of specific tools, some departments feel that their majors are underrepresented in GE courses. While this concern relates to the previous one, this takeaway emphasizes awareness instead of enrollment. Some departments believe that the focus on projects involving physical artifact construction and activities like coding, 3D design using CAD, and physical prototyping, disproportionately represent a small segment of the engineering majors at VT. To address this perceived gap, participants have suggested strategies such as incorporating shorter projects that highlight a broader range of majors, incorporating design-critique activities that emphasize transferable design principles, and using tools like CAD to create representations beyond physical devices, such as circuits or flow diagrams, which are pertinent to other disciplines. These suggestions seem feasible and require careful consideration of the logistics and implications behind their implementation. For instance, the requirement to build physical prototypes is tied to the program's expectation of use of the Frith Makerspace by first-year engineering students. Moreover, changing pedagogical choices, such as semester-long projects in the second course of the GE sequence and the formation of teams for the whole semester, must be discussed considering the evidence-based practices that inform those choices. For instance, the time necessary for student teams to achieve a performing stage or the time and scope necessary for projects to successfully foster project-based learning [6], [7].

Programming with a Purpose

Data analysis and visualization is widely recognized as a necessary skill across all majors. Programming is seen as a procedural skill related to data analysis, controls, and visual communication but preferences for different tools vary. Overall there is a drive for a more fundamental introduction to coding that is somewhat agnostic to programming language, especially in light of increased accessibility of certain software platforms (Python vs. MATLAB or Fusion 360 vs Solidworks)., In addition to developing familiarity with algorithmic coding, some departments suggest including development of simplified data processing skills in spreadsheet tools, such as MS Excel, due to the relative ease of use and ubiquity of spreadsheet-based coding in professional settings. Furthermore, several departments discussed students' lack of ability to communicate information visually (tables, graphs), which they tied back to proficiency with MS Excel.

Continued Collaboration

Department representatives in attendance expressed enthusiasm for making this communicative forum a recurring event. While they appreciated the general approach of the inaugural session, they suggested that future discussions concentrate on specific issues, such as major exploration and project variety.

The need for a diversity of roles involved in this collaboration also became apparent. For instance, Mechanical Engineering (ME) students have a Numerical Methods course at the start of their sophomore year that provides continuity to the programming introduced in GE. While instructors believe this to be the norm, it turns out that a significant number of students do not take the course as planned, breaking the desirable continuity. Both GE and ME academic advisors, on the other hand, were aware of this situation.

Concrete actions suggested for collaboration in the short term include the following:

- Sharing with all COE departments the summary of the feedback collected during this first communicative forum.
- Training GE instructors in the particularities of the different majors, including ideas and suggestions for potential projects and activities (e.g., case studies for ethics discussions) that showcase a broader range of majors
- Disseminating the theoretical underpinnings and strategies of the "Reflect and Correct" and correct approach among disciplinary departments to foster continued support to student academic success throughout the college experience.
- Increasing communication and collaboration between first-year academic advisors and department advisors to provide accurate information on all majors and disseminate self-regulation and academic success practices implemented in GE.

UGC Reflective Takeaways from Forum Design & Implementation

As the members of the UGC and authors of this paper reflect on the purpose of the forum and the objectives set, we feel that we have taken a step in the right direction and that the forum laid a strong foundation with which we can continue to build and develop our theory of change upon. We believe that we successfully met the short-term outcomes "Communicate the goals and implementation of the General Engineering (GE) program" and "Brainstorm ideas to foster collaboration and alignment between the GE program and the curricula of other departments" at the forum, and our department ADH has taken steps to maintain open dialog and collaboration in areas identified a having partnership collaborations by forum attendees, making progress on the third long-term outcome "Establish a foundation for ongoing dialogue and collaboration".

While many members of the forum design team were apprehensive given the critical conditions that had been brought forward in the pre-forum survey (e.g., Major Exploration discussed earlier in this section), the collaborative and partnership-focused tone of the event set the stage for discourse of a similar fashion. While many attendees expressed conflicting needs or viewpoints during the roundtable discussions, the tone always remained productive, informative, and empathetic. Upon reflection it was clear that nearly all participants, including those from DEE, left the forum having learned something new and with an increased understanding and appreciation of the complexity of the partnerships needed for a theory of change focused on increased alignment and collaboration across the 12 degree-granting COE departments.

While we were overwhelmingly pleased with the outcomes of the forum, we also were critically reflective of what could be improved or done differently in future iterations. After reflection, in future interactions we intend to incorporate GE advisors into the process more fully and at an earlier point. Advisors should lead several of the discussion topics at the round tables, particularly those of student success and major exploration. Furthermore, more departmental academic advisors should also be invited to attend as they can provide different important perspectives to the discussion. Some of the value we perceived was that we approached this at a programmatic level, whereas some stakeholders viewed this as a course classroom level discussion.

Conclusion

Often, first-year engineering programs and courses sit at a complex point in an academic or curricular structure, as there are many stakeholders to consider when preparing students to successfully navigate an undergraduate engineering program. In some cases, GE or First-Year programs are housed within a department or college and curricular alignment may be supported through the academic unit structure, but this isn't the case for all who work in the first-year engineering space. For first-year programs to effectively contribute to institutional strategic visions it is critical that programmatic elements align with the overall mission of the institute. The nature of academic units is such that energies are often inwardly directed. Crossing departmental or collegiate barriers can be a difficult undertaking, as higher education incentive structures often result in highly siloed units. Given this challenge we leaned on evidence based guidance related to higher education STEM theories of change and theories of change with partners in different disciplines within complex contexts [2], [4].

Given the fact that first-year engineering programs are designed to prepare students for success in a chosen engineering major, it is critical that such programs are viewed as supported and supportive members of a larger group of partners with a unified objective of developing and maintaining an educational environment designed to develop quality engineers. When change is necessary in the relation of a group of stakeholders, an important first step is to develop alignment in expectations and roles within and across the group. Overcoming the challenges associated with misconceptions, preconceptions, and 'othering' requires thoughtful planning to ensure that voices are heard and that a degree of psychological safety exists within the group such that effective and lasting change can be achieved.

We initiated a purposeful conversation designed to expose and dispel misconceptions or preconceptions across the stakeholder group, to provide a venue for our colleagues to express their opinions and requirements, and a safe forum where conflicting or complementary stakeholder needs and perspectives could be compared and contrasted with a targeted purpose of institutional improvement and programmatic alignment. We provided a structure and direction for the initial conversation in a way that highlighted our departmental objectives while providing space for tangential exploration of the needs and drives of our colleagues.

The outcomes of the forum reinforced the need for improvement in certain aspects of our program that we have been refining for some time. Not only did we develop a more complete understanding of how our program serves students through the feedback gathered from the degree-granting programs, but we also revised our own conceptions of the program in preparing

for the discussion. A salient example of this is demonstrated in the discussion around major exploration. Within the instructional faculty in our program we have often felt a challenge to fully expose students to the full breadth of the majors available across the relatively short 15-week semester. In developing the materials for the forum, we reaffirmed the fact that major exploration exists across the first year program - including both advising and classroom instruction, but that this exploration is significantly bolstered through extracurricular and intramural activities that exist outside of the GE program. Furthermore, our colleagues in the 12 degree-granting departments offered their expertise in their fields to work with our faculty to refine our projects and assignments to broaden exposure to the disciplines.

This forum served as the first step in our theory of change aimed at creating a COE-wide shared knowledge of the GE program outcomes and growing seamless alignment between the GE program outcomes and degree-granting program needs. We communicated the goals and implementation of the General Engineering (GE) program, developed actionable collaboration and alignment, and established a foundation for ongoing dialogue, meeting our short-term outcomes. Our impression has been that we have effectively provided a reintroduction of our department and its mission to our colleagues in the college, and we look forward to developing more short and long-term outcomes through our newly established theory of change partnerships to work toward creating positive change.

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Appendix A: Notes Sheets Example

1. Engineering Design	
Related Learning Outcomes	Foundations of Engineering I & II Student Learning Outcomes *Use a structured design approach to analyze problems and to propose engineering solutions.* *Identify the potential impacts of alternative solutions to engineering problems with respect to diversity, equity, inclusion, and access initiatives in social, cultural, economic, and environmental contexts.*
Question	**Discussion:**
Impressions and first responses	● Semester-long projects around a specific topic give the impression that we are directing students toward specific majors. o The requirement of building prototypes and the expected use of Frith Makerspace may limit the disciplines highlighted through projects. o Shorter projects—or case studies—around multiple topics may help connect to other majors. o How to connect major exploration to project description and/or selection? ● Engineering design could be presented through a systems engineering perspective. o Design is systematic decision making; students see it as steps to build something but fail to understand the systematic approach. ● To engage all students, require them to do individual work in preparation for the project before they work in teams. ● Are first-year students prepared to do engineering design? ● Between 25% and 33% of GE students are interested in Computer Science (CS); how to deal with the different approaches to design between CS and engineering programs?
Gaps that participants see in relation to the outcome	● A holistic approach to engineering design is taken at the expense of losing details relevant to different engineering disciplines. ● Students focus on specifics and often struggle dealing with the open-ended and ambiguous nature of real engineering projects (e.g., capstone project). ● Certain projects may be unappealing/uninteresting for many students. ● Students beyond first year still struggle to adequately scope problems. ● There is a missed opportunity to pair students with more design experience with less experienced ones, as happens with new hires in industry.
How is this important to your department or major?	● Some majors have sophomore-level classes that address the same holistic issues but are more focused on their program (e.g., CS). ● Some departments have an approach to design based on experiments and testing (e.g., Material Science & Engineering, CS).
How/where is this incorporated	● Departments have mini capstone (sophomore-level, Electrical and Computer Engineering) and capstone projects.

into your major?	● Ill-defined, real-life problems require students to identify (scope) the problem and determine how to approach it.
Brainstorm and ideation on opportunities for future alignment between our curricula – How can we as programs align with each other?	● Communicate with major-granting departments to give students a unified approach to design that transcends the first year. ● Help students see the overlap between design decision-making and academic decision-making (academic planning, major selection). o Frame the "how do I graduate in 4 years" as a problem that students can scope, brainstorm, etc. ● Teach design around everyday objects (e.g., bottle, chair, coffee cup) to connect with a broader range of students' interests. ● Teach engineering design backwards (e.g., criticizing existing designs, product failure) and highlight design principles generalizable across disciplines. ● Give students the opportunity to see how experts go about solving problems. ● Interest in GE approach that focuses on the design process and not just on finding a solution (Industrial and Systems Engineering).

Appendix B: Preliminary Analysis of salient themes for each discussion topic

Engineering Design

- Major-granting departments consider this to be a relevant learning outcome.
- The design process taught in GE aligns well with other department's approach, but the topics don't (i.e., discipline-specific topics are not well balanced).
- The major gap perceived is catering to broader student interests and majors; multiple short projects were suggested as a potential strategy to close this gap.

Engineering Tools

- Departments value coding instruction regardless of the language, but there are mixed preferences (e.g., MATLAB, Python, MS Excel).
- Departments have no expectation about the software used in GE to introduce CAD (currently SOLIDWORKS) but see Fusion 360 as a good, accessible alternative.
- Hands-on practical experience is generally valued, although prototype building is not crucial to some majors (e.g., CS, Industrial and Systems Engineering).

Holistic Issues

- Departments requested clarification on what is meant by 'holistic issues'; referring to engineering ethics and ABET Student Outcome 2 helped make sense of this term.
- Instructors should leverage the connection between ethics and academic integrity.
- Most departments discuss ethics at different points within their programs, including sophomore seminar, class projects throughout, and capstone projects.

Teamwork & Communication

- Many students continue to struggle with team conflict and visual communication.
- Some majors don't have teamwork until capstone project.
- Departments wonder how to align teamwork (projects) with students' career interests, and how to assess teamwork consistently.

Major Exploration

- Departments perceive Explore Engineering Week as an ineffective way to spark student interest in different disciplines; professionally made videos are suggested.
- Departments consider that increased exposure to disciplines could be achieved through class projects in GE tailored to specific majors.
- Exposure to majors can be more impactful through advising, especially in collaboration with disciplinary advisors and ambassadors.

Academic Success

- Participants commended the opportunity to expose more students to academic success concepts and practices in class than through advising.
- The role of advisors, both DEE and disciplinary, is mostly to coach students, while classes provide opportunities for practice.
- Departments expressed interest in seeing the conceptual underpinning and practical examples of the "Reflect and Correct" approach implemented in GE.