

STEM students leading cultural change: How agency and capacity for collective action are cultivated within a distributed network

Mr. Robert P. Dalka, University of Maryland, College Park

Robert Dalka is a graduate student in the Physics department at the University of Maryland, College Park. He is a part of the Physics Education Research Group, along with his advisor, Dr. Chandra Turpen. His research interests are in student leadership and organizational change.

Dr. Chandra Anne Turpen, University of Maryland, College Park

Dr. Chandra Turpen is a Research Assistant Professor in the Department of Physics at the University of Maryland. She has expertise in physics education research and engineering education research. Her work involves designing and researching contexts for learning (for students, educators, and faculty) within higher education. Her research draws from perspectives in anthropology, cultural psychology, and the learning sciences to focus on the role of culture and ideology in science learning and educational change. Her research interests include how to: (a) disrupt problematic cultural narratives in STEM (e.g. brilliance narratives, meritocracy, and individualistic competition); (b) cultivate equity-minded approaches in educational spheres, where educators take responsibility for racialized inequities in student success; and (c) cultivate more ethical future scientists and engineers by blending social, political and technological spheres. She prioritizes working on projects that seek to share power with students and orient to students as partners in educational transformation. She pursues projects that aim to advance social justice in undergraduate STEM programs and she makes these struggles for change a direct focus of her research.

Devyn Elizabeth Shafer

Dr. Brianne Gutmann, San José State University

Brianne Gutmann (she/her) is an Assistant Professor at San José State University. She does physics education research with expertise in adaptive online learning tools, identity-responsive mentoring and community building, and macroethics in science education. She received her PhD in physics at the University of Illinois at Urbana-Champaign in 2019, where she focused on mastery-style online learning for engineers in a large preparatory physics course. In her postdoctoral work at Texas State University, she co-developed and implemented curricula to engage students in conversations about ethics, science and society, with a research interest in how to best support students and instructors in these conversations. She recently finished a AAAS Science & Technology Policy Fellowship at the National Science Foundation, supporting and working with the Hispanic-Serving Institutions (HSI) Program. She is also an organizer for the Access Network, a national network of student-led organizations working for equity in STEM.

STEM students leading cultural change: How agency and capacity for collective action are cultivated within a distributed network

Abstract

In typical Engineering and Science education, students often are not given opportunities to build skills outside of narrowly defined, technical domains (Lucena 2013). Experiences that encourage students to engage in social justice and activist work is crowded out in traditional STEM programs. Oftentimes, these structures must be created deliberately in order to provide student leaders with this type of mentorship (Leydens 2014, Nieuwma 2011). One such initiative, the Access Network, aims to do just that. The Access Network is a collection of programs (sites) that are situated in U.S. universities that work towards a more equitable, diverse, inclusive, and accessible version of the STEM community (Quan 2019). Access prioritizes student leaders, both at the network-level and in their local sites, by empowering them to take the lead on actions and by providing support for this work. Access sites engage in activities that build inclusive learning communities, provide guidance through peer mentorship, and support growth in students' leadership around social justice.

One major function of the Access Network is to connect students across these local efforts and to facilitate the sharing of ideas and experiences between sites. One central way that this is done is through the work of Network Fellows (NFs), student leaders who work collaboratively in network decision-making and team projects that support the network and the sites. The NF position provides space for students to take power over decision making and supports them through mentorship in social justice and activist approaches (Amezcuca 2020). To better understand how students approach this role and view their work, we have conducted semi-structured interviews with nine Network Fellows who served in the role for at least two semesters. In our analysis of emergent themes, we have found that individual agency over their work, shared leadership in decision making, and building relationships across the network are key outcomes of the Network Fellow experience. We have additionally identified key conceptualizations of the team collaboration that Network Fellows discuss that cultivate the outcomes described above. We see these conceptualizations as important for capturing how the Network Fellow team conducts its work. We hope for our work to serve as a model for others that wish to cultivate similar experiences for their own students in STEM.

I. Introduction

Historically, students have been drivers of change; however, many equity-oriented change efforts in higher education have often overlooked or backgrounded the roles students can play in organizing for social change. While faculty members, administrators, and staff hold positions

through which they have authority to determine policies and enact practices within academic institutions, students also have the ability to drive change. Student-led change is often sparked from the ground up and benefits from students' perspectives and enthusiasm. These changes can include the building of new, inclusive, student-centered spaces to continue to move the work forward.

In typical Engineering and Science educational systems, students often are not given opportunities to build skills outside of narrowly defined, technical domains [1]. Experiences that encourage students to engage in social justice and activist work are crowded out in many traditional STEM programs. Oftentimes, spaces to practice this work must be created deliberately to provide student leaders with this type of mentorship [2], [3]. One such initiative, the Access Network, aims to do just that. The Access Network, henceforth referred to as Access, is a collection of programs (sites) that are situated in U.S. universities that work towards a more equitable, diverse, inclusive, and accessible STEM community [4]. Access prioritizes student leaders, both at the network-level and in their local sites, by empowering them to take the lead on actions and by providing support for this work. Access sites engage in activities that build inclusive learning communities, provide guidance through peer mentorship, and support students' growth in leadership around social justice.

Students within Access contribute to work within teams centered around shared leadership. These teams have unique features that we believe are important for how they conduct their work and create cultural change. In this paper, we present findings from our study into one of the student teams within Access, called the network fellow (NF) team. The research questions that have driven this project are (i) how do students describe the work of the NF team, and (ii) what outcomes are salient for NFs as part of participating in the work?

Through analysis of interviews with student leaders, we have identified important conceptualizations of work processes from student descriptions of their collaboration within Access. These conceptualizations are important for how students develop a sense of agency, deeper relationality, and inclusive leadership practices. We present how these outcomes are highly important for effecting change both as a part of Access and in other spaces students occupy.

In this paper, we begin by introducing background information on both Access and put the work of the NF team in conversation with other educational change initiatives. We then describe the methods we have used in this work. Next, we present the results of our analysis and reflect on these results in the discussion section. Finally, we use the conclusion section of this paper to discuss implications for other practitioners and motivate future research possibilities.

II. Background

In this section, we first describe how Access is organized as well as how the NF team fits into this organization. Then, we put the NF team and its work in context with reference to other frameworks for student agency and shared leadership.

A. The Access Network

The Access Network was formed in 2015 through connecting university-based organizations together to help support each other in their goals of supporting student leadership and advancing equity efforts within STEM departments. Access functions by leveraging member and site expertise around equity work and sharing knowledge to support all members and sites. The core principles and goals of Access were defined collectively by representatives from the founding sites. The core principles are as follows: (1) foster supportive learning communities, (2) engage students in the process of doing authentic science, (3) help students develop professional skills, (4) empower students to take ownership of their education, and (5) increase diversity and equity in the physical sciences. The goals of Access include the following: (1) empower students and faculty—especially those from marginalized and/or underrepresented groups—as agents in the design, implementation, and iterative improvement of efforts to support the success of underrepresented students, (2) facilitate communication and community among people involved in such efforts, (3) create and maintain a repository of materials and strategies generated through these efforts, and (4) support local communities in adapting these materials and program elements to their unique contexts and populations. Previous evaluation has shown how Access functions in relation to these goals through themes identified by survey data and interviews with student members—including empowering students as agents of change to support the success of underrepresented students [4].

There are now nine total sites within Access; the full list can be found at <https://accessnetwork.org>. All sites affiliated with Access share the common principles described above; however, they vary in the activities they organize and how their leadership is structured. Some sites have more horizontal leadership structures that are entirely student-run; others have strong involvement from faculty. Some sites may engage in individual support—such as mentoring partnerships and scholarships—while others may focus more on providing community support, such as diversity workshops and social activities. These differences are products of each site’s context and driven by local students’ needs and goals.

One component of the leadership structure of Access is the *Core Organizer* (CO) Team. The CO team is responsible for supporting communication, mentorship, and self-reflection in the network. The CO team meets on a regular basis to coordinate mentorship of student leaders, grant and funding applications, and future plans for the network. The team originated from the

various site leaders that came together initially to write the grant that funded the creation of Access. This team has changed and expanded as Access has grown and includes members both located at institutions with sites as well as institutions that do not have local sites.

The largest central activity that the network engages in is the *Access Assembly*, a yearly three-day conference that aims to build community and engage students in sharing ideas and connecting with each other. The Assembly is planned by student leaders within Access that form a team of *Assembly Fellows* (AF). Each site is represented on the AF team by a single student leader who is compensated for their time and travel by a stipend. The AFs organize Assembly sessions, social activities, and housing arrangements and are mentored by members of the CO team in doing so. Analogous to the AF team, there is a set of student leaders known as *Network Fellows* (NF), who oversee communication between sites and document, plan, and implement projects for network and site level activities. In practice, the AF team's work is focused intensely on planning the Assembly, while the NF team does its work continuously over a semester-long timescale. The NF team is the focus of our study in this paper.

The NF team is made up of student representatives from each site in Access. They are given a stipend that is compensation for their work during their semester-long tenure. The NF team includes both undergraduate and graduate students, usually at a 2:1 ratio, respectively. Students who serve in this role may also be involved in their own site leadership; some NFs have gone on to become members of the CO team. The NF team is co-mentored by two members of the CO team. These mentorship positions rotate among COs from semester to semester. The NF team mentors are there to guide NF team meetings and support students in their collaborative work. Often the mentors from the CO team are former site student leaders or faculty that worked in solidarity with student leaders around their site's work. The mentorship skills are developed within a community that critically reflects together on their leadership and collaboration practices.

While the mentors help to guide and support the team, the structure of the NF team is based on shared leadership among the students. The official responsibilities of the NF role include attending twice monthly NF team meetings, contributing to the project work, ensuring communication between local sites, and ensuring decisions of Access support the needs and interests of their sites. Each new cohort of NFs may define what exact projects they work on. This may include continuing past projects from the previous semester or developing completely new ideas based on the NF team's interests. Examples of past projects include updating the website, designing and implementing a winter workshop on mentoring, creating an Access Blog and preliminary blog posts, developing an Access alumni database, designing and creating an Access Newsletter, coordinating intersite travel, and developing a cross-site mentoring network.

Along with supporting communication throughout the network and between sites, NFs also gain important experiences themselves. Previous work has shown how equity and social justice can be

enacted by NFs. This study used an equity ethic framework—defined as “principled concern for social justice and for the well-being of people who are suffering from various inequities”—to show how NFs have developed in “their commitment to cultural change in physics, their desire to create more supportive college learning experiences for others (particularly for students of color), and their expansive forms of professional practice” [5], [6]. In this current study, we aim to understand how NFs conceptualize the work of the NF team to model how the team’s collaboration cultivates such outcomes.

B. Educational Change: Student Roles and Shared Leadership

Student agency has been defined in multiple ways within higher education. In a review of engineering education literature conducted by McIntyre *et. al.*, three broad types of outcomes due to students exercising agency were identified: student learning, persistence, and positioning [7]. While some of these examples focused on student agency related to problem solving and learning in the classroom, others presented agency in relation to various institutional constraints, structures, and engineering cultural aspects. These studies show the importance of empowering students to enact agency not only as an important skill for engineering, but also as a way to bring about change in engineering culture and structures. However, they also discuss the structural limitations of student agency in particular institutional settings, and advocate for faculty serving as a bridge to ensure change.

One popular framework for enacting change within teams of students and faculty is the Students as Partners (SaP) Framework. “Partnership” within the SaP model is described as a “reciprocal process through which all participants have the opportunity to contribute equally, although not necessarily in the same ways, to curricular or pedagogical conceptualization, decision-making, implementation, investigation or analysis” [8]. The model centers transformative change—where classroom and institutional practices are restructured—as these types of partnerships historically do not exist in institutions of higher education and often push against typical norms of institutions.

In a review of students as partners, Mercer-Mastone *et. al.* focus on developing themes about the domains of partnership for those involved in SaP. This review article categorizes the studies in the literature as either (a) subject-based research and inquiry, (b) scholarship of teaching and learning, (c), learning, teaching, and assessment, or (d) curriculum design and pedagogy [9]. Most SaP research work is conducted in the space of curriculum design and pedagogic consultancy. These are spaces that are generally difficult for students to affect directly without instructor input.

In typical projects for the NF team, the students are involved in change efforts and projects that create space or resources that extend past these typical institutional structures. They may not

need to be partnered with faculty in the same way as SaP and other educational change projects. When faculty bring students into a project, there will be institutional power dynamics at play. While the faculty involved in these partnerships may provide a useful bridge between student agency and institutional constraints, they may also end up holding more control over the work than what a true egalitarian partnership would look like.

In one study of Learning Assistants (LAs), undergraduate peer educators who assist with the design and implementation of a course, it was shown how the partnership between faculty and students can highly vary. The authors identified three types of partnership, from one directional partnership to co-design [10]. However, at each level, even the most equal partnership, the feedback and design process were initiated by the faculty member. In another study of LA partnerships, similar types of partnerships were identified: (a) students, (b) informants, (c) consultants, (d) co-instructors, and (e) co-creators [11]. The type of partnership that was experienced by students was found to be mediated within the discourse, meaning that these roles that an LA may take up were fluid and dependent on the context. Partnerships between faculty and students in spaces such as teaching and curriculum design are difficult to be completely open for students to take the lead.

In the NF team, we see something different from students as partners. The students really do have control over the team's direction. The faculty mentors are positioned away from the center of decision making. They are there to support and co-facilitate the team in enacting the students' vision, making collaborative decisions, and fleshing out and assessing the scope of projects. This makes the NF team a particularly fruitful setting for studying student agency and the forms of collaboration that emerge therein.

Individual student agency has been shown to be important for students' development of self-efficacy and for creating change that pushes against dominant engineering education institutions and systems. In one case study, researchers found how student agency could be expanded through processing minoritizing experiences in engineering academic spaces [12]. In another study, LGBTQ+ students were found to resist dominant heteronormative cultures within engineering through navigating these spaces and reaching out to build communities of marginalized students [13]. Yet, these models do not capture what it is like to pursue such changes as an organized team.

Previous work in engineering education has investigated what makes change teams of faculty successful [14]. They found that unified voice and group agency were central to how these teams functioned. Teams with these features helped to create larger and more successful changes than a single individual could accomplish alone. Our goal within this paper is to show how students on this NF team conceptualize the team's work and what that means for students' sense of agency, relationality, and capacity to enact inclusive leadership practices.

One of the team's structures that supports inclusive leadership practices is shared leadership, a set of ways to organize a team that seeks to involve many stakeholders and allow individuals to contribute as a team. Shared leadership, as defined by Kezar and Holcombe, can be structured in three different, possibly overlapping, ways: co-leadership, team leadership, and distributed leadership [15]. The Access Network, and the NF team, work in a sort of hybrid between team leadership—where leadership functions are distributed among team members—and distributed leadership—where leadership crosses institutional boundaries and the format is flexible depending on the context of those institutions.

In doing equity work within higher education, this approach to shared leadership has been expanded upon and termed “shared equity leadership structures.” Proponents of this model emphasize that shared equity leadership “scales equity work and creates culture change by connecting individual and organizational transformation” [16]. In addition to personal transformative work, this model focuses on how diversity, equity, and inclusion (DEI) work is structured within institutions, either through building on roles that individuals already hold within the organizational structure, or through how new roles are created. These different types of structures (hub-and-spoke model, highly structured model, the bridging model, and the woven model) are institutional, meaning that they are highly tied to the ways a particular institution wants to function [17]. We see the NF team as an example that does not neatly fit into any of these institutional structures and may offer important alternative conceptualizations.

III. Methods

A. Study Design

The data for this study comes from semi-structured, hour-long, interviews with NFs that were conducted in January of 2022 over the Zoom platform. C. Turpen conducted the interviews, and would often ask clarifying questions, using her own knowledge of Access. Although not the focus of our paper, we also note that NFs would occasionally use this conversational space to problem solve and brainstorm with C. Turpen around various challenges their sites may be facing.

All experienced NFs who had served for two or more terms were invited to participate in this study. At the time of the interviews, this included a total of 16 students. We chose to focus on students with extensive experience so they could draw on deeper understandings of the NF role through stories from more than one cohort. The motivation for these interviews initially came from COs' sense that the NF role has been: (a) occasionally tricky to recruit students for, (b) initially tricky for student leaders to understand and to find their stride with, (c) drifting in its purpose and activities during the pandemic, and (d) struggling to hand-off and follow through

with projects from one cohort to the next. These interviews were aimed at better understanding what students got out of being an NF to both better define the role for future students and identify any changes to the role that may be necessary.

This initial invitation to be interviewed went to the 16 former NFs who had served two or more terms; some are alumni of their respective institutions and have moved into other spaces, while some are still involved in Access serving in various roles. Ultimately, nine students were interviewed; of the nine students interviewed, seven agreed to participate for research purposes. We have selected four students for our analysis presented in this conference paper. The four selected students represent four separate sites, with an even split between graduate and undergraduate levels.

Table I: Table of participant demographics.

Pseudonym	Ugrad/Grad	Prior Access Involvement	Gender	Race/ Ethnicity
Greg	Grad	3-time NF 1-time Assembly Attendee	Man	African American / Black
Malikah	Ugrad	2-time NF 1-time Assembly Attendee (virtual)	Woman	African American / Black
Arpita	Grad	2-time NF 1-time Assembly Attendee (virtual)	Woman	South-East Asian Indian
Symone	Ugrad	2-time NF 1-time AF 2-time Assembly Attendee	Woman	Puerto Rican

All information about prior access roles is accurate as of time of the interview (Jan. 2022). Demographic information reflected in this table has been synthesized from post-Assembly survey data.

This research is a part of the larger goal of the Access Network research and evaluation team to better understand how students approach their work in the various leadership roles within the organization and consider possible iterative improvements to our organizational policies and practices. As a part of this research, C. Turpen had conducted these student interviews primarily for evaluation. However, she recognized the richness of the student insights that went beyond the pragmatic implications and noted the possible importance for the broader scholarly community.

B. Researcher Positionality

All four authors have been highly engaged in Access for the past several years. D. Shafer is a student leader of the Illinois GPS (an Access site) at University of Illinois Urbana-Champaign and has experience serving in the NF role multiple times. B. Gutmann co-founded Illinois GPS and is now an alum of this Access site. R. Dalka has been a site representative of Equity Constellation at University of Maryland, College Park. C. Turpen co-founded Equity Constellation and now serves as a faculty advisor for Equity Constellation. B. Gutmann and C. Turpen have each mentored multiple cohorts of Network Fellows. All authors have attended one or multiple Assemblies. Many of the student leaders in this research study have overlapped with the research team within NF team collaborations and Access Assembly activities. Our experiences of collaborating with student leaders within Access gives us a unique context for interpreting our participants' stories. Our familiarity within Access increases the trust that is built with the NFs and establishes a shared understanding. In our research, we orient towards a sense of solidarity with our participants and a commitment to the support of the organization.

Within the Access Network organization, we value supporting students in taking leadership roles and meaningfully sharing power with them. As individuals within Access, the research team members hold the values of Access as described earlier. These values contribute to our critique of traditional structures within academia and draw our attention towards particular features of the NF team that we see as importantly different to typical academic practices. Our findings and insights from this data set are shaped by our values and our experiences collaborating with student leaders.

R. Dalka is a white cisgender man, B. Gutmann is a white genderqueer woman, D. Shafer is a white cisgender woman, and C. Turpen is a white cisgender woman. As our research team is made up of all white researchers, we may miss particular ways that the NF experience is racialized for students of different racial and ethnic backgrounds. At times we noticed ourselves making sense of these interviews in relation to our own college experiences, which have been varied among the researchers. For example, R. Dalka completed his undergraduate degree, and continues his graduate studies, at large public R1 universities. He has had multiple opportunities to participate in leadership roles as a student and contribute towards academic initiatives. B. Gutmann was a first generation college student and Pell Grant recipient, and attended a small, teaching-focused liberal arts college without intention to pursue graduate work. She worked outside of academia for a few years after her undergraduate degree, then attended graduate school at a large R1 university. She worked throughout all of her education, primarily in roles that were complementary to her learning and interests in teaching. D. Shafer completed her undergraduate degree at a private R1 university and is currently attending graduate school at a large, public R1 university. She worked as an undergraduate research assistant in physics and as a teaching assistant and tutor during her undergraduate education. C. Turpen completed her

undergraduate and graduate degrees at large public R1 universities. To sustain herself while pursuing an undergraduate degree, she worked ~15-20 hrs per week often in early childhood education. Though not a central focus of this paper, reflection on our identities have been relevant toward understanding interview dynamics and our interpretations of the conversations.

C. Analytical Approach

As introduced earlier, the analysis presented here was guided by two research questions: (i) How do students describe the work of the NF team, and (ii) what outcomes are salient for NFs as part of participating in the work?

Interviews were recorded through the Zoom recording feature, with initial transcripts automatically generated. From these rough transcripts, author R. Dalka corrected for errors while listening to audio recordings. While R. Dalka was primarily focused on correcting the automatic transcription, he did note when common, or powerful, ideas came up across the interviews.

Once a transcript was complete, all authors read through the transcripts and annotated them with comments capturing emerging themes and cross-cutting experiences across the transcripts. We then began developing analytical memos on our noticings. Initially, our accounts of the role backgrounded the forms of collaboration that NFs engaged in. These early memos prioritized capturing the structure of the NF team but left out how students described the collaborative processes themselves. Through research team discussions, we felt that we needed to capture what students felt was important about the NF teams' ways of collaborating and what they valued from their experiences.

This led to us identifying students' *conceptualizations* of the NF team—a way to capture the different work processes that students describe. These emergent codes helped to bring to the foreground the processes that were salient for NFs and the ways of collaboration in the team. Rather than using predefined codes from a particular framework, we used a generative coding process that allowed for adjustments as new themes presented themselves in the data [18]. Our approach included tentative categories (e.g., catalyst, incubator, backbone, learning community) and an “other” category. Excerpts coded under “other” then motivated the creation of new categories (e.g., propeller). We were additionally interested in what students valued from the experience and what they identified as outcomes for themselves.

In our initial coding, we aimed to capture outcomes for students that were closely tied to the NF team (proximate) as well as more distal outcomes that were tied to other settings. Codes were built from what stood out in the NF experiences. In this paper, we have focused on results from the proximate outcomes. Distal outcomes that were recognized by students tended to be highly

context-dependent and will be the focus of future work. In our presentation of results in this paper, we will use “outcomes” to mean the proximate outcomes for NFs that we have identified.

All authors engaged in coding the interview transcripts. At least two authors went through each interview with the coding process. As described, during this process, some codes were revised, while new ones emerged. When there were discrepancies between coding between authors, they were discussed in a group meeting with all authors and resolved by consensus.

Once all interviews had been coded, the excerpts associated with each code were examined and used to build the understanding of that form of team processes or particular outcome for students. We found that this unique, small sample of student leaders helped us in identifying important aspects of team processes that may be hidden in larger sample sizes [19]. These results are presented below.

IV. Results

Our results section mirrors the order of our two guiding research questions. First, we present the ways in which NFs conceptualize the work of the NF team collaboration. Then, we present the outcomes that NFs describe experiencing as a part of the NF team and how these are connected to the ways of collaboration.

While we use present tense and active language in presenting these results, we recognize that the results are contextual to the time of the interview. We emphasize that these quotes represent the feelings and experiences of the NFs at a particular moment of time and should be taken as a slice of the full experience of the participants.

A. Ways of Conceptualizing the NF Team Collaboration

In this section, we present the different ways in which the NFs have conceptualized the NF team in their interviews. By using the term *conceptualization*, we aim to capture the fluidness in which the NFs describe their collaborative work. These abstract concepts are representations of the type of workspace that NFs describe engaging in as part of the NF team.

In our analysis, we have identified five conceptualizations that were common among our participants: backbone, catalyst, incubator, propeller, and learning community. Backbone describes how the NF team is structured as well as how information flows from NFs into the different spaces they occupy. Catalyst represents the type of idea generation that the team may engage in. Incubator captures the collaborative planning and further development of project ideas. Propeller includes the processes and potential impacts of carrying out NF team projects. Learning community encapsulates the ways in which NFs are open to learning from each other

and engaging in shared inquiry. While each of these conceptualizations is unique and has distinct features, they also overlap and can often come up at the same time in an NF's description.

1. Backbone

The backbone has two distinctive features. First, it describes the way in which the NF team is organized—through having site representatives come together on the team, the NFs connect each site to other sites and to other Access teams. This is the structural feature of the backbone conceptualization.

The second feature is the information flow of the backbone conceptualization. This captures how the work of the NF team is spread throughout Access. Ideas and projects that are worked on in the team move through the NFs themselves into different parts of the network. It can also capture movement of ideas and stories in the other direction, from the sites up to other parts of the larger network. Issues, challenges, and successes can be brought from one site into the larger Access discussion through the NF team. We find many NFs desiring more time for the movement of ideas through sites.

Both features rely on each other. The structure enables the information flow and the information shared strengthens the structure. Together they make up the backbone conceptualization of the NF team. This conceptualization is often the “go-to” way that NFs describe their role and the team when first asked to define the role.

Symone, an undergraduate student who has served as both an Assembly Fellow and a Network Fellow, provides a good example of how the nebulous role of the NF can be defined as the backbone.

“I would say not above, but, like, basically just like a, more higher position than the [*rest of the*] Access network. Basically, we do more like, I want to say like the organization, but like, how do I say this... um. We do like the program like, uh this is so hard, because based on the meetings that we did and from last year, I think we just we basically like do like information. Like I remember last not last year, the other year previous we did basically a website where we put like information, like just like an update, or we will talk about the [*pandemic emergency*] fund, what ways we could do to get a fund going.”

- Symone

At the beginning of this quote, Symone tries to articulate where in the Access structure the NFs reside. They don't want to say “above” but resolve to this “higher position” description. They go on to talk about how they drive organizing and information sharing within Access, centering the

projects that they have worked on. This backbone conceptualization helps Symone describe what an NF does.

The connections that are forged through NFs being these connectors can also transcend the NF team itself. Greg describes how through his position, he is able to build relationships that extend throughout Access.

“I think the most important role that they fulfill is connecting the sites to each other, right. Otherwise we are all just headless geese around, and the NF team, much like the AF team, is a way to actually make us a network as a way to actually communicate with each other and. You know I'd like to think that if I were friends with the NF and the NF has a friend that's friends with another NF and then that's that's that's a friend- the connection I can make through my friend and vice versa, and in this way our- our our our bonds do end up transcending the who's on the team and who's not on the NF team. It kind of it lowers the the activation- the the the barrier in order to- it's like an icebreaker, for say- for example, for Access to some ways.” - Greg

When the NF team is conceptualized as the backbone, Greg sees it as supporting communication. The team works to build a connective structure that is more than its parts. Each part is evolving in conversation with other parts of the system.

The projects that NFs work on as part of their responsibilities can also help to conceptualize the team as the backbone of Access. We can see this play out in the following quote from Malikah.

“Um, so I think I would describe the network fellow role as like a role in which you interact with other sites, other universities, and with students from there, together, collaborate on projects that focus on-- typically focus on including marginalized groups that are in STEM and into new opportunities or experiences. For example, the mentorship project that we're currently working on now focuses on connecting students and mentors between sites and providing them with perhaps like an additional resource.” - Malikah

In this case, the project itself reinforces the backbone functionality of the NF team by forging new connections among sites scaffolded by the existing bonds of the NF team and the network more broadly. Malikah describes how the NF team's project provides resources for mentorship relationships with marginalized students within the network. The project that Malikah sees as important to her time on the NF team is framed in the backbone conceptualization.

The effectiveness of the backbone conceptualization of the team is dependent on the unique contexts within which the NF works. Greg describes that he “see[s] the NF as- as a way for sharing ideas that come up at sites as a way of keeping sites aware of each other and most

importantly, as a way of having sites connected to each other.” Additionally, the backbone conceptualization is strengthened due to the NF role being built into his local site structure. At Greg’s site, local site leadership expects the NF to attend leadership meetings and convey information between the NF team and the site. However, this can also play out in the opposite way, where the backbone conceptualization is weakened by the local site contexts.

Arpita is a graduate student located at a site that is currently going through a period of transition after a faculty lead left their position and a new faculty lead has stepped into the role. This excerpt comes after an exchange between CT and Arpita in which she strategized about how the new faculty member lead could be brought more into Access.

“Yeah and actually I mean that that is actually also something that I experienced because when the- the sessions for which I was a Network Fellow, I wasn't actively involved as a [SITE] mentor. I would, I mean, I knew the people and I was connected but I think it felt like a different job but then it's also the awareness that okay I am the bridge between my site, so maybe a bit more integration there. [...] I think I mean that- that's definitely because I at the time my focus was, [...] it got to a point where was like less communication with my own site because this was a an entity of its own.” - Arpita

There is a tension here for Arpita between participating in the NF team and communicating with their local site. Because the backbone conceptualization places the NF as the “bridge,” as Arpita describes it, the NFs must work in both spheres and try to share ideas and information between spaces. When there are fluctuations and difficulties within the local site, we see the NFs struggle with the NF team being the backbone of Access.

Overall, we see how the backbone conceptualization of the NF team is a common way for NFs to first think about what the purpose of the team is. The conceptualization can be based in the formal and informal structures of how the NF team is created, how communication takes place in the network, and how projects are managed and work to connect Access. This is a complex conceptualization that may play out very differently for NFs in different local contexts. Nevertheless, this function of the NF team is a central way that they do their work and interact with each other and other Access members.

2. Catalyst

In their interviews, NFs describe collaborative ideation as the source of the team’s activities. Meetings are an environment that supports the generation of new ideas as well as a place where members can bring ideas from their sites. We term this facet of the team’s work “catalyst.”

Arpita reflects warmly on brainstorming with the team as the source of multiple projects that have now been implemented. After citing website management, the newsletter, and the cross-site

mentoring project, she reflects that she was “definitely happy like to be a part of that brainstorming discussion that kind of gave rise to some really cool ideas.” Importantly, the team was not assigned to work on these projects. Instead, they developed the ideas themselves, supporting students’ sense of agency and resulting in what we interpret in Arpita’s statement as a sense of pride in the ideas the team generated together and the projects that came out of them.

The team functions as a catalyst in part because the NFs serve as a backbone, connecting their local sites to the NF team and conveying ideas from their site to the team. Arpita articulates how the roles of the NF team relate to each other: “I think like the more like important idea of the role is just kind of sharing ideas that might come from our site and seeing how that can work together and executing all these projects.” Here, Arpita describes the flow of three project stages—sharing ideas (catalyst), scoping them out (incubator), and executing them (propeller)—enabled by the backbone structure of the NF team. The NF connects the site to the rest of the network, and in doing so, conveys ideas from their site to the NF team, which can grow and implement them.

The NF team does not function as a catalyst only by bringing representatives of different sites together; the team’s culture makes it possible for these representatives to ideate successfully. Malikah describes how community norms support the team in sharing and discussing their ideas:

“I think the way that we collaborated and the way that we focused on coming to consensus and stuff, I think that created an environment where people are more comfortable sharing ideas like that and explaining them to each other and without fear like being judged or dismissed. And I think that allowed for certain things, certain new things to be brought up people's attention.” - Malikah

Malikah relates an activity where groups of NFs would propose ideas by posting them on virtual sticky notes, and then team members would write their name on ideas they would like to work on. Then the team discussed the significance and appeal of the ideas. Most people gravitated toward two ideas, which the team went on to further develop and implement. Decision-making was discussion- and consensus-based, and everyone was encouraged to contribute. Furthermore, students had agency in what they could accomplish as an NF from the very beginning.

In examining NF descriptions of the catalyst mode of the team, we can see how it is distinct yet also clearly linked to other key features of the team’s operation. Healthy collaboration and consensus-building as well as the opportunity to bring site ideas into a network space supported the team in its functionality as a catalyst. Effective work as a catalyst provides a foundation for the team to operate as an incubator and then a propeller of projects. Generating and selecting ideas for further development supports students’ sense of agency, both directly from the ideation process and from the projects they grew out of these ideas. In short, the team’s work as a catalyst is an integral feature of the NF experience.

3. Incubator

Once team members identify ideas they would like to pursue, they work together to plan out how they can accomplish their goals. Students cite this step as an important one to support the success of their projects. For example, when asked what she was proud of, Malikah highlights the conversations that took place to develop and evaluate project plans:

“In deciding, like, what's realistic, what's not. Making sure that we don't get too caught up in working on something that we would ultimately have to abandon I think really thinking out like, what we actually want these projects to be in result in, instead of just coming up with, like, a vague idea and no clear way on how to implement it. I would say that that's what I'm proud of.” - Malikah

Similarly, Arpita references “seeing how [*ideas*] can work together” as a key step in the NF team’s processes between sharing ideas and implementing them. Both students emphasize the importance of developing the specifics of how a project could look and how it could practically be implemented.

Arpita references specific tools and strategies that enabled the NF team to work effectively as an incubator, including a life cycle diagram that helps to frame out steps of a project [20]. Arpita notes that she

“thought that was very productive because there it clearly highlighted like Okay where are some of the traps and I think that definitely gave a little bit more structure to the discussions that we had [...] And just kind of you know just generally like understanding some of the time sinks and like learning, Okay what kind of- just make some projects stall and that was definitely eye opening because sometimes we're we're stuck in that little frustration zone.” - Arpita

Arpita also describes the ways in which the backbone functionality of the NF team intersects with its work as an incubator: “Just getting all of these ideas- it's it's nice to know that you're not alone in that like other sites are figuring out like more productive ways to deal with some of these challenges. So just definitely having those discussions is very enlightening to be a part of.” Some discussions focused on analyzing difficulties in propelling projects, paving the way to resolve some of those difficulties.

“I remember it was kind of just centered around this discussion like from from the group leads that- in trying to understand like what how they can facilitate for us to be more productive in terms of like getting more progress in these little projects. And I think just

generally like that kind of opened up this discussion of like Okay what are some of the sinks and like what are some of the challenges.” - Arpita

Not only did incubation bridge ideation and implementation, but the kinds of problem-solving discussions that the team had supported continued project implementation and navigating challenges at individual sites. Furthermore, students gained useful tools to engage in this kind of planning and analysis.

4. Propeller

The “propeller of projects” conceptualization captures aspects of project implementation and project management that become central to the work of the NF team. This conceptualization captures the ways that NFs talk about executing projects by defining component tasks, developing timelines, distributing responsibility for tasks, coordinating the work, doing tasks to propel project work forward, and assessing whether projects are making progress. NFs talk about the work of the NF team as synonymous with the projects they are working on and emphasize the collaborative nature of that work.

For example, Greg describes the NF team as follows: “if I had to concisely summarize I'd say that we are a group of students that plan our projects and and volunteer on projects as a group, in a shared kind of leadership shared governance structure as opposed to a clear hierarchy.” Greg proceeds—after reflecting for a bit—to describe the specific projects that his cohort worked on: “We worked really hard to do an intrasite to travel between [SITE 1] and [SITE 2]. We tried setting up an alumni database and also a listserv for alumni to send out updates and stuff.”

Similar to Greg, Symone gives examples of three core projects they were working on when describing the NF team:

“Because I know I was working on the website, like, for example, right now. Like the newsletter we're going to do, diversity we're going to talk about opportunities like research and stuff like that, and then also we're going to talk about the mentorship and what can we do, and also expand on it, like you know have like different site mentorship I believe.” - Symone

Malikah describes “working on projects” as the best way to get a better sense of what the NF role was all about. Malikah sees the core responsibilities of NFs as having to do with “being committed to the projects that have been decided on and continuing to develop that. Being clear and honest about your ability to contribute.” Malikah continues to describe the NF role in terms of the collaborative projects that the NF team pursues and the important purposes that these

projects serve. The following quote from Malikah is an immediate continuation of the comment we presented earlier in the backbone section concerning the role that NFs play.

“As you know, mentors that are included and other sites aren't really obligated to report everything in the same way that a mentor that is part of the same site, as the student is, would be. So they can speak on topics that they might not be comfortable with doing so, otherwise. And they can also seek out mentors of certain demographics that may not be very common where they are currently. So things like that, where you're providing opportunities for these students and marginalized groups to be included. Where they otherwise might feel kind of cast out since we are-- we're in the minority-- they are minorities, and within STEM, it's even more drastic.” - Malikah

In this account, the NF team's projects, and their potential to shape the experiences of people from marginalized groups in STEM is a central aspect of the NF experience. Malikah is very deliberate about how this specific mentorship network could be consequential for equity and inclusion goals in STEM.

Arpita expresses some tensions between various roles NFs took on during the propeller conceptualization of the NF team:

“I wasn't sure if that [*acting as a bridge between the NF team and their site*] was my primary role, or if my primary role was more dedication to like executing the projects that we come up with like website management and things like that. So I think that's what I mean by saying like, being a better representative. So. Yeah, so maybe that would have been a bit more like, kind of fine tuning the role that I think I wasn't sure like where exactly that expectation was from me as an NF.” - Arpita

Here, Arpita describes a tension between being an effective “bridge”—as she put it in other places—between her site and the network and moving projects forward. Importantly, Arpita's site is experiencing rocky transitions in leadership, and she sees this as complicating her navigation of this role. This indicates how the backbone conceptualization may offer particular challenges, and affordances, for the propeller conceptualization.

Similarly, Symone notes that these NF projects were at times in tension with their interests in using the NF team as a resource or sounding board for how to go about revitalizing or relaunching activities at their local site. For example, Symone says,

“I think the last time I was a network fellow, I know it was you know basically doing like a website like a blog. And I think it was also talking about the mentorship or other thing.

But yeah I was just trying to see how we will contribute more like during the conference or, ...throughout the time. yeah you know, to make the site better pretty much.” - Symone

Here, Symone describes elements of NF projects that they were involved in but says that they would like to see how the work of the NF team could be brought into the conference and sustained over time toward the goal of making sites better. Symone articulates struggling to see how the work of the NF team connects to the Assembly activities and how it serves to strengthen sites. In other places in this interview, Symone expresses that their site needs to rebuild a sense of community, and they wish that the work of the NF team would be more directly connected to those goals.

When working in a propeller conceptualization of the team, NFs highlight how they see this as a primary way they make an impact in the role. They see the team as working with a purpose in mind and collaboratively manage the projects and bring them to implementation. This is supported by the other conceptualizations that set up roadmaps and build connections across the network. However, some NFs note how this work can pull them away from other local site activities, wishing for a greater balance between network-focused projects and site-focused work.

5. Learning Community

We consider “learning community” in two ways – students’ accounts of how the NF team learns together and students’ accounts of what is learned through NF collaborations. We will give detailed evidence on how students see building relationships as enabling learning and learning together as enabling community building. The learning community conceptualization, and the team processes captured by it, benefit from how they are strengthened by the various modes of collaboration described earlier. In this section, we will identify places where these conceptualizations work together to create the collaborative environment that the NFs experience. We wait until the outcomes results section to illustrate in detail what students feel they are learning from the NF experiences.

Many NFs described the “openness” of the community as helping the NFs to learn from each other. Malikah described “coming to meetings to talk to friends” rather than coworkers. Other NFs talked about friendliness within NF meetings as cultivating a degree of comfort needed for learning. Malikah elaborated further on this by saying, “the easygoing atmosphere that, you know, all the meetings had, I think that allowed us to kind of connect more than like a really formal meeting would-- would have allowed for. And I think just being able, being comfortable because of that atmosphere, to share like personal things about yourself, I think that contributed a lot [as] well.” Here Malikah describes being comfortable bringing one’s whole self to meetings, or sharing personal things, which facilitated making connections. Malikah contrasts the NF meetings with other meetings where this practice of sharing personal stories is less allowed.

Some NFs recognized specific collaborative processes that facilitated making space for learning and community-building. NFs talked about how mutual respect and holding each other accountable created an environment where learning and growth can happen. Other elements of consensus-building were described by Malikah, who shared, “I think the way that we collaborated and the way that we focused on coming to consensus and stuff. I think that created an environment where people are more comfortable sharing ideas like that and explaining them to each other and without fear [of] like being judged or dismissed. And I think that allowed for certain things, certain new things to be brought up [to] people's attention.” Malikah finds the NF team’s focus on coming to consensus as well as the non-judgemental atmosphere as noteworthy. Here we also see an overlap with the catalyst and incubator conceptualizations – through sharing ideas and elaborating further on ideas. The learning community conceptualization specifically highlights Malikah’s emphasis on how collaborative processes enabled new things to be brought to people’s attention, enabling people to learn from each other.

Another way that learning from each other plays out within the NF team is around discussions of challenges that sites are facing. This form of learning tends to overlap with the backbone conceptualization. For example, Arpita says:

“...understanding that there's like a lot of similarities like in terms of, you know, challenges that other sites are facing or like just kind of like new ideas and new things that they're trying to keep more interest generated in the mentoring projects. I think that was another thing that has been going on here recently is there's just like little dip in the enrollment for our mentoring sessions and I think just like learning how people are keeping it interesting. Just getting all of these ideas- it's it's nice to know that you're not alone in that like other sites are figuring out... like more productive ways to deal with some of these challenges. So just definitely having those discussions is very enlightening to be a part of.” - Arpita

Here Arpita describes learning that her site is not alone in facing particular challenges and appreciates hearing about strategies other sites are using to address the challenges they are facing. There are many examples in our data of how the sharing of resources, opportunities and programmatic strategies are being shared within NF team collaborations.

NFs at times describe tensions arising in trying to learn together, and these often arise at the boundaries of the NF team and other organizational structures (e.g., local sites or other Network leadership teams). Some NF describe experiencing discomfort or embarrassment around sharing about rocky transitions happening at sites. At times, NFs describe wishing that the COs would coach student leaders more directly by giving workshops or presentations on leading change efforts. Some members of the NF team noticed that their collaborations felt a bit disconnected

from the CO team and the “big picture” conversations they expect that the COs are having. These tensions are important locations for further collective reflection and potential refinement of organizational practices.

Also important to this mode of collaboration are the specific insights and learnings that are enabled. We briefly mention a few salient insights that NFs noted here but elaborate on them more fully in our description of outcomes in the following section. NFs described learning about the importance of mentoring networks for minoritized students in STEM, shared leadership, ways of communicating in more inclusive manners, and strategies for making sense of project evolution and potential pitfalls to be expected over the life cycle of projects. NFs also described developing important relationships and networks through their NF team collaborations. Some, such as Symone, even go so far as to describe Access as a “family.” We offer further elaboration on these themes as outcomes in the following results section.

B. Outcomes for NFs

While there may be many different outcomes for NFs as part of doing their work on the team, we have identified three main outcomes that are shared across our NF participants. These include building a sense of agency, developing a deeper relationality, and practicing inclusive leadership skills. In this section, we discuss how each of these outcomes show up for NFs and how they connect to the conceptualizations of the NF team.

1. Sense of Agency

Across our interviews, we see students express a sense of agency within the context of the NF team. What the students feel agency over and how this agency is discussed is connected to the varying conceptualizations of the NF team’s work. For example, when discussing the team as a backbone, a student may express a different aspect of agency than when they are discussing propelling a project.

i. Formative decisions of team projects

One way that students express agency is through their descriptions of being decision makers in the NF team space. NFs discuss the decisions that go into choosing which projects the team should take up and how they unfold. These decisions may be around ideation of what to work on, assessing the feasibility of project ideas, and planning and carrying out important steps necessary to each project. This work is captured through the catalyst, incubator, and propeller conceptualizations.

For example, Malikah displays a sense of agency over how the team planned NF projects. Malikah, as quoted earlier in the incubation section, expresses pride in the discussions that took place on the team around feasibility and clearly and intentionally defining desired outcomes along with a path to achieve those outcomes: “In deciding, like, what's realistic, what's not. [...] instead of just coming up with, like, a vague idea and no clear way on how to implement it. I would say that that's what I'm proud of.” She shows a sense of agency over her projects and the progress that the team has made, even if she did not achieve all of her goals in the term of her appointment. This type of work is related to the incubation conceptualization as the team deliberated and scoped out projects.

Similarly, Arpita discusses being involved in some projects that focused on documenting the work of the NF team, but we see her express how she enjoyed being a part of the team in deciding what the projects should look like.

“We did like work a bit more on like the website management site and [...] we were happy to get it a bit off the ground and it was really exciting to see like some of the other projects I wasn't too involved with but just generally kind of- that we were part of the brainstorming together, like there was a newsletter. And I think the mentoring thing kind of was bounced about like the cross-site mentoring but. It yeah I think it may be now there's more work kind of research going into that so so definitely happy like to be a part of that brainstorming discussion that kind of gave rise to some really cool ideas.” - Arpita

In this description from Arpita, we see how the students brainstormed these ideas that came to fruition themselves. This brainstorming space that Arpita describes corresponds with the mode of working as a catalyst. Earlier, in the catalyst section, we shared a portion of this quote; here we see how the full quote supports the sense of agency that Arpita feels due to contributing to these ideas. They had the ability to direct what the team worked on rather than being told what the team needed to do by the faculty mentors. The sense of agency for NFs is built through contributing to the NF team projects and evaluating the project ideas.

ii. Control over level of involvement

The ability to control how involved one is on the team is one aspect of agency that we see students discussing when conceptualizing the team as a propeller of projects. The work that goes into implementing the projects can vary depending on the project and the stage that a project is at. In the propeller mode, students are able to contribute to these steps as their availability changes. Earlier, we saw how Greg values the shared leadership structure to navigate propelling projects forward. Here, we connect this structure of the team to building agency in NFs. When referring to the lack of hierarchy, Greg states: “you only work on what you commit to, that no

one dictates what you work on. And that, by and large, we thrive on- off o- out of self discipline and motivation.”

Greg sees the team as valuing the ability for each NF to indicate how much they will contribute to the team and that they hold themselves and each other accountable rather than relying on someone above them telling them what to do. The NF team moves the work forward based on their commitments to one another, self-discipline, and motivation. Each NF commits to work that they identify with.

Malikah also shares a description of how she organizes her work around projects in a similar way to Greg. She does not use direct language, like “shared leadership”, but she indicates that she values these aspects of agency as important responsibilities of being an NF. In the propeller section, we saw this in Malikah’s quote about being “clear and committed about your ability to contribute.” Malikah continued in the interview to say: “I think holding others accountable, you know to whatever work was promised and also being understanding with each other and having that mutual respect. I think those are probably the main responsibilities that network fellows have to the network.”

There is a strong sense of agency built into the NF team as the students are able to determine their own time commitments and feel empowered to do their part. Rather than being dictated by someone above them, the NFs value accountability and being "honest" about what one is able to accomplish. There is both flexibility but also commitment to the work of the NF team and the projects that they have decided to carry out. This gives the NFs agency over their work and shows how that plays out when negotiating responsibilities amongst the team.

iii. Occupying a leadership role

In being in the NF position, students are given an opportunity to take a leadership role within the Access. Not only is this a position where they can make decisions and have an impact, but also where they can act as a representative of their site and connect with the network, as captured by the backbone conceptualization. NFs express a sense of agency that is tied to being in this position.

Sometimes, this leadership role can be hard to define for NFs. Access prioritizes the shared leadership within the network, and students are able to exercise additional agency as a part of the NF team. When discussing the backbone conceptualization, we included a quote from Symone where they struggle a bit when first describing the NF role. They focus on things like the “organization” and “information” when describing purposes of the NF role.

Symone describes the NF position as a place where they have more opportunities to make decisions in Access. It creates a space where the NFs may exercise their agency in enacting their projects. Additionally, we see that Symone sees supporting the organization of Access as a primary responsibility of the NF team. This position allows for agency to be built around being that source and caretaker of information.

When asked to describe the NF role, Arpita draws on an experience of needing to describe the position to members of their PhD committee. Arpita's description begins by focusing on the aspect of being that representative of her site.

“So, I mean essentially I would describe it as it's this forum where we act as representatives of our local sites. And try to see if we can learn some more from our interactions with people from other sites, try to incorporate anything that we can to improve the structure of our local mentoring project, and also sort of have this integration.” - Arpita

Arpita's agency can be seen here in the way that she describes being the focal point through which new ideas and information can be used to improve the site. In participating as an NF through a backbone conceptualization, we see how Arpita feels agency over that information flow and identifying opportunities for local site improvement.

Similar to Arpita, Greg describes how he sees communication between sites as an important part of their position as an NF. In Greg's description we see how their agency is tied to how their site has built the NF role into their local leadership structure:

“I think it as- since we do have our NF come to our leadership meetings and give us updates and they send us to meet- some some some summaries from the meetings as well. I feel, in that sense that at least [SITE] does- the NF at [SITE] does certainly fulfill its role and it's useful.” - Greg

Greg expresses agency in being the conduit point within the network in the NF role. Additionally, Greg feels “useful” to his own site because of the way that the NF is a part of the local leadership of his site, which broadens the domains of Greg's agency. When agency is built within the backbone conceptualization, we see that it can be highly tied to how the NF interacts with the local site.

2. Relationality

Another outcome of working within the various conceptualizations of the NF team is building a sense of relationality. Relationality here is defined as the ways that NFs are connected within

Access, including all of the interpersonal connections that they create and cultivate as a part of their work.

i. Supportive Mentors

While not a focus of our interviews with NFs, some students do mention the importance of their relationships with the mentors of the NF team. These mentors are members of the Core Organizer (CO) team within Access. Some of these mentors may have been present at the beginning of Access—some not—but all are committed to Access’ principles and goals and help to shape them.

The NFs in our interviews described the mentors as being supportive. Greg describes how, along with his peers in the NF cohort, the mentors supported him when he needed to take a step back.

“I had to do candidacy, and candidacy took me away for six weeks and um. You know, I made the announcement and most of the grad students and and and the NF- NF helpers... What is the role called? <CT: mentor> yes, thank you. The NF mentors, they... they understood.”

Greg mentions that he understood what he was preparing for as part of his responsibilities as a graduate student. Greg recognizes that the mentors have gone through similar experiences to him and feels that they are able to understand his current workload. Additionally, we see that Greg at first struggled to remember the title of “mentor”, instead describing them as “helpers”. This type of relationship is defined by helping the NFs to achieve their goals, which contributes to the personal connection that is expressed by using “helper.” Greg has built a relationship with the mentors where he felt comfortable to step back from the NF team when needed.

Malikah echoes this feeling of understanding when describing what interactions on the team were like. She presents the NF team mentors in contrast with other types of roles she has experienced in other spaces.

“I think everyone, both peers and mentors, were just like very friendly and not, kind of hard to put into words, but it didn't feel like... when talking to a mentor that you were talking to like your boss, or something like it felt, um, just much more personal. I'm not sure, like the specifics of that would be but it just felt like people were coming to the meetings to talk to like friends and not, you know, it didn't feel like we're really coworkers or something like that it felt a lot more comfortable.” - Malikah

In the above quotation, Malikah does not make a distinction between what interacting with a mentor and a peer felt like—they both felt friendly. The relationality that was built on the team

was “hard to put into words” for Malikah. She elaborates on the mentor relationship by contrasting it with what a boss would feel like. Through the mentor relationship, Malikah feels personally supported and comfortable on the team.

ii. Learning from Peers

An important aspect of the experience of being an NF is the amount of learning that happens for students in this space. We capture this in our analysis through the learning community conceptualization of the team. We also are able to see how through the projects that NFs work on, they may learn additional things about and from their fellow NFs, which is captured by the propeller conceptualization. When looking at outcomes for the individual NFs, we see this play out in their learning from each other through the relationships they build. This type of relationality played out for Malikah when she was first starting her position on the NF team.

“I think, communicating with other network fellows and also just starting out. Like just jumping into it, and I think the collaboration helped, and I also think that when I first joined, being told by people who are already within Access, who have already participated in those roles and what it's all about. That helped a lot, too, and instead of just reading out like the description.” - Malikah

Malikah describes how right from the start, she felt that communication within the team was comfortable. This learning community conceptualization of the NF team leads to a type of relationality where Malikah felt they could learn from their peers about the role itself. Malikah sees this as a better outcome than just reading a description of responsibilities.

While Malikah discusses learning about the role through their peers on the NF team, Arpita talks a lot about learning from other NFs experiences. In her interview Arpita discusses how through the projects that she engaged in, she made opportunities to learn from other NFs and hear about each other’s experiences being on the team and a part of Access.

“I think it was mostly sort of collecting like info from the fellows, sort of like putting that together. I don't know if there is like a lot more in in terms of like building the website side of things that I was aware of, but I think just generally like getting to know the NFs in more detail on their backgrounds and that was- That was like going a bit like more than the regular conversations we would have in the meeting so I definitely appreciated it that part.” - Arpita

As working in the NF team as the project propeller conceptualization, Arpita built stronger understandings of the other NFs in her cohort. She mentions learning more about the personal backgrounds of NFs and the different activities they have been a part of. The resulting

relationality between NFs is strengthened through this. The quote from Arpita shows that people bring their whole selves to the NF team space—more so than in other professional meeting spheres. Through doing her work in the NF team, Arpita has learned from experiences of the NFs. Arpita really appreciates this outcome from working on the project, showing how much value she places on the relationality of the NF team.

iii. Comfortability

One of the main features of the NF team that many NFs discussed was how comfortable they felt with everyone, not just mentors. This type of relationality is a result of working within various conceptualizations of the NF team, such as incubator or learning community, but also feeds back into those conceptualizations of the team and strengthens these modes of work.

Malikah shares how this comfortability comes out in the ability to share ideas and collaborate as a team. In the catalyst section, we saw how Malikah describes a team dynamic in which ideas could be brought up without judgment. Malikah frames this outcome as: “the way that we collaborated and the way that we focused on coming to consensus and stuff.”

This comfortability outcome is related to how the team works in the incubator and catalyst conceptualization. Through both generating and workshopping ideas in these conceptualizations, the team works on the comfortability and due to that comfortability, the team works better both as an incubator and a catalyst. The learning community conceptualization of the team also creates a space for comfortability to be built, making room for new ideas to be taken up by NFs and for them to be vulnerable with each other. However, sometimes this comfortability can be difficult to build through online meetings alone. Symone highlights this when discussing how she felt when connecting with people at the Access Assembly compared to the NF team meetings alone.

“It's really like more neutral like when we get in the meetings. um. You know, um not I mean we I feel like I have connected with a lot of people, you know we share ideas we talked about it, we you know we agree about it. But not nothing really too more of it, if that makes sense, just because. You know this is everything is online. I feel like I would get more like a personal kind of relationship, maybe we-- at the conference or. Just right now it's just like a meeting. I mean, I think, with [MENTOR1] I feel more comfortable and [MENTOR2], because I knew them for years cause I was an [AF]. So I feel comfortable coming to them, but I feel comfortable talking to everybody in there.”

- Symone

Here, we see how even through working on the NF team and feeling able to contribute to ideation and doing of projects, Symone still does not feel a personal connection. From Symone,

we see that NFs may feel one type of relationality when working on the NF team and another when participating in other, in person, Access activities.

3. Inclusive Leadership Practices

Another important outcome for students is learning about and practicing inclusive leadership skills as a part of being on the NF team. While we are able to identify various aspects of both agency and relationality throughout each of the four interviews, students are less likely to discuss the specific practices that they used while on the team. However, practicing inclusive leadership is an important outcome from engaging in the various conceptualizations of the NF team. These practices also strengthen the conceptualizations and the work of the team.

Greg discusses these practices in the most metacognitive way compared to the other NFs. When asked to clarify inclusive communication, Greg mentions “don't yuck my yum. [...] and green, red, yellow. Are two very striking examples for me.” These strategies are ubiquitous within Access' work. “Don't yuck my yum” is a norm in the Access community of respecting others' interests, even if they aren't shared. The green, red, and yellow cards are ways to build consensus that the team uses to make decisions. These leadership practices are things that Greg sees as important for his personal growth.

Making decisions by consensus is an important aspect of the NF team and learning ways to lead a team in doing this is important for many NFs. Consensus rather than majority rule also enables deeper engagement with conceptualizations of the team such as incubator or catalyst. As quoted earlier, Malikah foregrounds the comfortability among the team but also ties comfort to “the way that we focused on coming to consensus.” Though consensus building is not directly named as a “skill” that emerged as an outcome from the collaboration, it is clear that Malikah is aware of these norms and feels that they were important to the community relationships that emerged.

While we are focusing on outcomes that are closely linked to the NF team itself, we also see how students take some of what they have learned around inclusive leadership into other spaces. In the incubator section, we showed how Arpita values the life cycle diagrams as a tool for ideation around projects. In the interview, she goes on to discuss how this can be helpful in other spaces as well:

“There was this figure that [*NF mentors*] would bring up, it is essentially this flowchart of how to get a conceived idea into action. And I thought that was very productive because it clearly highlighted like, okay where are some of the traps and I think that definitely gave a little bit more structure to the discussions that we had. [...] I try to apply [*life cycle diagrams*] on research now, so it's like it's very useful to identify this.” - Arpita

The life cycle diagrams were originally introduced by the NF mentors, but Arprita describes how the team used it in an incubator conceptualization in order to develop the project ideas. Arpita notes how she wants to use it in her research as well, which as a graduate student is highly tied to their everyday work. Greg also discusses inclusive leadership practices to bring out of the NF team, but something more closely tied to Access, their local site.

“The most useful, and something that we want to do in [SITE], is to have mini activities. This is also to see greater participation by the department, but have small little tidbits that maybe a person could do within half an hour. [...] The NF [*team*] does a good job at this by trying to cycle through who takes which role during or between the next leadership meetings.” - Greg

Here, we see how Greg finds what the NF team does as useful and wants to use it in his own site. Along with being a leadership practice, this rotation of roles and mini activities is also described by Greg to give more agency to the team members. The ability to contribute is highly emphasized by Greg in their interview and is positioned as an important factor to shared leadership.

Inclusive leadership practices can be made up of many skills, both related to relationality and agency. The learning of these skills is made possible by the conceptualizations of the NF team that the students work in. NFs support each other in this learning through working together in the learning community conceptualization, and enacting the practices during the catalyst, incubator, and the propeller conceptualizations. They then may bring these different leadership practices into other spaces, sometimes through the backbone conceptualization and into their local sites.

V. Discussion

Although the NFs in this study have been members of different NF cohorts and span both undergraduate and graduate levels, we have identified commonalities in the ways that they conceptualize the way that the NF team collaborates and in outcomes for the individual NFs. In naming the conceptualizations, we have aimed to capture the different ways in which the NF team functions. While each of these conceptualizations has features that make them distinct from the others, we are able to see how they are connected to and influence each other.

The backbone serves not just as an organizational chart of roles for individuals but captures the purposefulness of the interconnections that the NF team creates. The backbone has implications for how each of the other conceptualizations are talked about by NFs. We see how this interconnectedness and sharing of information from around Access influences how ideas are generated in the teams (catalyst), how projects are carefully planned and problem solving happens (incubator), and how implementation and project management crosses boundaries

(propeller). The catalyst, incubator, and propeller conceptualizations do help track the progress of an idea to a project within the team, but there are not distinct boundaries between each of these modes of collaboration; they may loop back and forth, with NFs taking practices from one stage to another. The learning community conceptualization helps to capture the moments where new, inclusive, practices are seeded into NFs and the team. This conceptualization impacts how the team collaborates in the other conceptualizations and what practices NFs internalize for themselves.

The outcomes for NFs that we have identified may not typically be investigated as outcomes in other spaces. Agency, relationality, and inclusive leadership could be investigated as means towards other desirable outcomes. However, we have identified these as outcomes as we see NFs describe how agency, relationality, and inclusive leadership were cultivated in the NF team and how the development of each was supported through the conceptualizations. While the direct connections between conceptualizations and outcomes was not the focus of our analysis in this paper, we have identified a few specific examples within each section of the outcomes. As these outcomes are built through the collaborative work of the team, they may also help to reinforce the different conceptualizations. For example, a stronger sense of agency helps to strengthen the backbone; deeper relationships help to create a better space for the catalyst, incubation, and learning community; and inclusive leadership helps the team to act as a more effective and supportive propeller of projects. This feedback from the outcomes for individual NFs back into the conceptualizations of collaboration is important for the NF team to conduct its work.

Importantly, this team is led by students. Students have control over what projects to take up and how the team functions. The NF mentors offer guidance and do model some of these practices. However, as evidenced by the NFs we have interviewed, the collaborative work in the team is framed as students as the drivers and decision makers. It is necessary to keep this context in mind when discussing these conceptualizations and outcomes for students. The NFs saw each other as the central collaborators and the outcomes that they describe are surely a result of this type of shared leadership structure.

VI. Conclusion

A. Limitations

We see our results presented here as salient for the students that are represented in this study. However, we recognize that we have a limited scope in terms of the number of NFs. If we include more stories from other NFs, we may find that there are additionally important collaborative processes that are not reflected in this paper. The results here also capture the experience of veteran NFs, however there may be forms of collaboration and specific outcomes that are more salient for new NFs. These interviews were also conducted at a single point in

time, and the ways that NFs describe their experiences may evolve over time. We emphasize that the results presented here are reflective of a snapshot of the NFs' experiences.

Interviews may also only tell part of the larger story of how the NF team works. We are limited by this data as we do not formally include any direct observations of the NF team in our analysis. Additional forms of data would help us to better triangulate our results and add additional dimensions to the conceptualizations and outcomes for students. However, we are able to leverage our own deep knowledge of Access in order to help interpret the stories from the NFs. We see embeddedness as an advantage to our research process.

Finally, we have limited our analysis in this paper to experiences within the NF team. There may be other spaces, both within Access and outside of it, that have implications for how students view their collaborative work and what they value from it. We have chosen to focus on the NF team as this type of student change team is uncommon in traditional academic environments and is important to understand on its own.

B. Implications and next steps

The ultimate goal of Access is to bring about change, by challenging traditional exclusionary practices within STEM and replacing them with alternative visions. It is important that in pursuing this change, the teams collaborate using inclusive practices to support new ideas and bring new stakeholders into the process. We have shown how NFs are not only participating but valuing the collaborative model in the NF team. Other similar efforts may benefit through pursuing similar modes of work captured by our conceptualizations of the NF team collaboration, as participating in these modes have shown to be highly valued by the NFs.

In identifying common conceptualizations of the NF team, we have provided a way to talk about how this team functions. Describing the work of the NF team can sometimes be difficult as students have many responsibilities that overlap while they are in this role. We encourage others to think about the teams they are a part of, or investigating them, in terms of these conceptualizations. For example, identifying when a team may be functioning as a backbone and how that influences the incubation process of a new project can be helpful in understanding why work processes are unfolding in particular ways and identifying additional stakeholders.

In our future work, we plan to continue to understand how the conceptualizations of collaboration facilitate the development of particular outcomes for students, such as their sense of agency or particular skills for inclusive leadership. In this paper, we have shown how these are supported generally through participation in the NF team, but we believe that continued analysis of the NF team will reveal important mechanisms through which the forms of collaboration enable this development.

Many initiatives for change in STEM academia and higher education have focused on the importance of faculty members' contributions and their buy-in to the process. Although faculty members, administrators, and staff are important stakeholders for this desired change, we have shown how student teams are also able to contribute meaningfully to inclusive collaboration around change work. The NF team differs from other places where students are partnered with as they are given a great amount of autonomy to define their projects and goals. We hope this work inspires others to support these types of teams of students in spaces outside of the Access Network.

We have seen how the NF team does not seek to enculturate students into the old ways of collaboration in science but develop with them new forms of collaboration. For STEM culture to be more inclusive, the change processes must be inclusive. Students gaining experience with inclusive leadership is important for building capacity for this change work. We aim to further study the NF team through interviews with additional students, both to build upon the results we have presented here, but also to better understand how NFs bring what they have learned into other settings and affect change in those spaces.

References

- [1] J. Lucena (Ed.). *Engineering education for social justice: Critical explorations and opportunities* (Vol. 10). Springer Science & Business Media, 2013.
- [2] J. A. Leydens, J. C., Lucena, & D. Nieuwsma. "What is design for social justice?" In *2014 ASEE Annual Conference & Exposition* (pp. 24-1368). June, 2014.
- [3] D. Nieuwsma. "Engineering, social justice, and peace: Strategies for pedagogical, curricular, and institutional reform." In *2011 ASEE Annual Conference & Exposition* (pp. 22-609). June, 2011
- [4] G. Quan, B. Gutman, J. Corbo, B. Pollard, & C. Turpen. "The Access Network: Cultivating equity and student leadership in STEM." In *Proceedings of the 2019 Physics Education Research Conference*. Jan., 2019.
- [5] F. Amezcua, G. Quan, & C. Turpen. "Students' exploring and refining their equity ethic within the Access Network." Paper presented at *Physics Education Research Conference 2020, Virtual Conference*. July, 2020.
- [6] E. McGee & L. Bentley. "The equity ethic: Black and Latinx college students reengineering their STEM careers toward justice". *American Journal of Education*, 124(1), 1-36. 2017.
- [7] B. B. McIntyre, K. R. Maxey, D. Verdín, & A. Godwin. "A Review of Agentic Frameworks in Engineering Education." In *2020 ASEE Virtual Annual Conference Content Access*. June, 2020.

- [8] A. Cook-Sather. "Student-faculty partnership in explorations of pedagogical practice: A threshold concept in academic development." *International Journal for Academic Development*, 19(3), 186-198. 2014.
- [9] L. Mercer-Mapstone, S. L. Dvorakova, K. E. Matthews, S. Abbot, B. Cheng, P. Felten, & K. Swaim. "A systematic literature review of students as partners in higher education." *International Journal for Students as Partners*, 1(1). 2017.
- [10] F. Davenport, F. Amezcua, M. S. Sabella, & A. G. Van Duzor. "Exploring the underlying factors in learning assistant-faculty partnerships." In *2017 Physics Education Research Conference Proceedings*. Jan., 2018
- [11] H. E. Jardine. "Positioning undergraduate teaching and learning assistants as instructional partners." *International Journal for Students As Partners*, 4(1), 48–65. 2020.
- [12] S. Secules, A. Gupta, A. Elby, & E. Tanu. "Supporting the narrative agency of a marginalized engineering student." *Journal of Engineering Education*, 107(2), 186-218. 2018.
- [13] J. A. Yang, M. K. Sherard, C. Julien, & M. Borrego. "Resistance and community-building in LGBTQ+ engineering students." *Journal of Women and Minorities in Science and Engineering*, 27(4). 2011.
- [14] C. Margherio, A. L. Swan, J. M. Williams, E. Andrijcic, S. Mohan, & E. Litzler. "Unified Voice and Group Agency: Developing Teams to Transform Engineering Education." In *2021 ASEE Virtual Annual Conference Content Access*. July, 2021.
- [15] A. J. Kezar, and E. M. Holcombe. "Shared Leadership in Higher Education: Important Lessons from Research and Practice." Washington, DC: American Council on Education. 2017.
- [16] E. M. Holcombe and A. J. Kezar, "Organizing Shared Equity Leadership: How to Structure the Work," *Higher Education Today*, June 2, 2022. [Online]. Available: <https://www.higheredtoday.org>. [Accessed Feb. 1, 2023].
- [17] E. M. Holcombe, A. J. Kezar, J. P. M. Dizon, D. Vigil, and N. Ueda. "Organizing Shared Equity Leadership: Four Approaches to Structuring the Work." Washington, DC: American Council on Education; Los Angeles: University of Southern California, Pullias Center for Higher Education. 2022.
- [18] R. A. Engle, F. R. Conant, & J. G. Greeno. "Progressive refinement of hypotheses in video-supported research." In R. Goldman, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video research in the learning sciences* (pp. 239–254). Mahwah, NJ: Erlbaum. 2007.
- [19] A. E. Slaton & A. L. Pawley. "The power and politics of engineering education research design: Saving the 'Small N'" *Engineering Studies*, 10(2-3), pp. 133-157. 2018.
- [20] H. Lipmanowicz & K. McCandless (adapted from B. Zimmerman). "Ecocycle Planning". *Liberating Structures*. [Online]. Available: <https://www.liberatingstructures.com>. [Accessed Feb. 13, 2023].