Community Co-Created Research Agenda

For Ambassador-led Outreach Programs

Report prepared by Sandra L. Rodegher

Preface

This report is the culmination of a two year project conducted by the College of Engineering's Office of Outreach and Diversity at Boston University with input from 61 stakeholders including university administrators, non-profit organizations, kindergarten through twelfth grade (K-12) schools, and undergraduate engineering ambassadors. The purpose of this project was to develop a community co-created research agenda for ambassador-led outreach programs.

By engaging program administrators, K-12 partners, undergraduate ambassadors, and nonprofit organizations from across the nation, we sought to have a research agenda that captures the variety of experience across stakeholder group and geography. Ultimately, we expect this co-creation process to yield a pluralistic research agenda with widespread buy-in nationwide. This final component of pluralism and buy-in that is critical to moving the ambassador-led outreach community forward in an intentional, inclusive, and productive way.

Acknowledgements

As a community co-created research agenda, this could not have seen success without deep engagement from the engineering outreach community. Over the course of two years, 61 stakeholders participate in this project, giving their time and input via interviews, working group sessions, and remote feedback sessions - ultimately shaping the process and outcome.

A subset of 16 participants from 14 different institutions served as members of the steering committee and our research team, contributing their time, insights, and experiences. In particular, we'd like to call out the contributions of Stephany Santos and Darrell Tubbs. The grant personnel would like to extend a special thanks to the contributors (listed on page six) for their deep commitment to this project and to the communities that ambassador-led outreach programs serve.

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Process Overview
Multi-stage co-creation process

Introduction

Engineering has acknowledged and sought to address its inherent lack of diversity for over 40 years, with various programs including outreach and community support such as ambassador-led programs (Clark & Abron-Robinson, 1975; Levine, 1984, 1985). Engineering ambassador-led outreach programs, referred to as ambassador programs in this document, use undergraduate students to engage K-12 learners in engineering activities. Indeed, the potential value of undergraduate ambassadors and their importance as "near peer" mentors is supported by a large body of research that addresses the importance of mentorship in supporting the success and advancement of learners (Destin, Castillo, & Meissner, 2018). underserved, under-resourced and/or underrepresented populations[1] (Lee, 2019; Tenenbaum, Anderson, Ramadorai, & Yourick, 2017) including people who are Black and Indigenous People of Color, individuals with disabilities, women, low income, and first generation college students . However, the impact of engineering ambassador programs in particular has not been fully studied or articulated. Furthermore, despite the existence of outreach programs for four decades, the field of engineering has not seen a significant increase in diversity and is now struggling with a secondary problem as a result of this - a projected shortage of engineers in the millions (Giffi et al., 2018). Given this information, further nationwide study is warranted.

However, engineering ambassador-led programs are diverse and for an assessment to be useful and accurate, it should capture and account for that diversity. As such, it was critical to first understand the nature of the programs in existence, the problems they wrestle with, and the goals they strive to achieve. As a result, this project was born. The overarching goals of the project included five phases in order to create a shared research agenda. This project brought together leadership and other key stakeholders in the engineering ambassador community to create a plan for more in-depth evaluation of K-12 outreach programs that

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[1] All three of these terms are used throughout the paper based on stakeholder program language. "Underserved" refers to those who do not have access to services or programs to the same degree as others. "Under-resourced" is a more encompassing term which include a wider variety of lack of access to resources beyond services. In contrast, "underrepresented" refers to any group that holds a smaller percentage in a subpopulation than they do in the population as a whole.

focus on broadening the participation of traditionally underrepresented groups, while promoting engineering identity development.

Term	Meaning
Ambassador programs	Engineering and STEM outreach programs that use undergraduate students to delivery engagement activities and other learning experiences. Does not include campus ambassador programs that solely conduct university tours.
Stakeholders	Individuals and groups who are a part of the ambassador program ecosystem. This includes, but is not limited to: parents, K-12 schools, universities, nonprofit organizations, parents and families, education reserachers, and community organizations.
Ambassadors	University students who mentor and teach ambassador program activities and events.
K-12 learners	K-12 aged youths who are the recipients of ambassador programs. K-12 learners are often referred to within stakeholder quotes as "students."

Put simply, in this project, we sought to more fully unite the engineering ambassador-led outreach community in service of assessing and improving our collective performance. Over the course of two years, the grants personnel in this project facilitated a deep co-creation process with 61 stakeholders from 22 states across the nation, and Washington, D.C. Stakeholder groups represented include: university administrators, undergraduate ambassadors, researchers, K-12 administrators and teachers, non-profit organizations, and Science, Technology, Engineering and Math (STEM) identity researchers. See figure one for a map of states represented in this project.[2]

Understanding community co-creation processes

Participatory community co-creation processes are often lauded as the key to unlocking the door to social change (Davis & Andrew, 2017; Torfing, Sørensen, & Røiseland, 2019). By incorporating diverse perspectives during formative stages, the hope is that through engaging diverse stakeholders, diverse perspectives will be rolled into long-term planning. Ideally, the contributions of the stakeholders would result in a plan that is more robust and effective, serves more stakeholder needs, and ultimately be more equitable and just. Perhaps most important, through the co-creation process, shared ownership is built in such a way that allows for concerted action across participant groups (Collins & Ison, 2006). However, not all community co-creation processes are created equal and facilitators in these processes must be mindful of how they engage participants and how participants interact with each other.

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[2] Note: a number of researchers, ambassador programs, and non-profit organizations, did also have regional and national components to their offerings, so secondary reach and impact is even broader.
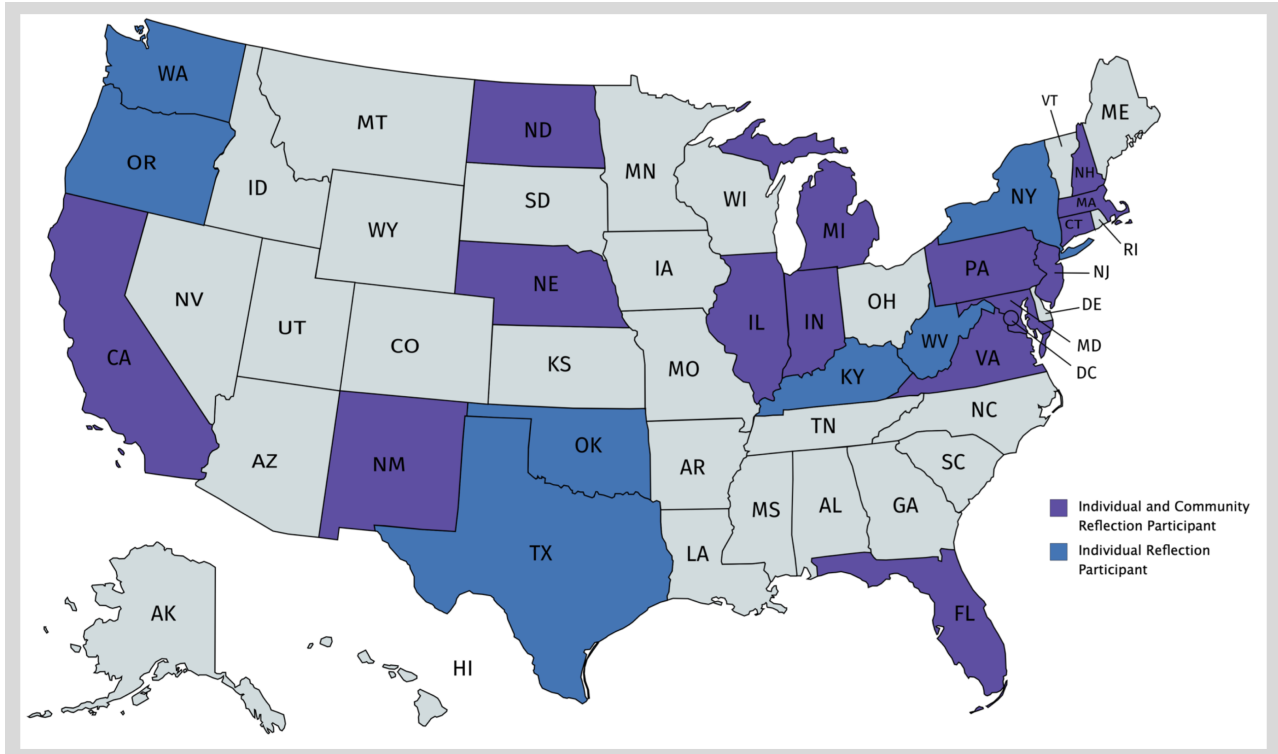
Figure 1. Map of community co-creation participants

In participatory co-creation processes some decisions must be made and implemented in order to focus the group and facilitate productive dialogue. The same structures, put in place to help facilitate dialogue, may also limit the scope and relevance of content across stakeholder groups (Paulus, Nakui, & Putman, 2006) and, in turn, who can participate in this dialogue. Additionally, power dynamics can develop quickly, even in newly formed groups. These power dynamics can then play out within group discussion and decision making, further skewing the outcomes of co-creation processes (Choi & Robertson, 2014). To combat these two specific challenges, this project takes a funnel approach to slowly hone the focus of the research agenda that oscillates between individual and group-level engagement. Through this, the goal was to refrain from prematurely limiting the scope of focus in the project and, instead, use community input to slowly define the focus and nature of each step while supporting community dialogue. Additionally, by shifting between individual and group-level participation, the benefits of group deliberation have been realized while the deleterious effects of group interactions, have been reduced. In short, shifting between individual and group-level participation facilitates the incorporation of diverse perspectives and limits potential tunnel vision and participation imbalances that result from power dynamics.

Our multi-stage process

Over the course of two years, a five part process was used in service of creating a robust, community-supported research agenda. An overview of the process is outlined in figure one and described in the remainder of this chapter. More detailed information about the process and findings are articulated over the remainder of this report.
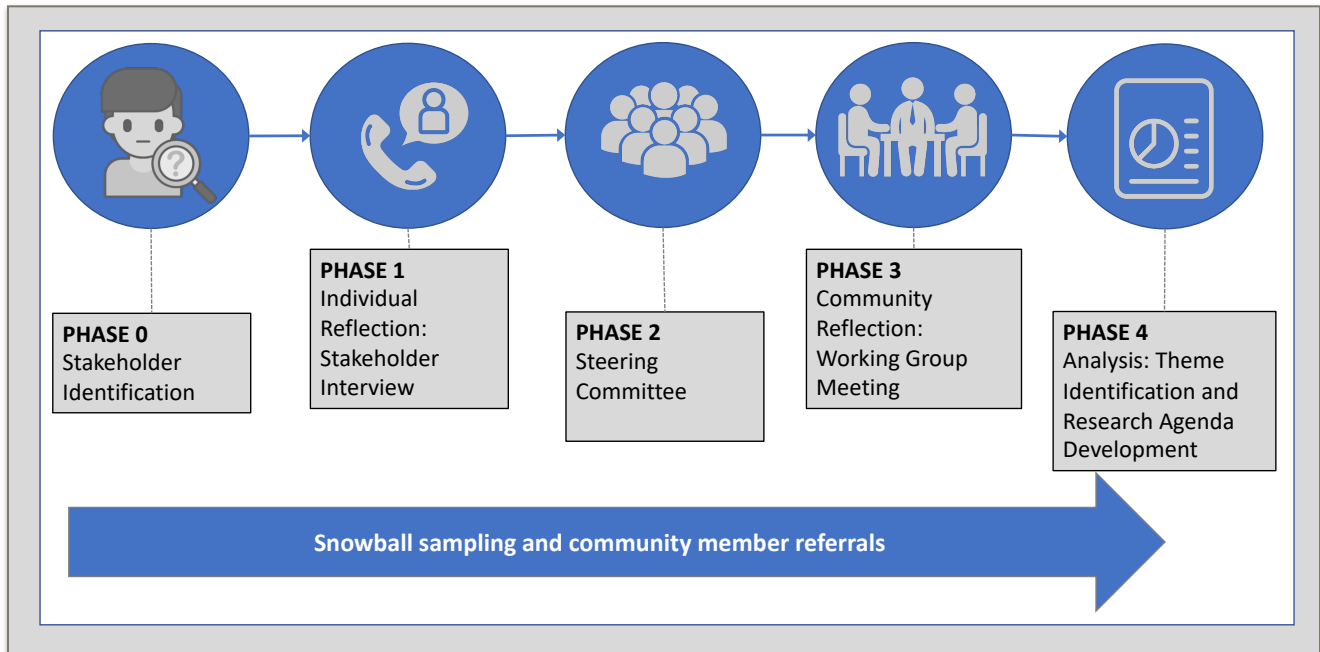
Figure 2. Multi-stage Co-creation Process

Phase 0: Stakeholder Identification

Though stakeholder identification is a normal part of any participative process, it is called out as a preliminary step due to its importance to the outcome of any co-creation process. Co-creation efficacy and relevance can be limited through the use of simple convenience sampling, because it results in researchers engaging primarily with their personal network and areas of interest. As a result, this project began by intentionally casting a wide net across three categories: university engineering and STEM ambassador programs, academic researchers, and nonprofit organizations. This was conducted via internet-based, key word search.

> **Outcome**: identification of diverse stakeholders invited to participate in phase one of this project.

Phase 1: Individual Reflection

Individual level reflection by stakeholders was elicited by 30-60 minute semi-structured phone interviews. Interview questions were designed to be broad in scope so that (a) questions would be relevant across stakeholder groups and (b) to allow diverse topics to emerge organically, which would be less likely to happen with more targeted research questions. Additionally, by starting with individual level engagement, participants are able to formulate their ideas and opinions free from the social influence that would occur in a group setting (Paulus, Dickson, Korde, Cohen-Meitar, & Carmeli, 2016).

During the interview process, participants were invited to describe their background and its relationship to ambassador-led outreach programs. They were also asked to reflect on critical factors and gaps in knowledge that impact engineering engagement in underserved communities, the role of outreach into the K-12 system, and, more specifically, the role that ambassadors might play. Participants were invited to nominate other relevant community stakeholders to interview and were also informed of the remainder of the project.

> **Outcome**: topical themes that captured the shared and differing viewpoints expressed by participants.

Phase 2: Steering Committee

The steering committee was formed to create a framework for phase three, the community reflection. The committee was comprised of a subset of volunteers from the phase one participant pool. Those who joined were provided with thematic findings from the individual reflection and used this information as a foundation to develop an agenda for the community reflection (also referred to as a working group meeting). Steering committee members met over the course of six months to flesh out the best way to create a fertile ground for information exchange and community capacity building.

> **Outcome**: development of content for community reflection including agenda, session content, and process facilitation.

Phase 3: Community Reflection

Phase one participants and other community members identified by phase one participants were invited to engage in a process of community reflection via a working group meeting. The meeting was structured around 10 focal question sessions, which were created by the steering committee and discussed over two and a half days.

The sessions were set up to elicit dialogue on critical topics meant to inform the research agenda including: the desired state of outreach programs, challenges and barriers faced, best

practices, and gaps in knowledge areas that would impact program formation and decision making.

> **Outcome**: elicit dialogue on the current state and future of engineering ambassador-led outreach programs.

Phase 4: Data Analysis

In this culminating phase, the dialogue from phase three (the two and a half day community reflection) was synthesized via qualitative analysis. Data included video, participant field notes, and written product from meetings (i.e., easel paper notes, typed documents). The video was transcribed into ethnographic field notes, which were used for this phase. The data analysis portion consisted of four sub activities: the analysis of the qualitative data from the community reflection synthesized into thematic findings, development of the thematic findings into research streams, synchronous and asynchronous individual-level feedback opportunities, and a group-level feedback meeting.

> **Outcome**: community informed theme identification and research stream formation.

Snowball Sampling

In an effort to continue casting a wide net, multiple opportunities were offered for participants to identify community members and potential participants beyond the snowball sampling that occurred during the individual reflection interviews (phase one). Snowball sampling is means for researchers to reach outside of their own knowledge areas and networks and is a method that is beneficial for identifying communities and social networks (Noy, 2008). In phase zero (stakeholder identification), those contacted for interviews were invited to suggest colleagues if they felt that they were a poor fit for the interview. In phase two (steering committee) and three (community reflection), participants were invited to identify colleagues (administrators or subject matter experts) that they felt could serve as participants or presenters. Through this process, we (a) incorporated our participants' networks to strengthen their community and (b) engaged participants who would have been difficult to identify via internet search (e.g., K-12 teachers or other partner organizations who were the recipients of outreach efforts).

Concluding remarks on co-creation

Though the events that occurred as part of this process were predetermined during the creation of the grant, as previously noted, the execution and success of this process relied heavily on participant engagement and dedication to the process. Stakeholders who took part in the research agenda co-creation wholeheartedly engaged, providing critical insight,

feedback, and questions. Their direct contributions shaped everything from the conceptual models presented in this document to the content and flow of the two an a half day community reflection. It is the hopes of the project team, that this is indicative of the utility of the resulting research agenda items. In the remainder of the document, we focus on phases one through four of this research model.

Report Layout

The layout of this report has been devised to provide transparency into the community co-creation process associated with the research agenda. Throughout the document, we offer insight into the steps taken, highlight findings, and provide clarity around how we have approached the development of a research agenda. Chapter two, three, and four focus on the preliminary steps that allowed for triangulation on the research agenda items. Chapter five presents the research agenda and associated theoretical components. Finally, chapter six provides insight into next steps and potential outcomes of a concerted effort to implement this research agenda. Those most interested in understanding the process of co-creation may find the most value in chapters one through three. Whereas those who are more interested in the current state of the ambassador-led outreach community may prefer to focus on chapters three and four. Finally, action-oriented readers, such as ambassador program administrators, may find the most value in chapter five and six.

Chapter 2

Stakeholder Interviews
Emergent Themes

Fifty stakeholder interviews were conducted between November 2018 and February 2019. The purpose of the interviews was to gather data in service of building an understanding of the current state of the ambassador-led engineering outreach community, including the current state, goals and challenges. Data from the interviews was used to develop the agenda and content of the working group meeting.

More specifically, the intent of this analysis was to provide a synthesis of the participants' perspectives and insights on ambassador programs with a specific focus on gaps in knowledge or challenges faced by the community. Twelve key thematic findings (11 main themes and one sub-theme) were identified. As the intent of this stage was to be community-informed, thematic descriptors were kept intentionally open and data was not heavily synthesized in an effort to allow the various perspectives of steering committee members to emerge.

Methods

Participants

Of the 50 participants, 27 stakeholders (54%) were identified via internet search and selected as a result of their involvement in engineering and STEM ambassador outreach programming and scholarship. An additional 23 interviewees were identified via snowball sampling. Women made up 82% of participants (n=41), with the remaining 18% identifying as male (n=9). Interviewees represented organizations in 22 different states and Washington, DC.

Participant's roles were gathered through the interview process. The majority of interview participants were ambassador program administrators (68%, n=34). For more details on the key roles participants held at the time of the interview, see table two.

Table 2. Interviewee roles held related to ambassador-led outreach

	N	Percent
Ambassador Program Administrator	34	68%
Researcher	5	10%
University Faculty	2	4%
Undergraduate Ambassador	2	4%
K-12 Faculty or Staff	2	4%
Other	5	10%

Procedure

Interviewees participated in semi-structured, thirty-minute phone interviews. There were seven content-specific questions asked intended to elicit their personal experiences with engineering (or STEM) outreach and ambassador-led outreach in particular. Questions were framed in such a way that they could be answered by a variety of stakeholder groups. Examples of questions include: What do you think are the most critical factors to get more members of underserved communities to pursue careers in engineering? What role do you think K-12 outreach plays in this? More specifically, what do you think are the impacts of having ambassadors visit K-12 classroom?

At the end of the interview, participants were asked to suggest any relevant experts that they felt should participate in the stakeholder interviews. They were also invited to participate in other aspects of the project including the steering committee and working group meeting.

Results

The descriptions of the 12 themes along with excerpts from interviews are below. As previously noted, the thematic descriptions are left broad so that steering committee members could add to the interpretations in phase two of the project. For this same reason, participant quotations are categorized but not overly contextualized. These themes and quotations were also provided to phase three participants (more detail on phase three is available in chapter three).

Theme One: Desire for a resource repository

Interviewees expressed a desire to have a mechanism to share resources, such as a repository, so that program administrators do not need to duplicate efforts and have access

to information around best practices, engineering identity research, etc. Though the discussion around this is not very nuanced, the requests were clearly and directly articulated.

> "It would be useful… to have a library of resources that have already been developed"

> "It would be good to have a way to share resources."

Theme Two: The need for (and challenges around) a cohesive approach to evaluation

Interviewees referenced evaluation frequently. In their discussions, they acknowledged that evaluation was important and not occurring often enough. They also identified facets that were likely to be particularly important and impactful to assess as well as their insights into why evaluation was not occurring at a higher frequency.

Interviewees regularly acknowledged a desire, and need, for more evaluation. The focus of the evaluation seemed to be on long-term program efficacy in terms of impacting the pipeline, rather than immediate impacts of engagement.

> "K-12 outreach is seen as a very squishy area and there are parts that should remain squishy… but we're selling ourselves short and the kids short if we aren't actually getting hard metrics."

> "We need to insist on better metrics and evaluations of the programs we run."

> "There needs to be more assessment of the knowledge they're gaining."

Many interviewees wanted to see a cohesive approach to evaluation with a particular focus on longitudinal assessment.

> "There is a lack of longitudinal work – we would like to be able to study cohorts of students such as robotics clubs."

> "It would be interesting to do a longitudinal study around why we aren't having more women and African Americans in STEM."

> "We have a lot of fragmented research but need a cohesive approach."

> "We need a longitudinal study of K-12."

> "We don't have a lot of longitudinal studies. We have kids who've graduated college. How do we know if we've actually influenced their college trajectory?"

Participants acknowledged that there are challenges and barriers in place that have limited the ability to gather data, including a lack of funding and limited incentive structures to support the implementation of evaluations.

> "Everyone wants data, but what will be meaningful data?"

> "Because we're always working on a shoestring and busy doing programs, we aren't good at systematically investigating what we do and what's effective."

> "There isn't a lot of evaluation in place for student-run programs – there isn't an incentive to evaluate."

> "Assessment is difficult – there are a lot of programs out there."

Theme Three: K-12 educators are important stakeholders.

Interviewees recognized that they often treated K-12 educators as gatekeepers to classrooms and K-12 learners, rather than collaborators in engineering education and outreach. The general sentiment was that, ambassador program efficacy would be strengthened by increasing engagement with K-12 educators and administrators, treating them as both partners in and the focus of outreach efforts.

Specifically, interviewees spoke to the importance of engaging K-12 teachers at the onset and creating content that better aligns with their day-to-day activity.

> "Preparing the educator who is scaffolding the education is huge."

> "We need to know how this fits into K-12 curriculum. The one-off activities are not useful. We need them to fit into their curriculum."

> "Should be bringing teachers on board - this is really important."

> "Lessons need to be tailored to meeting the common core or NGSS... bring in lessons and explain how they fit."

> "Should work with teachers... this shouldn't be a big departure from what they do. It should match so that when we're gone there is a natural flow for these ideas to continue."

There was some interest in the research that focused on building understanding of the impacts of more robust teacher engagement. This information could be important in strengthening ambassador program focus on K-12 teachers.

> "There should be more research on the impact of changing teacher biases and how it impacts students."

> "I've read a lot about the transferal of efficacy - if a teacher is nervous about teaching a subject, it impacts how they teach. if a female teacher is nervous or less confident, she will project that onto the female students... if we can strengthen the teacher's efficacy, we can increase student efficacy."

Interviewees also felt that ambassador programs should create more opportunities for teacher education and professional development (PD). Though PD is not a key component of ambassador programs, interviewees thought increasing teacher engineering competency would strengthen the efficacy of outreach offerings.

> "Give teachers more PD."

> I would start by strengthening knowledge and ability to do teacher education.... They're everywhere and reach all of the critical communities."

> "I tend to think that we are failing to educate our teachers and help them broadly understand math and science and how that is critical to empower everybody and it starts in K-5. If teachers had more confidence about math if they understood that they had subtle bias in the classroom... our jobs would be a lot easier."

Theme Three A: Engineering curriculum in schools

Interviewees saw value in supporting engineering curriculum in schools. K-12 learners need ongoing exposure to engineering for them to feel confident in pursuing it as a career. Interviewees acknowledged differences between how engineering was currently being treated across grade levels. Specifically, most outreach was reported as taking place at the late elementary or middle school level and engineering curriculum taking place at the high school level.

> "I think engineering curriculum in high schools is the next agenda... There has to be an engineering curriculum that is just a regular old class. Start high school and work back to middle school."

> "Are there any engineering charter programs for middle schools? If so, what are they doing?"

> "Add elements of engineering into schools, much earlier. They know what math and science are, because they do it all the time, but it is not until High School that students even get exposed to engineering or computer science."

Though curriculum in school is not the focus out outreach efforts, it may provide insight into the ways in which ambassador programs can be tailored to support K-12 educators.

Theme Four: We should develop a deeper understanding of all of the different program types

Ambassador programs vary greatly based on location, resources, and need. Interviewees expressed an interest in developing a deep understanding of each other's programs in service of gleaning best practices and new approaches that they can apply to their own programs. Areas of focus ranged from articulating each program's mission to using the process of information exchange as a mechanism for creating a community of practice.

> "We all have niches but we don't necessarily know what that is until we look at each other's programs."

> "I think you should create a program typology. Capture their theories of change, intended and actual outcomes…"

> "I think there is something to think about in terms of the differences of the programs… and the different models and where they might fit into the spectrum of things necessary to getting students into an undergraduate program."

> "professional learning of coordinators and a community of practice is so important."

> "Develop a rubric to get folks on the same page… what are our primary and secondary objectives?"

Theme Five: What do kids need beyond fun? (Resilience, math skills, etc.)

Outreach programs tend to focus on engagement, however, interviewees were interested in further expressing and exploring other facets of outreach that may be critical for young learners (e.g., math competencies, building academic resilience, etc.).

For example, some interviewees expressed clear missions in terms of student engagements that extended beyond engagement.

> "(our) implicit curriculum is about building confidence in order to be resilient."

> "Our mission isn't necessarily to turn every kid was an engineer – it is not for everyone and society would break down if everyone was an

engineering... But engineering design thinking is always useful... are we making them better problem solvers?"

"The intent of outreach – not just to go and not do something that is relevant, but to really do something that is well thought out."

The previous block of quotations implied a broad range of benefits associated with current engineering outreach programs, such as increased resilience and problem-solving abilities. However, this sentiment was not shared across all interviewees, with some expressing a sense of dissatisfaction with the lack of robust program offerings.

"What I don't like are these drop in one day make a kite, crafty things, that's fine when you're in K... this is not effective in building identity in high schoolers. This does not help with navigating the process."

"There is more to getting kids into engineering beyond doing fun stuff - academic and financial, etc."

There were also some foundational, theoretical underpinnings that interviewees considered important to intentional program development. As the quotes demonstrate below, some interviewees stated that they would like to see more research conducted in service of delineating of what the foundational elements are. Others felt that the knowledge already existed but was not being adequately used to inform programming.

"Some kids "can" do engineering but they're not going to make it – engineering has become glamorous to parents but we need to consider more trade-based work as part of STEM."

"we can see successes across the pipeline and see that people are going on to get stem degrees... but WHY? What are the critical/essential elements about these models? Is it a fluke?

What are the foundational elements? Is it enough to just count numbers? There likely isn't just one way but there might be an important nugget (or a contextual element) – can we do a better job of telling the story (and understanding the story) ... Ideally, the need for our work would go away."

"there is a lot of research of what is effective, but we don't do it all the time."

Theme Six: What is Ambassador 2.0?

Ambassador programs have been around for approximately four decades, making them rather well established.However, there were a number of questions and comments that suggested a need to upgrade programming to reflect the current zeitgeist, technological

developments, and societal needs. Interviewees offered questions and insights into how programs should shift to meet current challenges. The points raised ranged from discussing the use of online tools for training ambassadors to how the whole learner in outreach programming.

> "What is Ambassador 2.0?"

> "I don't know if this fits anywhere, it deals with making STEM multifaceted and polymathic. What I mean by that is: right now, many STEM fields are about technical competence. Very much: this is the way you do it. This turns people off of engineering. There should be a curriculum that encouraged individuals to bring their whole selves to their STEM degree/career. In computing I had a student who was ostracized for not wanting to work for google."

> "The show-and-tell model is fine, but what does it actually do for the K-12 students? But sitting down and co-constructing, and how it can benefit the students and the classroom teachers/students."

> "Online tools should be used more for training" (One participant example: a virtual program, which is run by undergraduates who Skype into middle and high schools and students coach classes around college readiness).

There was even one participant who expressed active dissatisfaction with the current state of ambassador-led outreach programming. Though they were in the minority with this perspective, the strength of their conviction made the point worth raising.

> "If I had a million dollars I wouldn't put it into an ambassador program – I think other programs just can have more impact."

Theme Seven: More cross-sectoral collaboration

It was a shared perspective across interviewees that the engineering pipeline is a leaky one. Thus, they continued to ask: how do we work across all sectors (K-12, university, and corporate) to lessen attrition of diverse populations?

> "When you think about it, higher education blames K-12 for unprepared kids, industry blames higher education for workers who don't have soft skills. We should connect industry to K-12. Each stakeholder is making their decision in a silo."

> "When you're talking about a pipeline for STEM, it has to go LONG into careers. Something like 40% of women drop out of STEM careers. It is not because they had a baby, it is because of the way they're treated,

opportunities they aren't given, expectations of behavior, etc. Must go through at least mid-career."

Theme Eight: There is a lot of acknowledgement of "near peer" (but whose near peer?)

Interviewees acknowledged that there is value in near peer mentoring, but wondered if simply bringing in ambassadors was sufficient. In various interviews, participants note that ambassadors aren't always representative of the populations they visit nor are they the most trained in education and communication.

Interviewees generally framed university students as role models and believe ambassadors are seen as aspirational and exciting by K-12 learners.

> "seeing someone just a few steps ahead of you is more impactful than an already successful industry person about their rise to success."

> "College students are cool. College engineering students are way beyond cool. (Students) look at them with awe and amazement."

Despite the potential benefits of ambassadors, interviewees acknowledge that ambassadors must be thoughtfully "deployed" in order to have the intended effect of reaching and engaging diverse audiences.

> "They can be great – and are so close to high school… but if they don't reflect diversity then they aren't going to make as big of an impact."

> "DON'T send a bunch of white frat guys to visit Hispanic girls. Students of color deal with issues of feeling accepted and supported by white people, so they should have some people who look like them."

Theme Nine: Speaking to and engaging with diverse K-12 learners

Interviewees felt that in order to successfully reach K-12 learners from diverse backgrounds, outreach efforts should be modified to address their different perspectives, values, and world views.

Interviewees expressed a need to think about diversity in a more holistic ways, including how the community is defining diversity and they enact that understanding of diversity in programming and activities.

> "We need cultural competence – understanding how to speak to people, understanding empathy, understanding stereotypes are a no-no, everyone is coming from different places- socio-economic diversity, and racial – like, not all African American children are poor."

> "If you can see it, you can be it. A lot of girls and youth in general have stereotypes what an engineer is. They don't see themselves and they also don't think they can do it or they are smart enough."

> "Stuff like FIRST[3] is problematic. It is a competition. Competitions still favor certain (often male) world views...."

> "We tend to focus on minority students based on race – is there anything for first generation [students] to be a bit broader?"

Building off of the critique of near peer engagement in theme eight, interviewees stressed that a more holistic approach to supporting diverse populations must include reflecting on ambassadors' potential shortcomings.

> "Even if you have student ambassadors, it doesn't mean they represent the URM population"

> "A lot of ambassadors are bilingual, but it is really hard if they don't speak the language and it does a disservice."

Interviewees also acknowledged the higher level considerations that should be considered when providing support to K-12 learners. Specifically, they believed that ambassadors and program administrators should be mindful of the whole student, challenges they may run into, and how ambassador programs can support or hinder them along the way.

> "It's one thing to get them [members of underrepresented communities in engineering] in, but how to keep them and then the hurdles of being the only woman or person of color in an engineering firm."

> "We have to avoid the "savior" issue. Meaning well isn't enough"

> "(We need to) look at engineering identity from a perspective of intersectionality as well as range/stages of engineering identity. How might engineering identity clash with other identities?"

Theme Ten: Thinking beyond the classroom to families and communities

Interviewees recognized that providing support for K-12 learners in pursuing engineering, required ambassador programs to reach beyond the classroom and engage families and communities.

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[3] The speaker is referring to FIRST® Robotics Competition. In this program, teams of high school students, under the guidance of coaches and mentors. Teams build robots and compete against each other based on their robot's ability to complete a series of tasks.

Interviewees acknowledged the importance of partnering with families in supporting engineering engagement in K-12 learbners. The ideal relationship between ambassador programs and families was viewed as bidirectional with program goals modified to reflect the aspirations of the families.

> "The community must recognize the importance of engineering and supporting URMs in doing engineering. Family can make a huge difference"

> "Getting family support (is critical) – getting an indigenous kid to come to the school, get them to understand how it can benefit the whole family and that we aren't trying to take them from their culture but that it could fit in their culture"

> "Talk to families who are in the community - what are their educational goals for their kids, how can they be met?"

Interviewees also spoke to structural challenges and their impact on K-12 learner success. For example, in the quotations below, interviewees refer to the challenges of partnering with over-extended school systems and families with competing demands for their time.

> "… there isn't enough social support systems and children are unsafe, schools don't function well (highest per capita expenses but low success)"

> "there are often factors around the families that are preventing students from pursuing careers – they don't understand what engineering is or what engineers do. They don't want their kids to go off to engineering schools. They don't have time to help support the career development. If we support families in understanding what engineering is…"

Theme Eleven: Identifying barriers and sharing means for overcoming them

Interviewees identified many shared barriers across outreach programs such as limited student time, funding, and transportation to remote locations.

Transportation was described as a critical barrier in both rural and urban locations, though the challenges look different in each setting. For example, interviewees reported that in urban settings ambassadors were more likely to rely on public transportation due to the expense and inconvenience of owning a car in a city. Thus, "remote" in the context of urban settings may be dictated by public transit routes. The challenges of transportation were also linked to shortages in human and financial resources.

> "the biggest barrier that we have is transportation and man power. If we don't have people that can drive we can't go to sites"

> "Our biggest challenge is actually transportation - on both sides: Undergrads out, schools in. Renting a bus, its critical to make it no cost for schools"

> "Transportation is a problem— the schools are very spread out."

Funding, in particular, seemed to trickle down to many other components beyond transportation. Interviewees reported that it resulted in shaping the educational experiences that ambassador programs are able to offer to K-12 learners.

> "If there was more funds available you could recruit diverse students"

> "An issue of lack of time, resources, and number of ambassadors. It would be so nice if the Engineering 101 courses required outreach components."

> "We only go once per semester to the schools – we would love to go more, but they don't have the funding to do that"

The lack of funding and its impact on the development of robust programming, seemed to be particularly problematic given some of the challenges faced by K-12 learners, specifically the lack of STEM/engineering identity.

> "A big barrier for STEM fields is that students just don't believe they can do it. Part way through an activity – you see a light bulb – I can do this, I can be an engineer."

Discussion

The benefit of eliciting individual reflections, as opposed to group, is that it tends to capture a wider breadth of topics due to the lack of explicit group influence (Paulus et al., 2016; Paulus et al., 2006). However, this breadth can also pose a challenge to the synthesis process. In this case, despite the significant and acknowledged disconnect between many ambassador programs across the nation with the exception of those who were active members of the Engineering Ambassadors Network[4], there was notable alignment across interviews. For example, many participants shared a need for more evaluation with a focus on longitudinal assessment. There were, of course, unique facets to the various programs as well as interpretations of programs based on interviewee role. For example, ambassador program administrators assessed the nuances of program implementation, whereas

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[4] The Engineering Ambassadors Network is a program that began at Penn State but is now national. This program trains undergraduate students on communication skills and how to discuss engineering with K-12 learners.

educational researchers often took a macro-level perspective, reflecting on models of learning and comparing ambassador programs to other types of outreach. However, interviewees agreed that programs needed to be refined to improve impact and that the community needs to be strengthened in order to accomplish this task

More specifically, interviewees identified a holistic view of challenges and focal areas which ranged from addressing logistical barriers like funding and limited time availability to foundational questions, like what programs should accomplish beyond engagement. The topics identified in this process were complex and require a high level of "unpacking" that was ideal for their intended uses - by the steering committee to shape the working meeting agenda, and by the ambassador-led community during the working meeting.

Steering Committee & Community Reflection

Reflecting on the themes and shaping the working group meeting

Though the steering committee formation and the community reflection were separate phases in the co-creation process, the two sections are woven together in this chapter because the content is intertwined - the steering committee was formed to create the community reflection and, in turn, the community reflection (also referred to as the working group meeting) is the direct output of the steering committee's work.

Steering Committee

The steering committee was comprised of 14 volunteers from the interviewee participants (see pages five and six for the full list of steering committee members), as well as two of the grant personnel. Over the course of six months they developed content and shaped the process for the community reflection (also called the working group meeting). To support the steering committee, the grant personnel offered prompts and suggested tasks for the the steering committee to accomplish, but the steering committee led all of the decision making that was critical to the development of the working group meeting

One of the most important tasks accomplished by the steering committee was establishing the foci for the sections of the working meeting. Steering committee members critiqued the interview themes presented in chapter two and, through a process of ranking and reflection, eliminated three themes and created two new ones. They ultimately identified ten focal topics, which the steering committee shifted into focal questions. These focal questions would function as workshop topics, guiding discussion in the working group meeting. See table three for the full list.

The steering committee eliminated three themes for various reasons. Theme 3.1 was eliminated because its focus on formal education was tangential to the focus of the project. Theme 6 and 9 were eliminated because it was felt that they would emerge through addressing the other themes. For example, building out a cohesive approach to ambassador programs (theme 2) could lead to insights into what skills ambassadors should have (theme 8) and contribute to understanding what ambassador 2.0 should look like (theme 6).

Table 3. Meeting focal questions and ranking

Original Theme	Focal Question	Ranking
1. Desire for a research repository	How do we construct a resource repository so that programs do not duplicate efforts and have access to best practices, engineering identity research, etc?	2
2. The need for (and challenges around) a cohesive approach to evaluation	What does a cohesive approach to ambassador program evaluation look like?	1
3. K-12 educators are important stakeholders	K-12 educators are important stakeholders – how can we work together to be better partners to them and possibly make them the focus of outreach efforts?	4
3.1. Engineering curriculum in schools		Eliminate
4. We should develop a deeper understanding of all of the different program types	How do we create an outreach map that provides holistic support to students?	9
5. What do kids need beyond fun? (Resilience, math skills, etc.)	How do ambassador programs move beyond engagement to incorporate other elements that may also be critical to creating engineers?	6
6. What is Ambassador 2.0?		Eliminate
7. More cross-sectoral collaboration	How do we work across all sectors to lessen attrition of diverse populations?	1
8. There is a lot of acknowledgement of "near peer" (but whose near peer?)		Eliminate
9. Speaking to and engaging with diverse K-12 learners		Fold into theme 7
10. Thinking beyond the classroom to families and communities	To be impactful and ensure that students have the support they need to pursue engineering – how do we think beyond the classroom and engage families and communities?	8
11. Identifying barriers and sharing means for overcoming them	What are the creative ways the different programs have addressed common barriers and what barriers still exist?	3
	Emergent Themes	
NA	How do we create an outreach map that provides holistic support to students?	7
NA	How do we provide multiple pathways to access engineering?	5

While it was expected that the steering committee would shape the agenda, some of the unexpected benefits came by way of their recommendations for pre-event processes. For example, they suggested that brief surveys be sent out so that participants could (a) sign up and prepare for sessions in advance and (b) provide facilitators with background information in advance. This allowed the facilitators to better prepare for the group that they would be working with, via understanding the demographics and background of those who chose to participants. Participants could also better prepare for their sessions in advance, via gathering institutional data from colleagues, reflecting on prompts, or reading articles provided by facilitators. Steering committee members also nominated keynote speakers, identified additional stakeholders to participate in the meeting, and identified tools that might be helpful for gathering data such as online polling software and digital document sharing to capture participant responses. They also functioned as session co-creators and moderators.

Working Group Meeting

The working group meeting took place in September, 2019 over the course of two and a half days. The first day of the meeting began with four keynote speakers who provided different perspectives on ambassador programs including: past ambassador, ambassador program administrator and researcher, graduate researcher on engineering thriving, and expert in K-12 program evaluation. Over the remainder of day one and day two, there were 10 working group sessions. Each session addressed one of the ten focal questions and was facilitated by a different steering committee member. Though each session was facilitated based on the steering committee member's design, the sessions were designed to elicit dialogue on (1) the current state, (2) ideal state (3) gaps in knowledge or skills needed to move from current to ideal state, and (4) proposed action items for resolving that gap. Additionally, there were full-group debriefs at the end of both day one and day two, and the final half day of the working group meeting was dedicated solely to debriefing and group discussion of priorities, action steps, and resource sharing.

Thirty-six people from 15 different states, including the three grant personnel (Drs. Duncanson, Freeman, and Rodegher), participated in this meeting. Of the remaining 33 participants, 22 were phase one interviewees. The final 11 participants included seven undergraduate ambassadors, three subject matter experts who presented on topics such as program evaluation and engineering thriving, and one participant who had previously been a K-12 teacher and recipient of ambassador programs. Twenty-four organizations were represented in the meeting. Industries represented in the meeting included: universities, non-profit organizations, and K-12 schools.

Data was gathered over the course of the two and a half days via student notetakers and video recording. Though the structure of the two and a half days was intense, requiring near-

constant and deep engagement from the participants, the group maintained a high level of energy and intellectual contributions. Overall, participants reported that the dialogue facilitated by this working group session resulted in (a) strengthened relationships and understanding between participants and (b) more robust insight into experiences, best practices, and needs of the participating organizations. The following chapter contains a synthesis of the thematic findings from the meeting.

Chapter 5

Themes
Findings from the community reflection

The current chapter provides a synthesis of findings across all ten working group and the three debrief sessions. Rather than summarize or analyze sessions independent of each other, thematic analysis was conducted across all sessions. However, at times emergent themes align with specific sessions and their associated focal questions. An example of this would be the presence of a theme called "online repository" which aligns heavily with the working group session that focused on the question "How do we construct a resource repository so that programs do not duplicate efforts and have access to best practices, engineering identity research, etc?" This analysis was conducted by a research team of five people, including two grant personnel and three community reflection participants (see page five for research team participants).

Method

The purpose of this thematic analysis was to identify trends within the community reflection (phase three) in service of developing the research agenda. To accomplish this, written, rich narratives, called "thick description" (Wolff, 2004), were used to make the ethnographic record. These thick descriptions were created using three data sources: video footage captured over the duration of the community reflection, ambassador field notes captured over the course of the community reflection, and work product created by group members. Work product included shared google documents, notes taken on easel paper, and sticky notes. The resulting ethnographic record was then analyzed by the research team using Dedoose, a mixed-methods data analysis platform.

Procedure

The data analysis was informed by Emerson, Fretz, and Shaw's (2011) three-part coding process, described in greater detail below.

- **Stage one:** the ethnographic record from the meeting were coded via an emergent, open-coding model. Researchers worked independently to develop and apply codes as they reviewed the thick description. This was a blind coding process in that researchers could not see each other's codes, and thus would not be unduly influenced by other's interpretations and biases. At the end of this first stage 208 codes were created.

- **Stage two:** researchers reviewed and refined the emergent codes, assessing for redundancy, overlap, clarity, and relationships between codes. Upon completion of this second phase, the researchers had developed a unified codebook.

- **Stage three:** the unified codebook was used to recode the excerpts from the open coding process. Where appropriate, sub-codes were used for more populous topics to capture sub-themes that may have emerged.

Since co-creation is important part of this project, the analytical procedure was designed to embrace and account for the diversity of perspectives held by the research team. This is reflected in three key facets. First, rather than dividing the ethnographic field notes between researchers to analyze, three researchers were assigned to analyze each section of text. Second, stage one of the process occurred independently and without group reflection, so that pluralistic perspectives could be maintained. Finally, though ethnographic data coding often involved training for inter-rater reliability, this process embraced duplicate coding. "Duplicate coding" in this context refers to allowing sections of text to hold different meanings for research team members.

Upon the completion of this process, the resulting codes and coded data was analyzed and clustered in order to identify key themes. See figure three for the full ranking of the top 20 emergent themes.

Results

Ultimately, there were 95 total codes created and 3050 total codes applied to 1868 excerpts. In what follows, we discuss the 20 most used codes from the analysis and their sub-codes, where applicable. The top ten themes are described in greater detail, with many broken down into sub-themes to capture the nuances associated with each theme. Themes 11 through 20 are briefly summarized.

Ambassador Program Models
614 excerpts

"Ambassador program models" was the most populated theme over the course of the meeting. This makes sense as community members repeated expressed interest in learning about each other's programs. There were 12 sub-codes that emerged under ambassador program models.
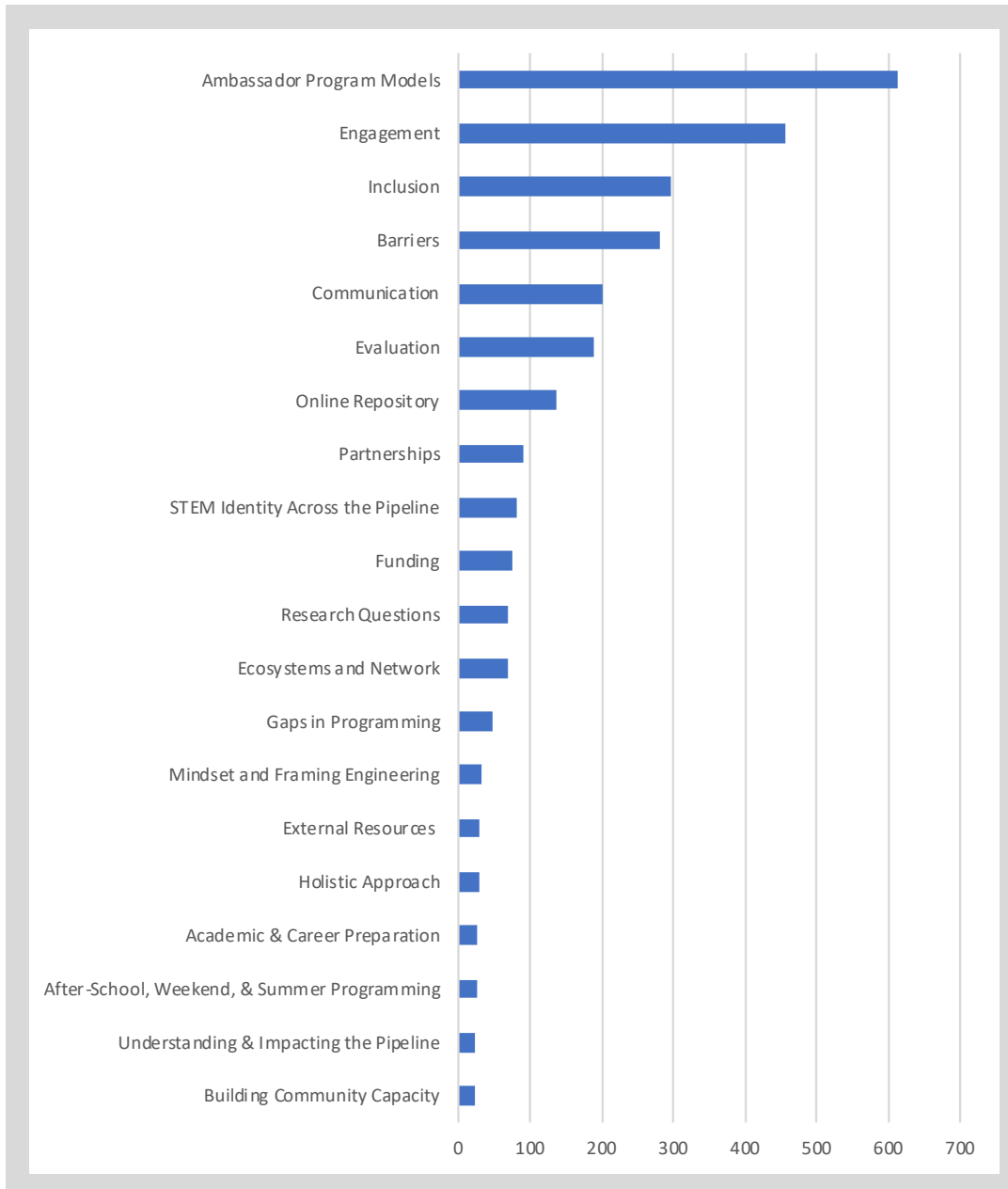
Figure 3. Top 20 Emergent Themes from the Working Group

Ambassador Roles: 58

"Ambassador roles" focused on the types and nature of roles given to the ambassadors. Some of the functions that participants considered potentially a part of ambassador roles included: educator, inspiration, mentor, and social justice advocate. Ambassadors also potentially functioned as recruitment support or university advocate by helping disseminate information about specific programs or broader university offerings.

Compensation and Funding: 10

This addressed the question of how ambassadors are paid. Some participants spoke to stipends or hourly pay, but volunteering was common among ambassador programs as was nontraditional "payments" (letters of recommendation, food, discounts on university offerings).

Program Models: 154

"Program models" captured the information offered by participants about how their programs were executed. This included factors such as: whether they went to K-12 learners or the K-12 learners came to campus, types of activities they experienced, how said activities were developed, and other logistical considerations.

Training: 39

"Training" focused on the varying training models used in ambassador programs. Primarily participants discussed how ambassadors needed a variety of skills ranging from: presentation to classroom management and diversity training. A need for a unification of training, either via national conference or online modules, was expressed.

Aspirations: 22

"Aspirations" were the high-level hopes for what ambassador programs might accomplish. Topics that emerged included: disrupting social imbalances, empowering participants, and creating ethical problem solvers.

Best Practices: 73

"Best practices" encompassed (a) an expressed need for best practice resources as well as (b) examples of best practices identified by the community – often in response to a logistical challenge. Examples included "Skype an engineer" as a method for reaching rural communities.

Goals: 105

"Goals" captured both the community's desire for more explicit identification of program goals and the array of real and aspirational goals that participants articulated. These ranged from immediate in focus ("developing problem solving skills") to more long-term ("creating future ambassadors"). Goals often extended beyond the sphere of the K-12 participant to the members of their community whose support would be important to their success including parents and teachers.

Actions and Problem Solutions: 84

"Actions and problem solutions" spoke to next steps that the ambassador community felt could be taken to increase efficacy, such as: partnering with other outreach groups on campus, developing training models, strategizing with other neighboring universities.

Program Assumptions or Questions: 28

"Program assumptions or questions" were preconceived ideas that ambassador program administrators must address. This included preconceived notions that they needed to address with ambassadors before meeting with K-12 learners (e.g., "trade school is not as valuable as university") and within the communities they serve (e.g. "engineering isn't interesting").

Soft Skill Development: 21

"Soft skills" emerged as important for ambassadors and the K-12 students they serve. Skills identified included: sensitivity, supporting equality, creativity, and problem solving.

Underlying Motivations for Programs: 8

"Underlying motivations for programs" captured the various reasons explaining how the ambassador programs came into existence. Though this was discussed in just a few instances, the rationale ranged from broad, social good, to more direct, increasing engineering majors at their school.

Underlying Change Mechanisms: 12

"Underlying change mechanisms" referred to the deeper goals that outreach interventions were trying to accomplish through their activities. Examples included: strengthening engineering identity, supporting growth mindsets, and building self-efficacy.

Engagement
455 excerpts

"Engagement" was a prevalent theme throughout the meeting. There were ten categories that emerged under engagement. Nine of the ten sub-categories were focused on different stakeholder groups to engage. The remaining theme ("Questions and Beliefs") focused on how ambassador programs should engage with different stakeholder groups. See figure four for the full breakdown of excerpt coding by stakeholder group type.
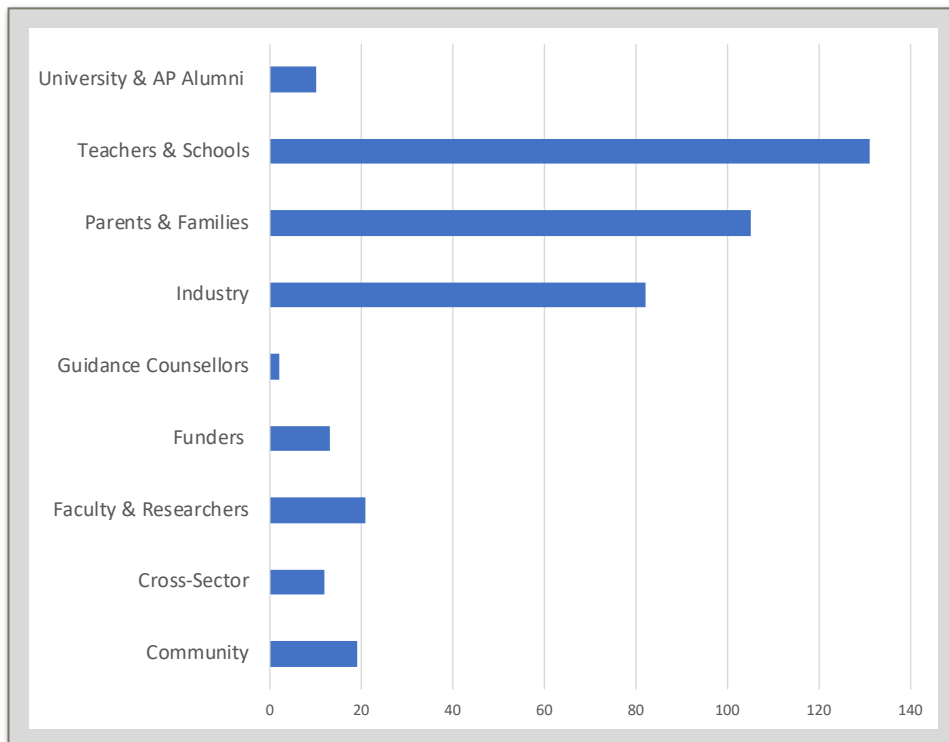
Figure 4. Excerpts by Stakeholder Group

Teachers and Schools: 131

"Teachers and schools" was the most populous sub-code, likely due to the role schools play as intermediaries between universities and K-12 learners and host sites for ambassador outreach programs. Teachers were generally discussed in terms of potential partnership roles, whereas administrators were characterized as gatekeepers. In particular, two topics were regularly discussed: the roles that teachers should play when ambassadors visit and understanding the types lessons or professional development related engineering teachers might want.

Parents and Families: 105

"Parents and family" importance emerged as pivotal to ambassador program success. Participants understood that parents and family were difficult to reach or overlooked, but also critical to student success. An emphasis was placed by the community to remind itself that there are many permutations of families and the term "parents" was frequently replaced with "important adults."

Industry: 82

"Industry" referred broadly to all corporate entities. Two main points were made: (a) the potential role corporate partners could play in providing insight into what organizations and

specific industries wanted in new employees in terms of skills and abilities and (b) the challenges of increasing corporate partner communication and strengthening engagement skills given their limited time availability.

Faculty and Researchers: 21

"Faculty and researchers" primarily focused on the desire to have more academic staff (i.e., engineers) involved in a direct or indirect way in ambassador outreach. One challenge that was identified was that faculty and researchers publicly expressed support for ambassador programs but less frequently followed this up by actually volunteering their time.

Community: 19

"Community" primarily focused on events that would be family and/or school adjacent. Though the nature of the events were not well-articulated, the purpose seemed to be focused on getting familial groups talking about engineering and exploring it together.

University and Ambassador Program Alumni: 10

"University and ambassador program alumni" were referred to in two key capacities. First, university alumni could be tapped into to strengthen partnerships with industries. Second, ambassador program alumni in particular could be used to participate in industry outreach events. This would address the challenge that many participants expressed regarding industry partners having inconsistent presentation skills.

Funders: 13

"Funders" had a lot of overlap with communication and evaluation. This is because the nature of the funder engagement expressed was primarily focused on identifying mechanisms for providing information in such a way that funders wanted to continue supporting programming. A primary belief was that funders needed to see quantitative metrics of success.

Guidance Counsellors: 2

On the opposite end of the spectrum of "teachers and schools" is "guidance counsellors." Though teachers and schools made up 28.8% of the 455 references to engagement, guidance counsellors were mentioned just two times (0.4% of total engagement references). This may point to an important gap in programmatic focus as guidance counsellors can often play an important role in: supporting K-12 learners in selecting the correct classes to prepare them for college, understanding what is required beyond course work to have a competitive college

application, and support through the actual process of selecting a university major and completing applications (for attendance and scholarships).

Questions and Beliefs: 60

"Questions and beliefs" focused on how ambassadors and ambassador program administrators should engage with the various stakeholder groups. In particular, participants were interested in understanding what the factors that contributed to "engagement" were and how they might vary across stakeholder groups and diverse populations.

Cross-Sector: 12

In "cross-sector", participants focused on the need for collaboration across all-stakeholders. Participants drew out the importance of demonstrating the interconnectedness of K-12 schools, universities, and industry. They articulated that failures within one sector would impact the ability for the other two to succeed, thus K-12 schools, university and industry must work together in order to have the greatest impact across the engineering pipeline.

Inclusion
298 excerpts

"Inclusion" referred, in general, to the way in which programs and institutions function to accommodate diverse perspectives and backgrounds. As "outreach" is an abbreviated term for "outreach to communities that are not reached by traditional structures and systems," it was not surprising that this emerged as the third most populated code. The 298 codes were divided into seven main themes.

Access: 52

"Access" referred primarily to systemics and resource-based challenges that participants felt limited participation in under-resourced and underserved populations and, thus, the content of these excepts overlap with theme four ("barriers") . Transportation to and from events was a common consideration. Other barriers included baseline skills expected of all student participants. Another barrier to access identified was the lack of knowledge around competing expectations placed on under-resourced students (e.g., care-taking for siblings, working, other household support).

Culture Shift: 79

Participants regularly cited the importance of a culture shift in strengthening inclusion. Participants continually acknowledged engineering's reputation as predominately privileged, white, and male. They also acknowledged that, along with the desire to engage more diverse populations, programs and universities create and embody a more diverse, pluralistic culture within ambassador-led programming, the university as a whole, and – most importantly – in the ambassador cohorts.

Gender: 19

"Gender" captured a wide variety of perceptions around gender in engineering – including some viewpoints that are in direct opposition with each other. For example, in one interaction one participant expressed a belief that "we are seeing a lot more women in engineering" while another felt there was no significant change as it related to gender. One place where there appeared to be agreement with participants was in terms of the belief that female stakeholders in engineering are not treated as on equal footing. For example, at the leadership level they are placed in the support or "helper role rather than expert" and then at the undergraduate level female ambassadors were "overshadowed" by their male counterparts. Participants expressed a belief that this institutional culture was then being embodied by female K-12 learners who were quoted as saying that engineering was not for them and that they "liked people too much."

Geographic Considerations: 12

"Geographic considerations" focused broadly on populations that were more difficult to reach due to distance or lack of public transportation. Participants suggested forming and strengthening partnerships on state and national scales and incorporating tribal, satellite, and community colleges.

Reaching Rural Populations: 21

"Reaching rural populations" shared some overlap with the previous sub-theme, however, "geographic considerations," had a more universal focus. This sub-theme was focused more narrowly on rural environments, with a particular focus on the rural poor and the unique challenges of accessing them despite limited resources. Solutions discussed – beyond the network outlined in the previous theme - included remote engagement, mailing physical resources, and overnight trips where longer or multiple events are conducted.

Representation: 82

"Representation" captured participant's expressed need to include a diversity of perspectives across multiple variables when conducting any task associated with ambassador-led outreach programs. This included critical reflection on biased perspectives that may be inserted into: communication and marketing strategies, activity creation, and even the engineering methods demonstrated. In addition to avoiding the "one size fits all" term pipeline, participants articulated that an effort should be made to "elevate conversation so belonging is intentional and acknowledged."

Understanding Target Audiences: 33

"Understanding target audiences" referred to the need to understand underserved populations[5] before effective communication and outreach strategies could be created. Participants identified the following items to consider: where community members gather so that marketing material can be placed in the most effective place, if there are any specific interests that might inform the engineering problems selected to discuss, and what type of support families may need.

Barriers
281 total excerpts

"Barriers" were an ever-present consideration for participants and over the course of the working group, it was also acknowledged that the barriers played a strong role in shaping how ambassador programs function and the audiences they could successfully reach. There were eight subcategories that emerged under barriers. As may be apparent in the summaries of barriers that follow, there was a significant amount of overlap between barrier categories because many of these issues are intertwined. Additionally, during one working group session participants were asked to rank barriers. "Time and money" were ranked the highest – this may be worth noting, despite the lower level of excerpts assigned to the funding category.

Challenges to Implementation: 58

"Challenges to implementation focused primarily on the logistics of program implementation. One topic that received a lot of attention was the difficulty of connecting with K-12 teachers to strategize when most of their daily requires face-to-face time with their

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[5] Note that underserved populations vary by ambassador program site and demographics. For example, outreach programs in Maryland serve a larger proportion of Black K-12 learners, whereas New Mexico programs have predominately indigenous and Latinx populations.

students. There were also more abstract topics discussed, which included the fast pace of engineering and universities which can be challenging for K-12 settings. Participants also expressed a concern that a cumulative effect of all of the other barriers resulted in a strong shift from program goals.

Funding: 14

"Funding" appeared to impact every level of programming. Lack of funds created challenges for simple, logistical tasks like getting participants to campus or ambassadors to participants. It also created more foundational impacts such as limiting the ambassador pool to those who did not need to work and could afford to volunteer to perform the work for free.

General: 22

"General" spanned a variety of topics. An issue that arose repeatedly within this category was the issue of liability particularly when sharing expenses resources and equipment with underfunded schools. One participant shared an example on the challenges of leaving a drone or robot at a school for K-12 learners to use and how the responsibility for the resource should be established and the questions that arose: If it got lost or broken, should the financial burden be placed on the K-12 school or the university? Another topic that emerged was the variations between how different schools and districts functioned. These variations would require constant "tweaks" to programming and approaches.

Institutional: 46

"Institutional barriers" varied greatly due to the unique components of each participant's institution. However, many participants shared a concern over the limitations or expectations placed upon them. Several reported "wearing several hats" and, thus, were spread thin in terms of the time and effort they could dedicate. There were also institutional tensions that were identified which included a sentiment of "administration knows what's best" and that, while the goal of the program might be to serve local K-12 schools, the real "customer" or target audience was the undergraduate students.

Participation: 42

There were a variety of "participation" barriers that were identified, a number of which had to do with individual variations that may occur over the course of an event. Participants identified the following ways in which K-12 learners may vary: experience with computer programming, vocabulary size, degree of structure preferred during activities, and cultural backgrounds and norms.

Scheduling: 34

"Scheduling" was a challenge that was regularly acknowledged. In addition to the challenges of day-to-day availability, participants acknowledged that teachers time was limited by lesson plans and objectives that needed to be met in order to reach state standards and, potentially, prepare K-12 learners for state testing. On the other side, participants also reported that ambassadors' schedules were also complex and change a number of times over the course of the year. Often their schedules are in direct opposition with the schools. In fact, it was acknowledged that ambassadors are often most available on Saturdays – when schools are obviously closed, but perhaps more importantly it is a day where K-12 learners must rely on parent resources, availability, and interest in order to attend an event.

Time: 35

The issue of "time" was closely coupled to scheduling, in that scheduling was limited due to a lack of time. However, the lack of time impacted other facets of outreach. For example, if industry partners don't have time to attend trainings than the quality of their communication is potentially reduced. In particular, participants acknowledged the time lost to support activities: communicating with schools and ambassadors, purchasing materials, commuting between the university and the outreach site, etc.

Transportation: 30

"Transportation" emerged as a surprisingly sticky barrier. Few participants reported having access to university fleets and, as a result had to rely on other, more expensive options which included fare-based car services like Uber and Lyft for schools in more urban areas or renting buses for those in rural areas. This transportation issue became even more challenging when dealing with programs that occurred outside of normal school hours because, in addition to getting the ambassadors to the site, there was the problem of each student's individual transportation issue (versus simply getting them to and from their school where they could take buses to their respective homes).

Communication
200 total excerpts

"Communication" repeatedly emerged as a critical topic through group discourse. Though there were many excerpts linked to communication, there were three primary areas of interest that were identified.

First, participants identified communication challenges and logistical considerations that were important from a marketing standpoint. This included reaching key stakeholders, using social media, and maintaining bidirectional lines of communication.

Second, participants regularly commented on their concern that biases might be inadvertently, but regularly, embedded in communication strategies. This, in turn, impact who ambassador programs reach. They noted that biases could be used to select the real or virtual venues used to communicate, the assumptions and values that are imbued in communications, and the access to resources target audiences may or may not have. Examples that participants offered included: neglecting to hang fliers in religious centers, continually prioritizing competition over social good, and assuming that children will have access to transportation outside of the school day.

Finally, participants wrestled with complex issues such as how communication done "wrong" can reinforce societal imbalances. For example, they discussed the role of deficit language and the perception that K-12 learners were "lacking" and how societal dynamics played out in how ambassadors interact and were received. One participant acknowledging that their female ambassadors were often "overshadowed" by male ambassadors and there was some question about the implications of this for the female ambassadors and the K-12 learners observing this. Another complex question that was asked was more closely coupled to logistical communication: "how do you manage maintaining your mission if you think you want to maintain focus on under-resourced communities? Are the requests coming from them… or are they coming from more resourced parents and teachers who are just looking for a lot of opportunities for their kids?"

Evaluation
190 excerpts

"Evaluation" as a whole received less attention than the research team anticipated. There appears to be two main contributing factors to this. First, as articulated in the barriers code, ambassador programs are (a) operating with insufficient resources which include time and money and (b) grappling with a lack of clarity around what to measure (articulated in more detail below). Despite this, participants seemed to be interested in evaluation and even dedicated time to brainstorming other benefactors for evaluation in order to strengthen its utility. Below are descriptions of the seven subcategories that emerged.

Need for More: 18

"Need for more" captured participant's acknowledgment that there was not enough evaluation being conducted which resulted in many blind spots. For example, they observed

that even if the goals of ambassador outreach were very clear, it did not mean that the ambassador were causing the desired positive change on the classroom he/she visits. Participants also expressed a desire for more resources to support them in conducting evaluations. They specifically asked for a resource repository of evaluation tools and the development of a database of ambassador-led outreach specific evaluation questions.

General: 14

"General" captured a broad array of participant insights and questions such as reframing how we think about evaluation to be less about assessing "participants" and more about asking "how is this helping K-12 students?" Also, participants suggested a need to be mindful of how assessment can change the interaction for participants – moving the experience from "learning opportunity" to strangers coming into to room to get something from you.

Challenges: 23

Numerous, diverse "challenges" to evaluation were identified. These included: lack of clarity on program goals/objectives, unwillingness of schools to participate because they don't want to know how they are failing, the challenges of studying already over-studied groups (e.g., underserved communities), and the difficulties of adequately assessing "low dose" outreach programs (e.g., a single 45-60 minute visit).

Best Practices: 30

"Best practices" captured the various recommendations that participants made on how to conduct evaluation. This ranged the full spectrum of the evaluation process – from student design to data collection techniques and analysis. Many participants focused on mechanisms or approaches for collecting data, which included: phone apps, the use of iPads in classroom settings, and how to partner with teachers to get surveys completed.

Needs Assessment: 35

"Needs assessment" emerged as particularly valuable in understanding why many participants reported that program evaluation was lacking. Participants expressed a lack of clarity around what information was most important to other stakeholders. They also posed the question "What is success?" several times, observing that without understanding how to define success, they could not accurately assess for it.

Goals and Uses: 35

"Goals and uses" captured participants' interest in discussing how evaluation information could be used. There were two commonly identified uses, beyond program improvement. First, participants wanted to use evaluation to provide a source of data for K-12 partners to use based on the K-12 school's goals and needs. Second, participants wanted to create reports for funders as a means of updating them in general as well as to secure additional funding. It is worth noting that the "Funding category" also has a subsection articulating this relationship specifically ("Funding and Evaluation", 18 excerpts).

What to Assess: 35

"What to assess" aligned with "needs assessment" in that participants seemed to be unclear on what they should assess and, as a result, identified an expansive list of potential topics. These included: communication effectiveness, teamwork, problem solving, skill development, parent/teacher goals, resilience, intercultural competency of ambassadors, and more. As a result of this broad array of topics, participants also identified an equal broad understanding of who they were assessing which included: K-12 learners, ambassadors, teachers, etc.

Online Repository/Platform
137 excerpts

During the meeting planning phase, grants personnel and steering committee members believed that the online repository would function as a typical resource repository, in that it would contain information relevant to ambassador programs (e.g., article sharing, program model sharing). However, as the focal question dialogue unfolded, participants expressed a desire for a tool which functions in a more robust way, including providing housing for multimedia resources and, notably, contributing to the formation and maintenance of ambassador community interactions.

There were five key features identified for the repository. They were: program evaluation questions, trainings, a resource vetting process, opportunities for community networking, and repository flexibility to accommodate diverse user groups. More robust description of these five criteria are presented in table four.

Table 4. Key features of the research repository

	Allows…
Suite of evaluation questions	Allow for parallel studies to be conducted nationally and contribute to the creation of a broad data base of information so that efficacy of different programs could be established
Trainings that include certifications	Ambassadors to have documentation of the skills they have acquired (this can be used on resumes)
Oversight or vetting process	A standard to be applied to the repository, insuring a cohesive, high-quality, and up-to-date repository
Networking component	Stakeholders to collaborate or otherwise benefit from peer-to-peer interactions regardless of the barriers created by resource scarcity (e.g., time and money)
Flexibility for user groups	A broad audience, including families, K-12 learners, teachers, industry partners and funders, to use the platform to access resources, thus increasing accessibility to engineering education processionals and resources

Partnerships
91 excerpts

"Partnerships" included general calls for partnering, venues for partnering, and rationales for the value of partnering. Though, of course, conceptually coupled to "engagement," the differences in these two categories lies primarily in the more transactional nature of "partnerships" (rather than the broader and more transformational goals of "engagement").

Some of the focal points within this subcategory include:

- Potential partner identification: children's museums, public library systems, teachers, researchers, after school programs, community colleges, policy makers, professional societies, working group members

- Request for resources on partnering: participants wanted to know if there were any best practices on how to engage with and formalize partnerships

- Goals of partnering: these varied based on the partnership being discussed. For example, schools were identified as potential partners for making activities, whereas internal marketing departments were pinpointed as potential contributors for developing more cohesive and effective communication strategies and materials

STEM and Engineering Identity Across the Pipeline
80 excerpts

"STEM and Engineering Identity Across the Pipeline" was a diverse set of codes that captured the need to support STEM and engineering identity from every point of the pipeline, which includes recruiting otherwise overlooked STEM identity advocates such as parents, peers, and other community members. Tied to this, participants also felt ambassador programs needed to embrace a more expansive and holistic understanding of what a STEM or engineering identity encompasses. Participants felt that ambassador programs should embody the message that "if you solve problems, you're an engineer" and emphasize the notion that STEM professionals care about social justice and society.

Additionally, when thinking about supporting STEM and engineering identity, participants regularly acknowledged that it is important to consider those who might have unique life situations such as juvenile detainees or K-12 learners with incarcerated parents and to create strategies and approaches that embrace these diverse backgrounds. In other words, participants felt that STEM identity should be supported equally across all populations.

Funding
75 total excerpts

Participants often reported their programs were underfunded. For example, one participant stated that in addition to their ambassadors being unpaid volunteers, it was challenging just to find funds to provide food for ambassadors during training. Though potentially an extreme example, this demonstrates the importance and challenges that funding created for ambassador programs.

Limitations and Needs: 36

"Limitations and needs" echoed many of the themes in the "barriers" section related to funding. Participants articulated where funding is lacking and how programming would be improved with greater funding. In particular, participants stated that increased funding would lead to increased access in two key ways (a) addressing transportation issues and (b) supporting persistence in participation of K-12 learners who are more financially insecure. Some solutions for obtaining more funding were also identified including: partnering with industry sponsors and developing clear, concrete program goals to increase likelihood of being awarded funding.

Relationship with Evaluation: 18

"Relationship with evaluation" captured how participants believed funding opportunities could be offered as a motivating factor in getting leadership buy-in for investing in more robust evaluations and reports. Participants identified measurable program outcomes as incentives for university, state, and national programs to grant additional funding to programs.

Underlying Components: 21

The sub-theme of "underlying components" was comprised of a variety of factors that identified potential opportunities for securing additional funding. Participants suggested partnering with K-12 schools to get title IV grants or engaging K-12 learners and ambassadors to communicate the value of ambassador-led outreach programs. Challenges for securing funding were also identified. For example, one participant stated, "We were sidetracked by funding. How do you stay true to your messaging but still get funding?"

Additional Theme Summaries
Themes 11-20

This session provides brief overviews of the remainder of the top 20 most populated themes in the community reflection analysis.

Research Questions: 69

"Research questions" referred to unanswered questions that participants raised during the meeting. Many of the excerpts aligned with content that fell in the "Needs Assessment" subcategory of "Evaluation". Topics included: defining success, understanding facets of engagement, communication strategy effectiveness, and understanding underlying factors that might impact ambassador program effectiveness.

Ecosystems and Networks: 68

"Ecosystems and networks" was used to represent the needs of all stakeholder groups impacted by engineering outreach. Participants expressed the belief that learning and engagement ecosystems should be created for everyone including: participants, administrators, ambassadors, and the larger student body ambassadors sit in, industry partners, etc. Ideas included conferences that would bring various stakeholder groups together to learn from and partner together to make a more robust engineering "web."

Gaps in Programming: 47

"Gaps in programming" focused on limitations that existed within ambassador and outreach programming. Common groups that were identified as underserved by outreach program was elementary-aged students and parents. There were some questions voiced around the value of engaging early elementary aged students in general.

High-level gaps were also discussed. In particular, having ambassadors embracing a holistic understanding and execution of their roles as more than just "presenter" but as a role model and thoughtful mentor who engages across diverse populations to uplift.

Mindset and Framing Engineering: 33

"Mindset and framing engineering" captured participant interest in supporting a variety of cognitive and attitudinal changes in both participants and ambassadors. Namely they emphasized:

- Minimizing limiting language both in how stakeholders think about themselves and others (e.g., engineering is too hard for me" or "there is only one way to be an engineer") and supporting a growth mindset

- Supporting the "Engineering mindset" which bolsters creativity and problem solving when faced with constraints or a problem

- Creating and enhancing STEMinist[6] thoughts and behaviors and developing other social-justice informed mindsets

External Resources: 29

"External resources" captured the various resources shared by participants throughout the course of the working group meeting. Recommendations included: books to read, such as "For White Folks who Teach in the Hood"; organizations to research, including Alaska Native Science and Engineering Program; and funding opportunities to explore, such as NASA Space Grants.

Holistic Approach: 28

"Holistic approach" referred to a need for a holistic approach, which participants highlighted in terms of three main facets. First, for ambassador programs to be truly effective they must find mechanisms and partnerships that allow for supporting participants throughout their

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[6] "STEMinist is a portmanteau of "STEM" and "feminism" and is a term used to describe those who support equality and social justice in STEM fields.

K-12 career. The type of support may change as participants enter different stages of their educational careers.

Second, universities must also take holistic approaches for their ambassadors and student body at large. It is not enough to graduate engineering majors, but they must also prepare them for the workforce and be ethical and just in service of creating a greater culture of inclusion at the university level which will trickle out to K-12 and industry interactions.

Finally, ambassador programs must take a holistic approach to understanding target audiences. This includes understanding motivations, barriers, and being creative about the multiple points of entry to engineering.

Academic and Career Preparation: 27

Participants acknowledge that exposure to engineering was just one small facet of what people need to be successful in gaining entry to engineering and succeeding at the university and career level. "Academic and career preparation" pointed to opportunities for better preparing participants and ambassadors for success ranging from math, robotics, and coding skills to building resilience and support networks. The latter competencies would support adapting to life away from community supports and adjusting to the fast-paced, demanding industry setting.

After School, Weekend, and Summer Programming: 26

The focus of "after school, weekend, and summer programming" is two-fold. First, participants identified an opportunity for more programming that occurs outside of the classroom, particularly summer programming as this was identified in the education literature as a time where skills can either be strengthened or lost. Second, participants highlighted a need to understand and overcome barriers to participation in programming that occurs outside of school. Without understanding these barriers, these programs become yet another opportunity that privileges the already privileged.

Understanding and Impacting the Pipeline: 24

"Understanding and impacting the pipeline" captured the critical questions about the institutional barriers in place that limit access to diverse populations and the importance of some of the barriers. For example, participants were critical about the math requirements associated with engineering degree program admission and wondered, given the prevalence of computational software programs, if high math skills were still necessary for engineering success or if this was an artifact of previous requirements. Similar questions were asked about university-level engineering programs and their relevance to pursuing a career – "Is engineering preparation that is currently offered actually what it takes to become an

engineer?" and "Are the requirements *actually* what it takes to be a practicing engineer for engineers of today?"

Building Community Capacity: 24

"Building community capacity" captured participants' sentiment that ambassador programs had limited capacity to provide the full gamut of support that K-12 learners need in order to pursue engineering activities and careers. Participants generally shared the perspective that families and community members must be engaged and supported so that they can support and empower young learners in pursuing engineering activities.

Discussion

The numerous themes that emerged from this analysis are indicative of the in-depth, open conversations held over the course of the two and a half day community reflection. It is particularly worth noting that the gaps identified through this process is a direct result of participants trusting each other enough to openly express programmatic shortfalls, knowledge gaps, and areas with contested assumptions or beliefs. It was the good faith efforts of the participants engaged in this process that built the path forward for the development of the research agenda, which is presented in the next chapter.

Chapter 6

Research Agenda
From analysis to action

The themes from the stakeholder interview and community reflection began to draw attention to potential action items, such as the need to more intentionally engage with K-12 schools and teachers. This chapter takes the data and insights elicited in phases one through three and turns them into explicit calls to action. These "calls to action" take the form of the research agenda items as well as an action framework, which is informed by Lewin's action research model, a process for simultaneously generating and sharing knowledge, which will be described in greater detail in this chapter.

Method

The construction of the research agenda was informed by a four step process of (1) individual-level critique of the community reflection themes presented in chapter five, (2) draft research agenda creation based on this critique, (3) group deliberation of research agenda draft, and (4) modification of the research agenda. In the first step, before the research agenda was drafted, our 61 stakeholder participants were given a document containing the themes presented in chapter five along with potential questions that the research agenda might address. They were then invited to provide individual comment or critique, which served to generate a diversity of ideas and reactions to the themes and questions. In the second step, the feedback received from participants was used alongside the themes to create an initial draft of the research agenda. In step three, the draft research agenda was, once again, shared with the stakeholder participants. Rather than provide individual feedback as the did in step one, interested participants engaged in a group deliberation and feedback session held via video conference. Group deliberation at this stage is critical to identifying and resolving points of contention. Identifying areas of disagreement is generally intended to support community fit which, in turn, strengthens community buy-in, uptake, and ownership. In step four, the research agenda was modified to reflect the input from the group deliberation meeting.

The research agenda presented in the remainder of this chapter is the result of this four-step process and, more specifically, the input provided by our community members. Through this design, community co-creation was still embraced and grant personnel bias was minimized in this final stage of creation. In what follows, we first present an overview of the six research streams and a framework for how these streams connect to each other. Then, the research

streams are described in greater detail. Finally, we present an action framework that is intended to provide insight into *how* the agenda should be enacted for greatest impact.

Foundational Thinking about the Research Streams

Six research streams were identified as a result of the thematic analysis. In the numbered list that follows, the research streams are prioritized in the order which they should be addressed. They are:

1. Gather targeted, foundational research on learning and decision making
2. Define and operationalize "success" for ambassador-led outreach
3. Engage with and support stakeholders
4. Develop an evaluation framework
5. Build an intentional sharing community
6. Communication: a cross-cutting consideration

Priority, in this instance, is not defined as level of importance or quantity (e.g., an aggregate of themes). Rather, is representative of how knowledge gleaned from earlier streams can be used to inform the subsequent streams. For example, one must first clearly define realistic, research-backed expectations for single-touch, hour-long outreach (stream I) so that they can then establish the goals and objectives of ambassador program (stream II). This in turn would then inform the development of an evaluation plan (stream IV).

This prioritization provides a recommended order for entering the body of research, but it is a necessary oversimplification of the relationship between streams. The prioritization provides an entry point, and does not represent how the streams should be treated over time. The process of building such a robust body of knowledge is iterative and not linear and there is a complex interplay between the six streams. Being cognizant of these connections will help the ambassador program community maintain a nimble and resilient agenda that helps us adapt to the academic-nonacademic intersection critical to this work. Specifically, as research findings are established, information in one stream is likely to inform or interact with the information in others in a nonlinear manner. To elaborate using the previous example, as the evaluation plan (stream IV) is implemented, findings may add to the body of foundational research (stream I). In figure five, a more robust, theoretical understanding of the relationship between the streams are provided.

At the heart of the model is "defining success" (stream II) and "engaging and supporting stakeholders" (stream III), which sit at the center due to their importance to ambassador
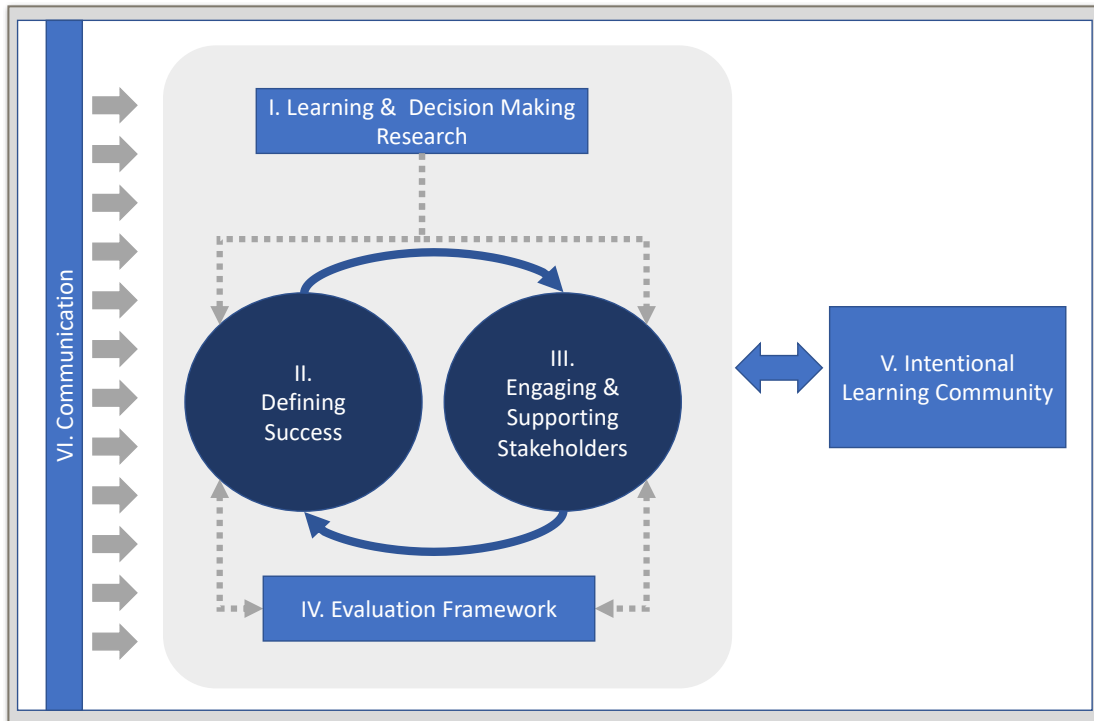
Figure 5. Research Stream Model

program success. Through engaging stakeholder groups, like families and teachers, a more robust and community-informed understanding of ambassador program success can be formed. Similarly, these definitions of success may impact how community members are engaged and in what capacity.

There are two key inputs informing the feedback loop between stream II and III (illustrated in figure five): "learning and decision making research" (stream I) and "evaluation framework" (stream IV). Stream I refers to foundational research on topics such as engineering identity, self-efficacy, or community engagement for engineering success. The information gleaned from this research would necessarily inform definitions of success (stream II) and how stakeholders are engaged (stream III). Stream IV functions slightly different than stream I because has a more of a bi-directional relationship. To elaborate, findings from the evaluation will inform definitions of success and community engagement. However, definitions of success and approaches to community engagement will also influence what evaluation questions are created.

Streams V and VI sit on the outskirts of the model but that is not indicative of a lack of importance. Indeed, both are critical to the success of all of the other steams. Stream V (building an intentional sharing community), in addition to being valuable in its own rights, is a critical facet for dissemination of information and, in turn, the creation of societal change as a result of improvements in ambassador-led programs.

Stream VI (communication) is equally important in its role as a cross-cutting consideration. Effective communication is at the heart of any outreach activity, thus if ambassador-led programs do not have robust data, best practices, and strategies for communication, then they cannot be successful. Stream VI requires explicit attention in terms of advancing and evolving the research agenda itself, the manner in which the findings are disseminated, and ultimately how programs engage stakeholders.

In what follows, each of the six streams are discussed in greater detail. Sample questions that each of research streams might address are included, as are recommendations for actions that could be taken for entering and addressing each research stream.

I. Targeted learning and decision-making research

Underlying many of the trends that emerged from the working group meeting are gaps in understanding of basic research that would direct the development of content and training for ambassador-led programs. These topics are often centered around the K-12 learners that are the recipients of the outreach efforts. Many of the questions that arose centered on analyzing core components of ambassador-led outreach such as focusing on engagement over learning ("What is engagement?"), how outreach should function over the K-12 trajectory ("what is the role or impact of exposure to engineering at an early age?"), and how engineering outreach may have benefits beyond awareness of engineering ("How does STEM impact ELA (English language arts) and Math scores at the elementary level?", "Is there any research on the impact of hands on learning? Can we validate the benefits of hands on learning on science, math, and writing outcomes?"). See table five for additional research questions.

There was also a call to better understand the concepts that lay the groundwork for outreach. For example, participants wanted research that explored and parsed apart concepts like "engagement" and "engineering identity" and related components such as "self-efficacy," with additional focus on topics that are particularly important to underserved communities such as "stereotype threat" and "agency." For a list of sample questions derived from the working group meeting, see table five.

Table 5. Sample research questions for stream I

Research Questions Posed by Stakeholders
What is engagement?
What do we really mean by engagement? What are the components and features? Who is involved?
What impacts engagement? Does cost impact engagement? How does the selection process impact engagement? What are the other barriers to engagement?
How do we move beyond engagement? Is it possible to move past engagement?
How are we increasing equity?
What is the real impact of seeing K-12 learners once versus multiple touch points?
What is the role of exposure to engineering at an early age? What is the most important substance of the exposure?
"How does STEM impact ELA (English language arts) and Math scores at the elementary level?"
"Is there any research on the impact of hands on learning? Can we validate the benefits of hands on learning on science, math, and writing outcomes?"

Actions: There is some data available on these topics but not with the specific permutation that research agenda participants identified. Specifically, studies on these topics tend to focus on the undergraduate student experience (see Anagnos, Lyman-Holt, Marin-Artieda, & Momsen, 2014) or the impact of long-term engagement between K-12 learners and ambassadors (see Holmes, Redmond, Thomas, & High, 2012). To better align with the structure of most ambassador program models, additional studies studies should be conducted that focus on the impacts of short-term, ambassador-led outreach model on K-12 learners. The concept of critical tipping points for impact should be further explored. Specifically, research should explore whether there is a simple cumulative effect or if tipping points exist. Where tipping points are found, additional research should be conducted to understand outcomes of hitting the tipping point as opposed to not hitting it (i.e., is there a marginal impact even if a tipping point is not reached?).

II. Define and operationalize "success"

One impetus for this project was to push toward a robust, nationwide assessment of ambassador programs to better assess impact of these programs. However, what ultimately was revealed was a lack of clarity around long-term, big picture objectives or, in other words a shared vision of success. Indeed, this question was explicitly asked a number of times: "What is a successful ambassador program?" and "There are measures of success – but how do we capture data? And, more importantly, what are the measures of success?" Participants often asked questions like "How do we increase efficacy?" but efficacy for who and in what? (For a list of sample questions derived from the working group meeting, see table six)

This lack of clarity seems to come from two places: (a) the obligation to balance "triple customer" needs (university leadership, undergraduate student, and K-12 learners) and (b) a lack of clarity on what can be accomplished through a one-hour intervention. Programs may have goals that are not aligned with the "dosages" that they are able to give in light of limited time and resources.

Additionally, there is a need to approach success through an "ecosystem" framework. This means that, first, programs need to consider how they fit into the suite of outreach programs that the K-12 learners are exposed to in service of understanding the specific gaps that ambassador-led outreach programs are filling. Second, this means that they must consider the whole student including their values, family dynamics, community, etc. For example, some under-resourced high schools do not always offer the prerequisite courses necessary for gaining acceptance into an undergraduate engineering program. Thus, outreach programs must account for this and adjust resource offerings and support structures accordingly. In other words, if ambassador programs do not take an ecosystems and whole-student approach, programs can meet programmatic goals and definitions of success and still fail the K-12 learners that ambassador programs strive to serve.

Table 6. Sample research questions for stream II

Research Questions Posed by Stakeholders
How do K-12 learners and ambassadors interact in a classroom setting? (We must consider both mechanism and outcome)
What are the reasonable expectations for what K-12 learners should do or know as a result of outreach? ("We want knowledge outcomes but that isn't necessarily reasonable, nor should it be the only goal.")
Are we really trying to create more engineers or just the engineering mindset?
How do we teach K-12 learners to hurdle, rather than stop, when faced with barriers?
What is success? How does it vary by age? How is it defined?
There are measures of success – but how do we capture data? And, more importantly, what are the measures of success?
How do we increase efficacy?
Can we develop a resource that articulates appropriate definitions and metrics of success based on age group?

Actions: There are a number of steps that are important to acting upon in this stream. First, the previous objective on foundational research could provide insight into creating clarity around how different interventions function within the target population given different age groups and the constraints of outreach models. This would provide grounding for what success looks like. Second, data gathering should occur based on what metrics programs

currently are assessed on by leadership, funders, etc. Finally, the definition of success must be reflexive and consider the whole student. This means that it should employ flexible definitions, pathways, and metrics of success that place the K-12 learner at the center. In other words, an ambassador program is not a success if it's internal goals are met but it does not, in some way, create success for the K-12 learner.

III. Engage with and support stakeholders

Stream III (engage with and support stakeholders) is the largest and most loosely bounded stream. This is because there is a wide variety of stakeholders that ambassador-led outreach programs engage with and the needs, interests, and values of stakeholders can vary greatly. Stakeholder groups can be divided into three categories: target audience, outreach partners, and ambassadors. Across all groups, a deep understanding of their needs will allow programs to find synergies and have greater impact. Furthermore, engagement informs stream II (defining and operationalizing success) but also should be informed by stream II. For a list of sample questions derived from the working group meeting, see table seven. In what follows, each of the three stakeholder groups are described in greater detail.

Target audience

Target audience includes the K-12 learners that ambassador-led outreach programs seek to interact with, as well as their families and communities. Adequately engaging and supporting target audiences requires a robust assessment that starts with understanding barriers to participation. Additional literature review-based research can be conducted to enhance understanding of barriers and the identification of possible solutions, such as within the field of cultural and gender psychology (see Mendez & Westerberg, 2012), and the anti-racism literature (see Dillon, Skelton, & Reitenauer, 2019; McMahon, 2003; Wiggan & Watson, 2016). However, there are a number of topics that may require deeper engagement and dialogue with the local community. For example, program administrators must also understand the diversity of motivations and interests that learners and their families may have. Through this information, new programs and activities can be created or existing ones modified to better communicate to, accommodate, and engage learners from diverse backgrounds and cultures.

Outreach Partners

Outreach partners span a variety of backgrounds such as industry, funding agencies, nonprofit organizations, and K-12 teachers and administrators. They may also include internal partners such as university administrators, faculty, researchers, and other outreach programs. Similar to the "target audience" category, it would likely be helpful to conduct an assessment of needs, gaps, and existing barriers. This knowledge could be used to increase

efficacy and quality of outreach, bolsters engagement from partners, and would allow the ambassador-led outreach program to offer additional value-add to partners. For example, through assessing industry partners, administrators may learn that attending in-school events might be challenging to accommodate, but mentoring ambassadors at the end of their workday may be more feasible.

Ambassador Programs

Despite their important role, ambassador programs (and ambassadors) are listed last because the way in which they are engaged and supported must align with insights garnered from assessing target audiences and outreach partners. For example, knowledge gained from target audience insights can be used to enhance and inform cultural competence and sensitivity training in ambassadors.

Table 7. Sample research questions for stream III

Research Questions Posed by Stakeholders
How do we engage **parents and families**? What are the most important outcomes of this engagement?
How do **parents** engage with schools, teachers, and their student learning?
What do **parents** want and how do they see these programs?
What are the barriers that exist to enrolling in out of school activities and how can we help? Is it shifting hours to align with **parent** work hours? Is it help filling out forms?
What are good unintended consequences of ambassador programs for **teachers** and **parents**?
What do **teachers** actually want or need?
How many **teachers/schools** do follow up activities or programs?
What technologies do **teachers** have in the classroom?
Do **teachers** use the extension activities that we create?
What is the role of **guidance counsellors**? How do we engage them?
How do we make sure ambassador programs take a holistic approach to understanding and impacting their target audiences?
it doesn't matter how much we prep K-12 learners or bring in diverse students if **industry** doesn't improve. How do we help them look at themselves and their role in the leaky pipeline?
What do train the trainer model for **teachers**, **parents**, **industry**, etc. look like?
What are best practices for cross sector collaboration?
How do we design learning experiences that best meet all stakeholder's goals?
What factors/limitations contribute to stakeholder engagement (or lack thereof)?

Actions: The diversity of stakeholder groups identified in this section, warrants an equally diverse approach to engagement, particularly since local context may impact their needs and capacity. This will likely require tailored engagement that suites their unique characteristics, thus, the creation of assessment tools for all stakeholder groups could be a beneficial first step in establishing baseline data. This data could provide preliminary information that would prepare programs for entering the engagement process, or else it could provide potential partners with assumptions and beliefs to respond to. This assessment could be useful at two levels. First, it could provide local, program specific assessments to determine immediate actions for individual programs. Second, data could be compiled across programs for regional and national level analysis. Additional community engagement resources and best practices could be compiled from fields such as community psychology, engineering education, and public health.

IV. Evaluation framework

Ambassador program stakeholders share a believe that evaluation is critical, however, evaluation does not occurring broadly and consistently for a number of reasons, including: lack of clarity on foundational components (stream I) and definitions of success (stream II) and shortage of resources and time. Additionally, to truly understand the impact of programs requires a longitudinal and/or national approach to assessment that tends to be outside of the bounds of what a program administrator can do.

Given these factors, an evaluation framework and database can be an important tool to providing programs vetted questions and processes to allow them to easily create evaluation tools to assess the effectiveness of their programming. Additionally, through the use of standardized questions across programs, data can be compiled across programs. Through the engagement of stakeholders (stream III), parallel questions can also be developed and administered to outreach alumni at other stages in their life, such as in the university or industry setting. For a list of sample questions derived from the working group meeting, see table eight.

Table 8. Sample research questions for stream IV

Research Questions Posed by Stakeholders
How do we develop shared language that provides a framework for guiding our assessment processes?
How might we assess the effectiveness of our communications and communication strategies?
Can we get deep information on how kids do things and feel things?
Are we gathering the right data? Are we too focused on "the pipeline"? What about people who do not go into engineering but do engage in: creative thinking, problem solving, iterative processes?
How can we assess our programs through using data that is already collected (e.g., test scores)?
How do we gather data while making sure that it is communicated that we are focused on the kids first and foremost?
What are the outcomes that we have not studied but would like to study?
What kind of data can shift policy to support progressive pedagogy for STEM?
How do we gather and share data that is important to us and our stakeholders? (specifically, funders, teachers, and schools)
Topic: **Are K-12 learners more likely to come to school on a day when ambassadors are coming?**
Topic: **Are the current degree requirements ACTUALLY what it takes to be a practicing engineer for engineers of today?**
Topic: **What are the top 3-5 barriers faced nationally? Are they the same as those identified in the working group session (transportation, funding, and time)? How well do people meet these challenges? What are best practices for addressing them?**

Actions: through reflecting on the data derived from Streams I, II, III, and V, along with evaluation best practices, a suite of questions can be developed that span, or are focused on, different age categories and outreach programming models or goals. However, evaluation questions are only as good as the way they are used. As such, a flow chart should be constructed to guide the user through the process of evaluation ranging from question selection to data collection and analysis. Additionally, evaluation best practice resources can be linked into the flow chart to further support how evaluations are conducted and analyzed. Given the specialized skills and time investment needed for evaluation, some stakeholders may prefer to use an external evaluator to conduct the work. As such, there may be a need for a secondary flowchart that that functions similarly to a health self-advocacy flowchart in that helps program administrators effectively partner with evaluators.

There are a few complex, or sticky, issues that may be important for this research stream to address. An important challenge that should be addressed during the development of this

evaluation question data base is whether it is possible to create "baseline questions" that would be applicable and beneficial to all programs so that nation-wide analysis can be conducted. Another sticky issue to consider at greater length is addressing the needs of programs that may not have the resources or skillsets to conduct evaluations. Specifically, it is unclear whether an evaluation hub could successfully provide the dual function of (a) being a center for capturing and analyzing nationwide data while also (b) supporting the outreach community by facilitating the capture and analysis of program evaluation.

V. Intentional sharing community

Program administrators work to "keep multiple balls in the air" including program design and improvement, assessment, funding, ambassador training, audience-appropriate engineering activity development, managing ambassador and K-12 school schedules and relationships, and so on. Such a wide variety of responsibilities require equally diverse knowledge bases and experimentation in problem solving. Though a conference model with face-to-face engagement would be beneficial, it can be logistically and financially challenging for program administrators to attend. Furthermore, conferences allow for information sharing but typically occur annually and, thus, do not facilitate the ongoing knowledge exchange, discussion, and problem solving that stakeholders identified as important.

Over the course of data collection, an online platform emerged as a key need. Stakeholders described an online platform that functioned as a resource hub where administrators (and others) could find vetted information ranging from: activities, diverse in focus and sorted by age level; best practices and research on pedagogy, communication, and community engagement; and - perhaps most important - a mechanism for sharing and troubleshooting problems. Some participants also felt that this hub should be "whole life cycle" in focus, offering support to young learners and career engineers alike.

As the dialogue continued, the suite of questions posed by participants (see table nine), led to a broader question:

> Is the idea of a resource repository really a "filler" seeking to account for the lack of community and connectedness between ambassador-led outreach programs?

It is often through recommendation and word of mouth that people learn about other programs, new articles, and other resources. Given that engineering ambassador programs are often the only ones of their kind at their institution, they may ultimately need a more tightly coupled community.

Table 9. Sample research questions for stream V

Research Questions Posed by Stakeholders
How can we have shared language, missions, and definitions?
Can we work together as a community to develop a robust, holistic STEM and engineering identity that can be operationalized to inform programs and activities?
How do we continue being thought partners for each other?
How might we share research directions that allow for different entry points and contributions so that all of us, and our unique programs, contribute to a shared product (or assessment)?
What are the components of ambassador training? What are best practices?
Who is the repository for? What are the needs it will meet? Who will vet it?

Actions: A robust community assessment should be conducted to (a) gather information on programs, activities, barriers, and resources used and (b) identify the priorities and preferences in the development of an online community hub. Though some of this assessment is best conducted via survey, the importance of focus-group methodologies should be incorporated. Though more difficult to analyze, focus groups are more flexible in nature and allow for responsive construct exploration and data collection, structured more by the participants rather than biases and preconceived notions of those designing the survey.

Related to this, follow up assessments should be conducted every two to four years so that the content of the hub maintains relevance. Based on this information, resources and protocols should be developed in service of sharing information and fostering community. Offerings may include an actual resource database, but might also include monthly newsletter, partner talks, and other opportunities to engage with and learn from each other.

VI. Communication

Though communication could be nested under stream IV (Engaging with and supporting stakeholders), its importance to program implementation and the execution of a robust research program cannot be overlooked. For example, gathering robust foundational data (stream I) will require some interdisciplinary collaboration and dialogue and thus an ability to communicate across disciplines will be critical. Similarly, to successfully develop a web-based hub in service of building an intentional community (stream V), it may be critical to understand best practices in digital communication and, of course, engaging with and supporting stakeholders (stream four) require that communications be thoughtful and

appropriate right from the beginning. Despite the overlap with other streams, there are also components that are unique to communication. For example, stakeholders identified the importance of advocacy, as a subset of communication, for advancing the agenda of engineering outreach in policy and funding arenas. The success of code.org, a nonprofit organization that advocates for computer science in school curriculum, can provide a framework for how informal and formal engineering education programs can advocate for institutional integration in K-12 settings.

Table 10. Sample research questions for stream VI

Research Questions Posed by Stakeholders
How do we assess communication strategies across partners? How might we assess the effectiveness of our communications and communication strategies?
How do K-12 learners and ambassadors interact in a classroom setting? We must consider both mechanism and outcome
How might we assess the effectiveness of our communications and communication strategies?
How do we change the conversation? We know that there are key messages that resonate with youth, women, and minorities
How do we get to families and parents and then keep reaching out to them?
We are seeing an increase in female participants, but not so much in underrepresented minorities. What are we doing wrong? How are we communicating to their parents? Given that these programs are for everyone, can we target them while including information that is appropriate for everyone?

Actions: Much of this can be accomplished in parallel with streams I and III. It is important to understand research around communication best practices for the various target audiences. Further data on communication preferences can be gathered through the assessment tools developed in stream III. Additionally, the role of communication in terms of community advocacy should be explored and incorporated into communication strategies and best practices

Action Framework

This research agenda, which focuses on action-oriented, applied research and community building, is informed by the action research philosophy and methodology developed by Lewin (1946). "Action research" is a collaborative problem-solving approach that equally values data gathering (research) and implementation (action). Generally, action research takes an iterative approach of planning, acting, observing, and reflecting (see figure six) (Hearn, Swan, & Geels, 2019; Lewin, 1946).
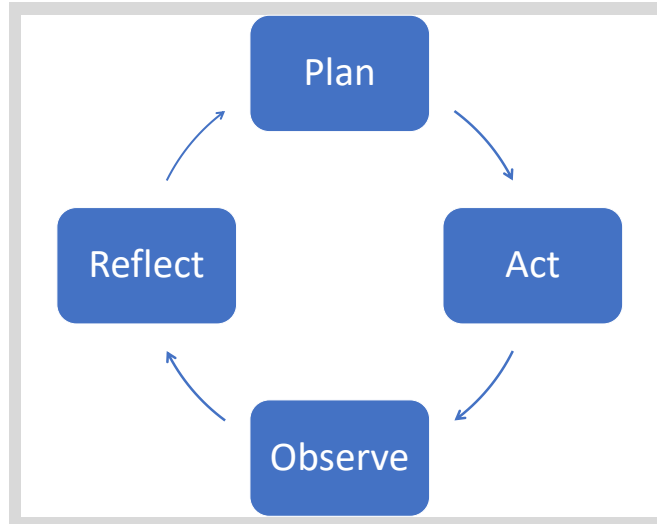
Figure 6. Lewin's Action Research Model

However, this method is possible because the projects tend to be smaller and more unified in focus than our current, multi-institution, nationwide focus. As such, the three-step model we propose suggests the iterative, action-oriented focus of Lewin's model while also reflecting the unique context of our project (see figure seven). Indeed, one could imagine Lewin's four-part process taking place within and between each of the four components identified in the model.

ASSESS: Are we lacking a baseline understanding? Did we (or will we) implement some type of change?

IMPLEMENT: Do we have a clear plan with buy-in from all relevant stakeholders?

SHARE: Will you be taking an action that stakeholder groups will want to help shape? Have you taken an action that a stakeholder group would benefit from learning about?
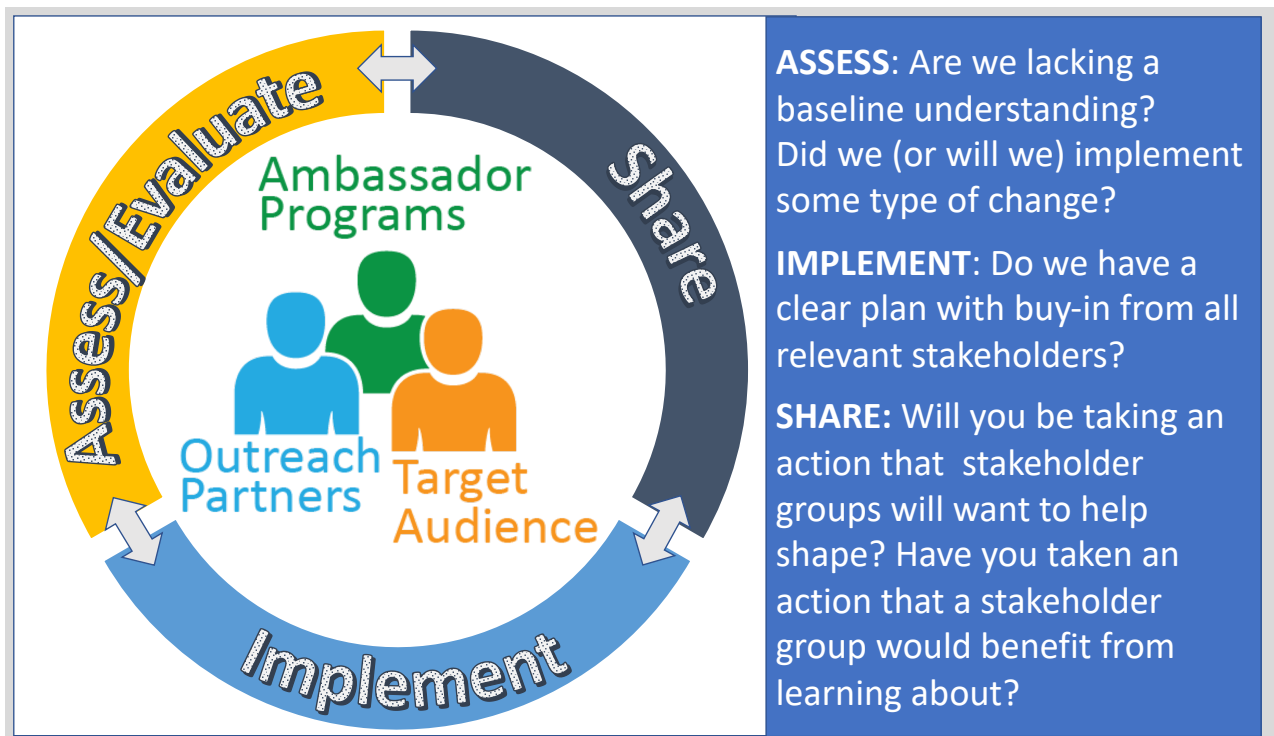
Figure 7. Research Agenda Decision Tool

To elaborate on this model, there are three main actions that could be taken: assess/evaluate, share, and implement. "Assess/evaluate" refers simply to gathering data in a systematic way in service of decision making. It may also be gathered initial, baseline data in order to measure the effectiveness of an intervention. "Share" refers to discussing data, ideas, outcomes, etc. The language on this variable, in particular, is broad because "sharing" may vary the most based upon the audience, the project, or even the stage of the project. It may look like reporting out, marketing, or a feedback session. "Implement" in this context refers to the execution of any initiative. As noted, any of these actions may look different depending on the audiences engaged and the level of active participation.

The categories of audience are captured in the middle of the diagram. "Ambassador programs" refer specifically to engineering and STEM ambassador-led outreach programs. "Target audience" refers to the K-12 students, their families, and communities (which may include schools, after school programs, and religious organizations). "Outreach partners" include partners that are internal and external to the organizations. External partners are industry, funding agencies, nonprofit organizations, and K-12 teachers and administrators. Internal partners include university administrators, faculty, researchers, and other outreach programs.

Though models sometimes function to provide directionality and a clear course of action, such as Lewin's circular process, the purpose of this specific model is, instead, intended to function as a decision support tool that, much like the Social Cognitive Theory model (see Bandura, 1999), also captures the bidirectional relationship between key facets. The traditional model of action research would imply that the process would start with assess/evaluate to gather data, then move to implementing change as a result of the data, and finally end with sharing and disseminating the information. However, the multi-directional, open-ended nature of the model was created in order to guide the research team's efforts, and the efforts of the broader ambassador-led outreach community, to maintain a reflectiveness and responsiveness that allows for adapting to changing situations as well as the nature of the various needs embedded in the research agenda. For example, when engaging with and supporting stakeholders (stream III), researchers and practitioners may rely heavily on the "share" component as follows: sharing with our stakeholders our objective, assessing engagement themes informed by their insights, sharing our findings with our stakeholders, and then implementing solutions based on their insights. Conversely, though gathering foundational research (stream I) will take an iterative approach in its own right, it may be a more linear process: assessing and evaluating how underlying factors such as engagement function, sharing the findings with the ambassador program community, and then diffuse implementation will be led by the individual programs.

The biggest strength of this framework is the way in which it asks the users to engage in a reflective process rather than simply follow a framework that may not apply to their specific ambassador program. However, herein also lies a potential weakness. This intentional vagueness can be, at times, overwhelming or create a sense of uncertainty. As a result, questions have been embedded into the model in an effort to support the process of reflection. Through this approach, we ultimately hope to foster the development of a just and inclusive body of research, and actions, that values and benefits all stakeholders (Kemmis, McTaggart, & Nixon, 2014).

Discussion

The identification of research streams, a research model, and framework provides a starting point for thinking critically about the implementation of ambassador programs and the underlying research that can guide it. These resources are not intended to be prescriptive, but instead function as a way to harness the strengths and efforts of stakeholders across the nation who are working to increase the effectiveness of ambassador programs. The following, concluding chapter articulates the desired impacts of the research agenda and also presents ideas for steps to begin implementing this research agenda.

Chapter 7
Concluding Remarks
Putting the data in context

Over the course of two and a half years, researchers have worked to engage the engineering ambassador-led outreach community in service of creating the community co-created research agenda laid out in the previous chapter. The six research streams span a diversity of upstream and downstream topics including: foundational research and an evaluation framework, that would contribute to more effective outreach programming; engaging stakeholders, to more effectively build an engineering ecosystem to support K-12 learners; and an intentional sharing community, so that both problems and solutions can be quickly identified within the community.

Though broad in scope, such a robust research agenda, and its resulting findings, could have a large impact on the effectiveness and impact on engineering outreach across the nation. The potential direct outcomes of implementing this research agenda span from increased K-12 learners engagement in engineering-informed, creative, problem solving to an increase in numbers and diversity of applications and enrollment in engineering programs.

However, the greatest societal impacts as a result of this research agenda and its holistic approach is that it could play a role in shaping the engineering ecosystem. First, the studies that this research agenda is designed to lead to should improve the quality of training for teachers and engineering ambassadors. Second, it also would more tightly loop families, communities, and industry partners into partnership for supporting K-12 learners. Accomplishing these two goals would lead to stakeholders who could provide more intentional, effective, and ethically-grounded support to K-12 learners interested in engineering.

Behavior changes notwithstanding, the stronger communication between the stakeholder groups alone could allow ambassador programs to be more responsive and effective. resulting in a more robust ecosystem In particular, changes in the ambassadors and industry partners may be particularly broad in their impacts. Engineering attrition occurs at a disproportionately high level for underrepresented populations through university and career settings. However, capacity-building in ambassadors and industry partners can transfer to settings other than outreach, such as within the university setting. Similarly, from the K-12 learner's perspective, there is a higher chance for increased resilience and well-being. This is because early and continued exposure to more effective engineering outreach

has the potential to increase foundational skills, enhance understandings of the challenges associated with engineering, and build relationships with mentors and role models - all factors that are critical for building resilience in the face of challenges.

Limitations

One limitation within this project was the lack of representation within a few stakeholder groups. Specifically, there was minimal participation from K-12 administrators and staff and industry partners, despite efforts were made to invite and include. In terms of K-12 stakeholder, participants included one administrator, two teachers who are currently the recipients of engineering ambassador outreach programs (one in the Southeastern and one in the Northeastern United States), and one individual who is currently university faculty but previously was a teacher who was a recipient of engineering ambassador outreach. Most notably, though a number of ambassador program administrators came to to their university position after working within an industry setting, we had no representation from individuals currently working within industry. As future work is built out, there should be additional effort to incorporate K-12 and industry stakeholders. This may require shifting mechanisms of engagement or tapping into personal connections to establish mechanisms to increase participation.

This need for more participation from K-12 and industry stakeholders, may mean that their voices, perspectives, and priorities are not reflected in the proposed research agenda. This may mean that there are critical issues, that are of importance to them, not represented in this document. Engaging these stakeholder groups before taking action on the research agenda may be critical to getting buy-in while also increasing the robustness of the agenda. It may be important to conduct additional, targeted workshop sessions in service of allowing these groups to contribute to the body of research. Potential outcomes from such involvement might include: modification of the existing research agenda, either by modifying existing streams or adding additional streams, and the creation of a sub-agenda.

Moving forward with the agenda

When thinking about the implementation of the research agenda, it may be helpful to begin with assessing common approaches to gathering and assessing data as well as their limitations. For example, researchers often rely on uni-directional, efficient forms of data gathering, such as survey instruments. However, the over-reliance on survey methods has three critical short-comings. First, surveys do not as readily allow for emergent themes to surface to the same extent that real time conversations can. Second, it does not support the formation of relationships and community but is, instead, more extractive in nature. Finally, this lack of community also translates into a lack of capacity-building, and limiting of potential facilitation of future capacity building, across all stakeholder groups. It is through the open exchange of information and resources that stakeholders learn more fully about

each other's work and the ways in which they can overlap and be symbiotic. Implementation of research agendas could also rely on broadly distributed ownership. This may not be a viable option in the case of ambassador programs, given the diversity of programs, administrative workload of key stakeholders which does not allow for conducting research, and limited resources,

There are many means by which this research agenda could be advanced, but the heart of this advancement should be the understanding of the partner organizations and the scarcity of key resources - namely time and funding - and the logistical challenges that they may create. A consortium-type model of implementation may be both most useful and most likely to make headway. It could function as a way of resource sharing, meeting the goal of stream V (creating an intentional sharing community), but could also meet a number of other goals. For example, the consortium could provide a unified focus for executing the research agenda. It could also partner with member-institutions and provide a seamless pathway for participants to receive and respond to findings as well as provide them with a mechanism for implementation in a way that does not add additional burdens to their resources and time and. In terms of the research agenda, this would also create a sense of ownership over an otherwise diffuse body of work.

Though formal education is more heavily studied within academia, it is less flexible and limited by state education standards and school district requirements, which currently do not include a strong focus on engineering. Ambassador programs and other informal education pathways are better positioned to quickly adapt and respond to societal need and, in turn, are better equipped to address the issues related to the lack of diversity within the engineering ecosystem. The undertaking of a systemic, nationally focused research agenda is an important step in increasing ambassador program effectiveness and impact.

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