

Siloed Efforts and Collaboration Among STEM Equity Initiatives: An Organizational Network Analysis

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Work in Progress: Siloed Efforts and Collaboration Among STEM Equity Initiatives: An Organizational Network Analysis¹

Introduction

In the decades-long pursuit of fostering inclusive and equitable learning environments, universities in the US have increasingly prioritized equity, diversity, and inclusion (EDI) initiatives, reflecting a broader societal commitment to equity and social justice [1]. This paradigm shift has prompted universities to engage in numerous initiatives aimed at creating a more inclusive environment for students. The benefits of EDI efforts in higher education are well-documented, ranging from enhancing innovation to improved academic performance and retention rates among underrepresented student populations [2], [3]. As the US grapples with shifting notions of equity and justice, recent Supreme Court decisions in *SFFA v. Harvard* and *SFFA v. UNC* which have effectively eliminated affirmative action have added a significant layer of complexity to the landscape of EDI efforts within institutions of higher education.

While there has been substantial research examining the individual-level effect of student-focused EDI interventions in higher education, there has been less focus on the institution-level. Little is known about how EDI efforts are organized and how they manifest within a complex network of stakeholders, departments, and other programs. Our work aims to empirically examine the network of efforts to improve equity at the University of Washington (UW) through a mixed methods approach. We utilize semi-structured interviews with practitioners and a network survey of campus organizations with an EDI focus to answer the following research questions:

1. How are EDI initiatives structured regarding contact, information sharing, and collaboration between organizations at a sizeable 4-year university in the Pacific Northwest?
2. What factors contribute to effective coordination and collaboration among EDI initiatives?

Our research is motivated by insights garnered from our center's decades of work as the evaluator of STEM equity efforts. Practitioners involved in efforts to improve equity on college campuses often note the siloed nature of programs serving marginalized students. Conversations

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between members of our research team and practitioners working on STEM equity efforts suggest that this siloing, while sometimes necessary and beneficial, can also contribute to duplication of efforts and serve as a barrier to collaboration. Applying methods designed for social network analysis allows us to examine the extent to which perceptions of the siloed nature of equity efforts are supported by empirical evidence and identify individual efforts' locations within the broader contexts of communication and collaboration between EDI organizations. Qualitative survey and interview data provide additional information about factors impacting effective collaboration between aligned efforts.

Our study was conducted in collaboration with the Pacific Northwest Louis Stokes Alliance for Minority Participation (PNW LSAMP), a program providing academic and social support for students from racial/ethnic groups minoritized in STEM (Black/African American, Hispanic/Latinx, Native Hawaiian/Pacific Islander, American Indian/Alaska Native). Evaluation findings from the first ten years of LSAMP suggest that LSAMP serves as a point of connection/resource hub for STEM equity efforts due to its cross-disciplinary focus/broad reach. While part of our intention is to use social network analysis to examine whether this is the case, this line of questioning gave rise to broader questions about the structures of EDI efforts across college campuses and factors contributing to or reducing the siloing of mutually aligned efforts. Moreover, understanding the organizational dynamics of EDI efforts provides valuable insights for policymakers, administrators, and practitioners seeking to strategically allocate resources and support to better meet their equity and social justice goals.

While much of the literature on stratification in STEM education focuses on the impact of EDI interventions on students, there remains a crucial gap in our understanding of how these initiatives are organized within broader institutional contexts. This study aims to provide insight into institutional structure and its implications for STEM equity efforts. In doing so, we hope to add to the growing body of knowledge regarding transformational and systemic changes that go beyond individual interventions to better “prepare students for an increasingly globalized economy and diverse workforce, and to embody the values of social and cultural pluralism and equity” [4, p. 315].

Background

The landscape of EDI efforts in STEM at colleges and universities

Colleges and universities increasingly recognize the importance of equity, diversity, and inclusion for groups who have been minoritized in or who face structural barriers to higher education [4]. STEM fields have been highly stratified disciplines historically and this persists despite concerted efforts to diversify them [5]. STEM occupations are both in-demand and higher-paying [6], and thus represent a notable opportunity to address broader social inequities by facilitating greater economic mobility for socially disadvantaged groups. While colleges and universities have expressed increasing commitment to EDI in STEM in recent years [7], most efforts are designed as individual-level STEM intervention programs (SIPs) aimed at “helping students historically underrepresented in STEM to prepare for and graduate from STEM fields”[8, p. 2]. Examples of SIPs include: summer bridge, mentoring, research experiences, tutoring, career counselling and awareness, learning centers, workshops and seminars, academic advising, financial support, and curriculum and instructional reform [9].

Research on the effect of SIPs suggests that many help improve academic preparation, self-efficacy, STEM identity, sense of belonging, and ultimately persistence in STEM [10]–[12]. While investment in these focused interventions is important for mitigating the effects of systemic inequity within education and society more broadly, the structure of higher education institutions contributes to a patchwork of student support programs that are difficult to sustain and often operate in parallel [13], [14]. The lack of consistent coordination and collaboration across efforts can lead to redundancies and gaps in services, inconsistent access to student resources, and limited capacity for systemic change [15] [14]. Thus, there is a need for research to better understand how to promote, enhance, and sustain these EDI-focused efforts on campuses and invest in systemic change necessary to achieve equitable representation in higher education [8], [9].

Vertical organization and “siloeing” in higher education

Most higher education institutions are vertically organized within four primary units: academic affairs, teaching faculty, student affairs, and student success services, each addressing its own challenges and opportunities to support students [16] [13]. As a result of their vertical organization, higher education institutions frequently develop a siloed organizational structure [13]. Departments, colleges, and other units function “in parallel with one another, more focused on promoting their own internal goals and objectives than on adhering to, elucidating, or accomplishing broader institutional purposes” [13, p. 22]. Often, there is little to no

communication between units and a competitive rather than collaborative atmosphere. These silos are strengthened by policies, missions, and cultural differences between units [17] and can result from institutional responses to changing social, political, legal, and historical contexts. Individual units within colleges and universities must adapt to evolving contexts in order to provide consistent support to their students. As a result, the current structures "lead to duplication of services, for example, when academic programs develop their own orientation programs rather than working with student affairs to coordinate with a general orientation already being organized and run through student affairs" [14, p. 16], [18].

This fragmentation and disconnectedness can confuse students as they "often receive conflicting information due to the lack of cross-divisional communication" [14, p. 16]. Students receive uncoordinated and disconnected interventions, a barrier to improving retention and graduation [19]. Without coordinated support to develop the knowledge, skills, and motivation to access the range of available services, resources are frequently under-utilized (especially among those who would benefit most) [20]. Even though some degree of siloing occurs in most colleges and universities, research suggests that institutions can improve coordination and communication by integrating services and collaborating to support student success through a more horizontal, holistic, and coordinated approach [16]. An important part of this change is addressing campus culture and how leaders support and work towards equity and incorporate collaborative strategies [21]. Holcombe and Kezar [14] call for creating a "unified community of support" that will work together to break down barriers and support students.

Our research empirically examines the organizational landscape at the University of Washington. We explore how programs and organizations interact, communicate, and collaborate and identify factors that inhibit or contribute to the siloing described in the literature. This work helps illuminate where the siloing mentioned in the literature exists, especially concerning STEM equity efforts. We believe this to be the first step toward developing strategies to address said siloing, if necessary, to support practitioners and students.

Study context: PNW LSAMP

Our research was conducted in collaboration with the Pacific Northwest Louis Stokes Alliance for Minority Participation (PNW LSAMP). PNW LSAMP programs vary somewhat across the five universities and four partnering community colleges within the Alliance, but all university students from eligible racial/ethnic groups (Black/African American, Hispanic/Latinx,

Native Hawaiian/Pacific Islander, American Indian/Alaska Native) expressing an interest in STEM are automatically affiliated with LSAMP and are welcome to access the LSAMP Center on their campus unless they elect to opt-out. At UW, the campus we focus on in this analysis, the LSAMP Center provides study/social space for students, computers, printers, and access to LSAMP staff. The LSAMP program also provides services such as tutoring/academic support for students, professional/career development opportunities, information about graduate studies in STEM, peer mentorship programs, and research stipends. While LSAMP programs vary widely across the country and within the PNW Alliance, they are all intended to generate productive partnerships among educational institutions and support students by strengthening academic and research skills [22].

The current research was motivated, in part, by evaluation findings identifying LSAMP as a hub for students to access resources and opportunities across silos. This research was also motivated by conversations within the Alliance about the institutionalization/sustainability of LSAMP and aligned efforts to improve equity in STEM. LSAMP staff noted that, while they tried to serve as a student resource hub, this function and their connection with other aligned efforts is often difficult to sustain given the institutional structure. Inquiries around LSAMP's place in the institutional structure were the starting point for this research.

Data and Methods

This study utilizes a mixed-methods approach, including insights from semi-structured interviews with LSAMP program coordinators, which informed the development and distribution of a survey of EDI-focused efforts at four universities. A mixed-methods approach allows us to explore the more objective structure of the relationship between campus organizations through a social network analysis (SNA) alongside a subjective understanding of the processes generating that structure discussed in interviews and qualitative survey responses. While our broader research project spans four universities, this study focuses on quantitative findings from one university (UW). Qualitative findings were relatively consistent across all four institutions, so data from all four institutions are included in the current analysis. Our data were collected in Fall 2022-Spring 2023, after in-person instruction had resumed following the onset of the COVID-19 pandemic, but while organizations were still coping with the disruptions it caused and re-establishing regular programming.

Data

The researchers first conducted hour-long interviews through Zoom with LSAMP program coordinators at four of the five PNW LSAMP universities. LSAMP program coordinators were selected for interviews because our line of inquiry originated from questions about LSAMP's location within the network of STEM equity efforts [23] and they possess a unique institutional knowledge of EDI efforts across their universities. The interviews followed a protocol that asked about LSAMP's relationship with other organizations on each campus, the potential gaps in services, and how their institutions might help or hinder their work toward improving equity in STEM. Interviews were recorded and auto-transcribed within Zoom.

With the help of the interview respondents, the researchers compiled a list of organizations on each campus that were aligned with LSAMP's mission of improving equity in STEM. Researchers conducted a web search of equity-related services and organizations on each campus to expand the list provided by LSAMP coordinators. Because of LSAMP's location at the intersection of STEM and EDI, organizations identified for inclusion in these lists all have a specific EDI focus or specific STEM focus, but not always both. Each list included details regarding the population served by each organization, the resources they offer, their mission statement, and their administrative and geographical location. Coordinators were asked to review the lists to indicate which organizations LSAMP interacts with and the nature of their relationship with LSAMP. Because these lists were generated based on LSAMP coordinators' perceptions of alignment with LSAMP's mission, several organizations without an explicit EDI focus are also included. For example, advising offices within STEM departments have been strong supporters of LSAMP's programming at the university, that is the focus of the current study, and are thus identified by the LSAMP coordinator as important units to include on the list of EDI-aligned efforts across campus.

After reviewing the lists and asking clarification questions, the researchers created a survey using Qualtrics – an online survey software – to obtain more information. The survey was modeled after other instruments developed for SNA [24]–[27]. The survey asked questions regarding organizations' relationships with others on each campus. Specifically, respondents were asked how often over the past year they had contact (meetings, emails, phone calls, etc.) with the other organizations (never, once or twice, every few months, monthly, weekly, daily); how often they exchanged or shared information (event invitations, organization updates, internship/scholarship opportunities, etc.) with other organizations (never, once or twice, every

few months, monthly, weekly, daily), and how many events they organized in collaboration with the other organizations (open-ended numeric response). The survey followed a fixed-choice approach in which participants were provided a roster of organizations to choose from. This roster reduced potential bias from memory recollection by having participants recognize relationships instead of reporting them. However, this roster pre-specified a certain number of programs and organizations, which could lead to some being overlooked or ignored [28]. Therefore, researchers added questions asking participants if they recalled any other organizations not previously mentioned. The survey also asked descriptive questions about population served and resources provided to fill in gaps in the initial list, and two open-ended questions asking participants to reflect on factors facilitating and inhibiting collaboration with other organizations.

Researchers sought feedback from the four interviewees to edit the survey before distribution. The survey was distributed to program coordinators, directors, or other points of contact identified by LSAMP coordinators and/or web searches. When additional organizations were named in survey responses, researchers also contacted them to complete a survey. We received a total of 75 responses out of the 170 surveys were distributed across the four participating institutions, an overall response rate of 44%. The current study incorporates qualitative data collected from all 75 survey respondents and the four LSAMP coordinator interviews. Our quantitative analysis is limited to data collected from 21 organizations responding to the UW network survey (46% of the organizations the survey was distributed to).

An abbreviated version of the survey was also distributed to students receiving the PNW LSAMP annual evaluation survey (all students in a STEM or pre-STEM major identifying as Black/African American, Hispanic/Latinx, Native Hawaiian/Pacific Islander, American Indian/Alaska Native) at each university. Students were asked to identify which organizations they were familiar with and how often they had contact with those organizations. Fifty-five UW students answered the survey.

Analysis

Qualitative Analysis

The interview transcripts and open-ended survey responses were analyzed using qualitative analysis software (NVivo). Inductive coding was carried out by one member of the research team and reviewed by a second research team member. Themes arose concerning the

questions that were asked – in particular, passages were coded according to whether they described factors contributing to or detracting from collaboration and sub-coded with more detail about their nature. For example, when practitioners mentioned the importance of interpersonal relationships for creating opportunities for collaboration, it would be coded as "trust & relationships" under the central theme of "effective collaboration." A passage noting that guidelines and grant reporting requirements hinder the ability to collaborate would be coded as "grant requirements" under the central theme of "barriers to collaboration." A detailed coding scheme is available upon request.

Social Network Analysis

We use SNA methods to analyze the survey data. Our data represent a bounded network within each university campus that includes (to the best of our knowledge) all organizations on each campus that share LSAMP's aim of improving EDI. While SNA typically includes individuals as nodes, our focus is on inter-organizational networks, so organizations rather than individuals are the unit of analysis. Each organization acts as its own entity that forms and maintains relationships with other organizations.

Dealing with missing data in SNA is a critical consideration, as it can significantly impact the validity of the results. Because we received survey responses from less than half of the organizations included in our network, we had a considerable amount of missing data. Symmetrization is one approach to address this issue, and it involves transforming a directed network into an undirected one while accounting for missing ties. The survey data initially represented directed relationships between organizations, indicating the strength of connection in each category (contact, information sharing, and co-planning). To prepare the data for SNA, a symmetrization process was employed using the average or mean method. We employed this procedure to treat relationships as bidirectional, assuming mutual organizational interactions. While no approach to dealing with missing data in SNA is perfect, alternative methods, such as deletion of missing data or imputation, risk the loss of valuable information. Symmetrization circumvents this issue by leveraging the available data and allows for a more complete view of the network structure and dynamics among organizations.

Our analysis focuses on the density of the network as a whole, the existence of and boundaries around clusters/communities of organizations within the larger institutional network, and the centrality of particular organizations. Degree centrality is the measure that looks at "the

prominence of a particular organization in a network” ([26, p. 414] in terms of how many other organizations it shares a relationship or tie with. Organizations with a high degree centrality might possess more influence over other organizations as they have access to more information or resources through their high number of connections relative to other organizations in the network. This measure is important to examine as it represents a critical organizing feature of the network.

In this study, we employ SNA to analyze the inter-organizational relationships within the university campus context. This allows us to gain insight into how organizations interact, share information, and collaborate. To visualize the networks, we utilize the Fruchterman and Reingold layout algorithm [29], which generates force-directed, two-dimensional layouts that arrange nodes based on the strength of their connections. The algorithm simulates a physical system where nodes repel each other while edges act as ‘springs,’ ultimately reaching a state of equilibrium. This method eases the interpretation of the network data by providing a clear and intuitive representation of the networks’ structures, allowing us to visually identify clusters, key organizations, and potential organizational silos.

The network visualizations also incorporate node attributes to convey additional information. The size of the nodes reflects the scaled degree centrality or the scaled number of ties each organization has. In our visualizations, the larger the node, the more connected the organization is in terms of contact, information sharing, and collaboration relative to all other organizations in the network. We also consider whether or not organizations are focused on STEM students (square-shaped nodes) or the general student population (circle-shaped).

To further analyze the network structure, we applied the Lovain clustering algorithm [30], which is particularly effective in detecting communities that are densely connected internally while having fewer connections between communities. The algorithm optimizes the network's modularity, seeking to maximize the strength of community structure. In our analysis, communities detected within the inter-organizational network represent cohesive groups of organizations that are in close contact, share a lot of information, or collaborate frequently. Moreover, it allows us to assess the degree to which organizations are or are not siloed.

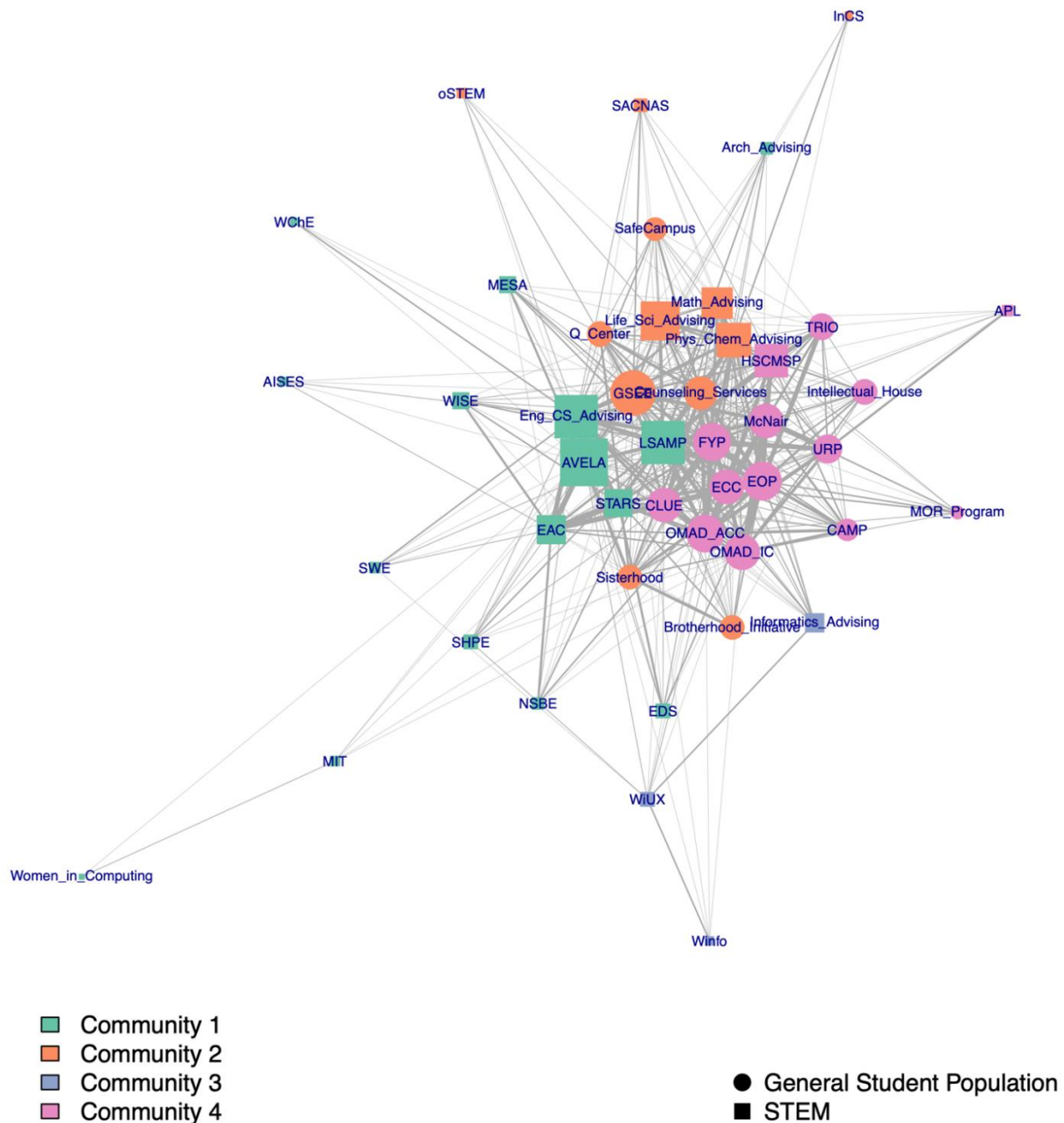
Quantitative Findings

Frequency of Contact

Figure 1 shows results from SNA of EDI efforts as nodes and the frequency of contact (meetings, emails, phone calls, etc.) between organizations as ties. The size of each node reflects the degree centrality, or the number of other organizations the node is in contact with. The width of each tie corresponds to the frequency with which organizations contact one another. The dense (network density = 0.427) contact network suggests high levels of contact among

STEM/EDI efforts. The detected communities suggest some degree of siloing along the lines of the university's organizational structure.

Figure 1: Contact Network with Communities



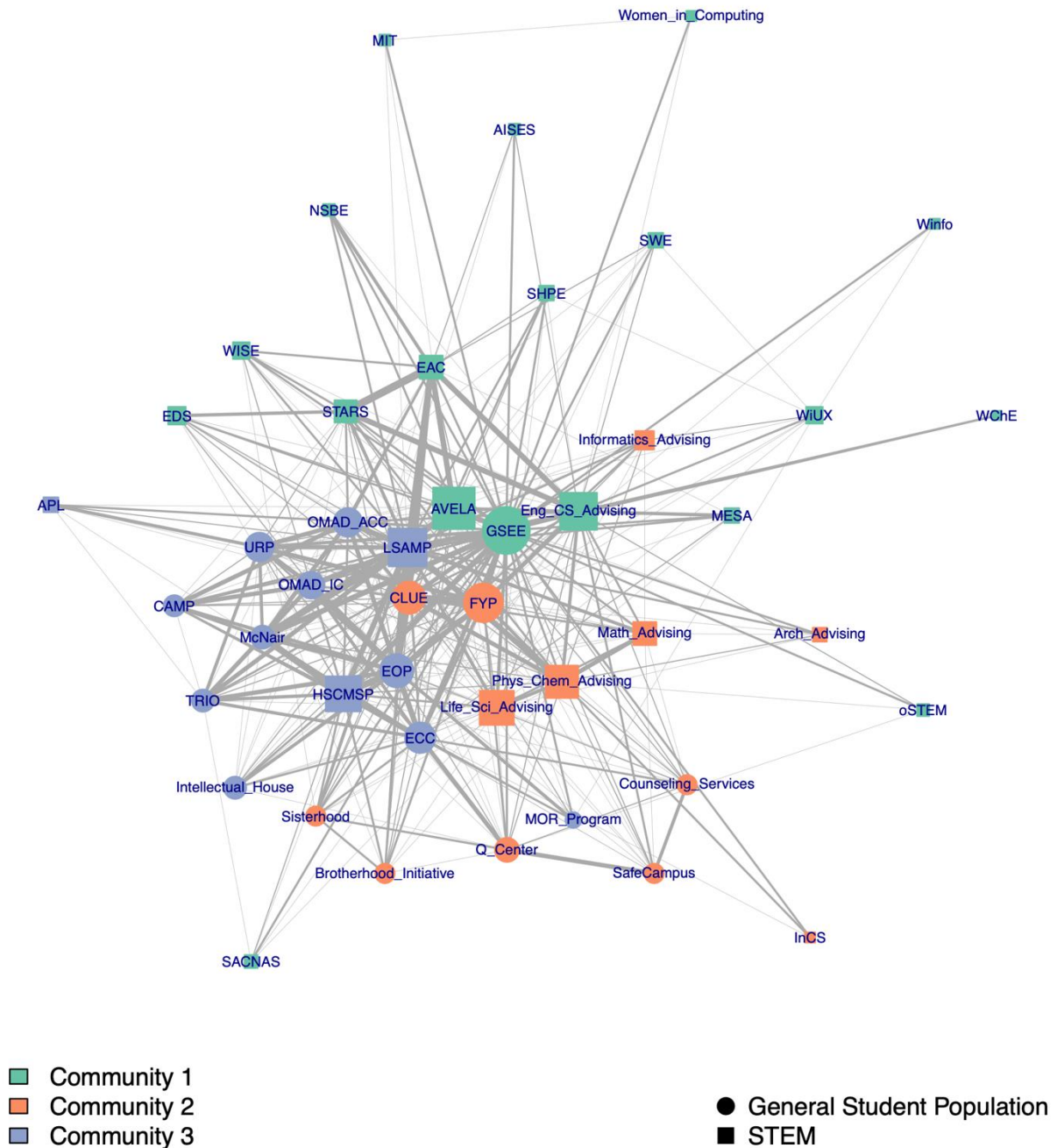
Community 1 is exclusively comprised of organizations serving STEM students and primarily engineering students. The organizations in this community that are most highly connected and centrally located within the larger network include the computer science advising office, an academic support center serving all engineering students, a cohort-based holistic academic and social support program serving engineering students from economically marginalized backgrounds, a student-run organization that provides technology-focused outreach to high school students from groups minoritized in STEM, and LSAMP (one of the only organizations in Community 1 serving STEM students outside of engineering). Organizations more loosely connected to the larger network primarily do so through these central organizations. The inclusion of LSAMP within Community 1 is notable, given its focus on STEM disciplines more broadly and its administrative location within the university-wide EDI office. LSAMP's position within Community 1 suggests that it serves as a bridge/broker between efforts within the College of Engineering and the university more broadly. Community 4 is linked closely to Community 1 through LSAMP and is mainly composed of organizations administratively located within the same university-wide EDI office as LSAMP. These are primarily programs aimed at providing academic and/or social support for students from groups racially/ethnically minoritized in higher education (both STEM and non-STEM). These include ethnic/cultural centers, instructional centers, programs supporting undergraduate research, and other academic support programs for minoritized students university-wide. Community 2 comprises advising offices for STEM disciplines outside the College of Engineering, student organizations for minoritized students in non-engineering STEM disciplines, and some general undergraduate academic support/tutoring programs. The three organizations in Community 2 that are most central/tightly connected to the larger network are an office serving graduate students from minoritized groups, a tutoring center serving the general undergraduate population, and the office of first-year programs. Community 3 is the least connected to the rest of the network and comprises organizations related to the Informatics department (the advising team and two student organizations).

Information Sharing

Figure 2 depicts results from SNA of STEM/EDI efforts where ties represent information sharing between organizations (examples include sharing invitations to events, organization updates, internship scholarship opportunities, etc.). While overall network density is less than the

contact network (network density = 0.364), results suggest a high degree of information sharing occurs amongst organizations.

Figure 2: Information Sharing Network with Communities



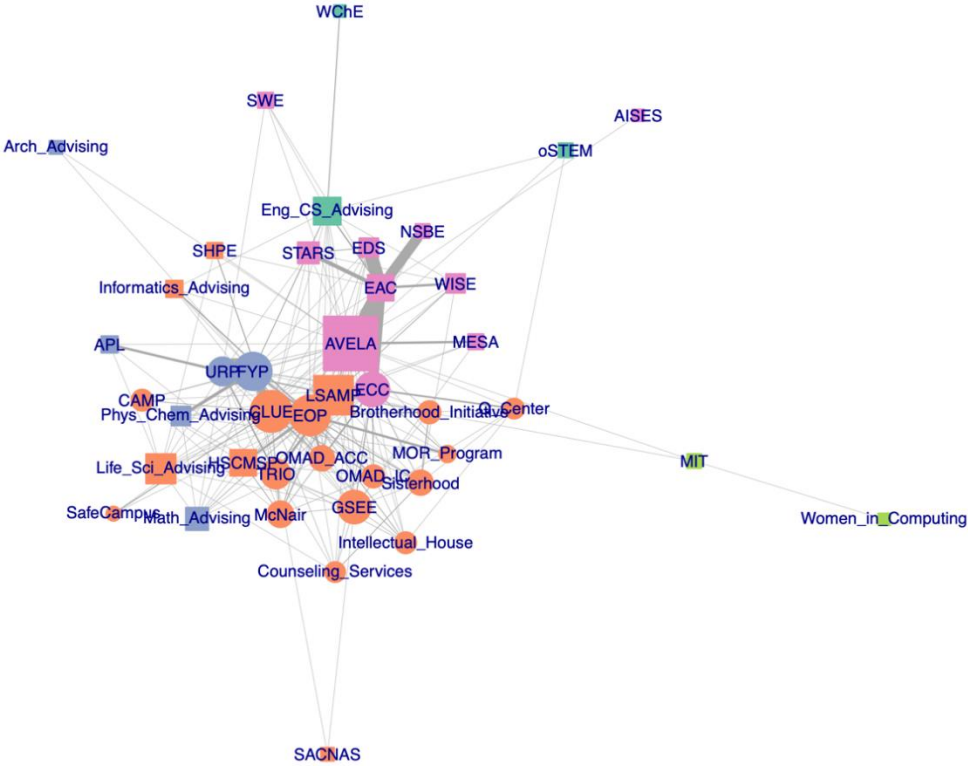
The communities are similarly composed to those of the contact network, with some key exceptions. In this network, all of the campus branches of national professional organizations (i.e., Society of Women Engineers, National Society of Black Engineers, Society for the Advancement of Chicanos and Native Americans in Science) and the student-run organizations are in Community 1 except InCS (Inclusion in Chemical Sciences) which is in Community 2 alongside advising offices and academic/social support services available to students in all disciplines. In the information-sharing network, LSAMP is in Community 3 alongside the other organizations administratively located within the university EDI office. Like the contact network described above, organizations with an engineering focus seem siloed. However, there appears to be more connection between these organizations and student organizations focused on STEM fields outside of engineering when it comes to sharing information (not merely communicating).

Collaboration

Figure 3 shows results from SNA of EDI initiatives with ties representing collaboration between organizations (indicated by the number of events or activities planned together or co-hosted in the past year). The collaboration network is much sparser (network density = 0.221) than the contact or information networks, with the frequency of collaboration within Communities 2 and 4 much higher than all others. The high frequency of collaboration within Community 4 is mainly driven by the frequent collaborations between a student-run organization conducting tech-related outreach to minoritized high school students, an engineering academic support center, a program providing first-year support to minoritized students in engineering, and the National Society of Black Engineers campus chapter. There is a predictably high frequency of collaboration between organizations co-located within the university-wide EDI office (most of Community 2). There is also strong collaboration between the undergraduate research office and the office of first-year programs, both of whom also collaborate frequently with LSAMP. Like the contact and information-sharing networks, there is a distinct community of engineering-focused organizations. In contrast to the communication and information-sharing networks, the collaboration network includes three organizations that are isolates, or not connected to any other organization, which constitute Communities 6-8.

Overall, our analysis shows that the same few organizations seem to appear at the center of the network for each dimension under investigation (communication, information-sharing, and

Figure 3: Collaboration Network with Communities



Winfo

InCS

- Community 1
- Community 2
- Community 3
- Community 4
- Community 5
- Community 6
- Community 7
- Community 8
- General Student Population
- STEM

collaboration). Most of these centrally-located/highly connected organizations are also organizations that student survey respondents identified as the organizations they were most

frequently in contact with (meetings, events, emails, phone calls, etc.). LSAMP was the organization students reported having the most frequent contact with. Forty-eight of the 55 students (87%) who responded to the survey mentioned knowing about LSAMP, and 18 (33%) said they had been in contact with LSAMP coordinators at least monthly over the past year. Other organizations that students identified as being in frequent contact with include a university-wide academic support/tutoring center, the office of first-year programs, advising and academic support programs geared toward students minoritized in higher education (located within the university-wide EDI office), and the university-wide ethnic cultural center.

An interesting and unexpected finding is the central and important position of an organization conducting tech-related outreach to high school students minoritized in STEM. This organization is student-led, which contrasts with all the other student organizations primarily on the outskirts of the networks. This organization is very interconnected with the other units within the College of Engineering, likely due to institutional support of their programming. However, they are also highly connected to organizations outside of engineering. This organization also has partnerships with public schools and sponsors at the university and beyond in the community. Based on publicly available information, this student organization appears to be very active with strong and motivated leaders who may be doing a lot of reaching out and sharing with other organizations. That being said, students who replied to the survey were not as familiar with this organization—only nine out of the 55 responding to the survey knew about the organization.

Qualitative Findings

As supported by our quantitative analysis, participants suggest that collaboration between organizations is less frequent than communication and information-sharing. Our qualitative analysis was aimed at identifying factors that facilitate or inhibit collaboration. Findings from this analysis were extremely similar across the four institutions, so even though we are focusing on only one of the institutions in the SNA for this paper, we believe that looking at all the survey answers provides a more holistic picture and more insights into program coordinators and staff's thoughts. We interviewed four LSAMP coordinators and received 56 responses to the open-ended questions at the end of the survey (74.7% of survey respondents).

Effective collaboration

Some program staff mentioned co-location as a helpful way to form relationships and make connections, as close proximity makes it easier to have check-ins and get to know each other. They mention being in the same building as helpful since they can have informal conversations and build more personal relationships, “Having a shared department contributes to the strongest relationships I have.” This comment may help explain how the organizations within the College of Engineering and the university-wide EDI office seem to have the most communication/coordination.

Additionally, respondents expressed that having a common goal/mission and shared values are important factors for effective collaboration. The most commented shared goal throughout the data is "supporting students." Program coordinators mention that having similar or aligned visions streamline collaboration. They emphasized the value of shared goals, values, and mission and the staff's willingness to work together to better support their students. “I think it’s like a shared understanding of what these populations need. And I think that, there again, we're all very student focused on service.” And “We have a really solid relationship with the units whose missions are tightly aligned with ours.” This might explain why organizations with overlapping populations or services seem to collaborate and communicate the most, according to SNA.

Open and ongoing communication is among the most frequently mentioned ways to foster effective collaboration between programs. Open communication is defined as answering emails, being honest and forthcoming, frequent communication, and sharing information. Such as "Frequent formal and informal, scheduled and unscheduled updates to each other (i.e., over-communication)" and "Regular check-ins, not recreating the wheel, making sure we are sharing info about each program and event and being open to having students from other programs join!" and "Clear/convenient email communication - receiving announcements about upcoming events, language that can be directly forwarded to students without making edits" and "setting reasonable times to meet and discuss shared goals, and utilizing feedback from stakeholders and our respective audiences contributes most to effective collaboration." Contact and information-sharing visualizations look to be connected. Therefore, it could be said that practitioners are doing as much as they can in what they believe is an effective way to foster collaboration. Overall, “To make that happen, communication is key to making an effective collaboration. While it isn't about splitting 50:50, it is about being mindful and respecting each other's time and

efforts. Given the resource limitations that programs have, it is about finding the balance between collaborators to make the relationship work in a positive way for everyone involved.”

Another salient factor contributing to effective collaboration is personal relationships and trust that people will do what they say and know what to expect. Trust and respect are essential factors for effective and continuous cooperation. Staff mentioned how "Knowing individuals with whom we can work - trusting relationships based on past experience with professionals who are dedicated to supporting students" and "Having a genuine relationship that is fostered over time with regular information sharing contributes to effective collaboration." And "Having personal connections with the staff working in those units. Feeling like I know an individual to reach out to and having the confidence that they know that I'm a good person to contact for my program." Program coordinators also commented on the need to have a sense of safety in conversations that allow for sharing ideas, feedback, and working together, like "I think the best relationships are the ones where I feel really safe going to that director or that coordinator and saying, can we collaborate? Can I bring a student over to meet you? Can we put some of our activities in your space?" Another helpful component is having a history of collaboration between organizations/programs and long-lasting personal relationships between staff. Interpersonal relationships are hard to pinpoint in the visualizations, but qualitative findings suggest that the organizations that communicate and collaborate the most may have staff members with strong personal relationships. Those relationships also take time, so coordinators in the same position for a few years may help foster these relationships, unlike those with higher turnover rates.

Barriers to collaboration

There seems to be a consensus on the different ways collaboration is complicated or impossible from both the interviews and the open-ended survey responses. Many programs and organizations at different institutions are funded through grants, meaning they have requirements, reports, and deliverables to be accountable for with the outside grant agencies [31]. Program coordinators explain how this can be a barrier to collaboration: “Based on our grant regulations, our funding is for students in our program so hosting events for students who are not part of our program is challenging” or “From our program's perspective, we have a specific grant mandate and defined obligations to our funding agency. As a result, this creates barriers.” because “You're on the hook to deliver for your grant, that's what you have to do. So, even if you

want to collaborate there's just such a fixation." Therefore, organizations often do not lean on each other and collaborate as they must show how they are spending their funds to help the students enrolled in their own program, so they must create the events independently. This may explain why, even with high levels of communication between organizations, there are not more events organized collaboratively. Therefore, the way grant requirements are currently structured is not conducive to collaboration between grant-funded organizations.

Another frequently mentioned barrier to collaboration is the lack of information and communication between programs and organizations across campus [16]. Participants mentioned not knowing who to contact, not knowing what is happening on their campus and who is doing what, and not having reliable communication as people do not respond or staff turnover breaks down connections. This lack of information leads to staff not being aware that other organizations on campus might be providing similar services to students. For example, staff mention the "Lack of understanding among these organizations about what each of us does." And the "lack of knowledge for what they can provide/offer for students or departments, responsiveness to inquiries" and the fact that "I'm exhausted and have way too much work. Hard to know what's out there, what folks are doing, how to get in touch." For the university that is the focus of the current analysis, this feeling may be related to the overwhelming number of existing organizations. As can be observed in the Figures, there are 45 different organizations, which is not an exhaustive list of everything available. The sheer number of organizations could make it difficult to have sufficient information to know if/when/how to collaborate. Another staff member summarized it as "A huge barrier is reluctance to share information about program management and admissions, etc. Since we're a relatively new program, I have contacted many advising teams to ask how they handle certain situations, but oftentimes my emails or Teams messages go unanswered." This reported lack of information suggests that while the contact and information-sharing networks (Figures 1 and 2) are much denser than the collaboration network (Figure 3), the content of contact and information-shared might be more clerical in nature; communication related to navigating the organization structure of EDI efforts rather than communication beneficial to collaboration.

Staffing issues and lack of resources are big concerns too. Staff turnover seems to greatly impact communication breakdown between organizations as personal relationships are lost, or information is not transferred to new hires. Therefore, as people leave, collaborations are broken,

and it takes time to build them again if that is even started. Practitioners highlighted the need for “Knowing who to be in touch with - staff turnover makes relationship building harder”; “There are a lot of programs on campus, and they are hard to find or keep track of. I also do not know if some groups are active. When people leave positions or the boards change for student groups they are not always told about our program, so we lose that personal connection.” The lack of funding and resources exacerbates the issue as it diminishes the staff’s capacity to form relationships and create events.

Time is an additional constraint as program coordinators work on their daily tasks; there is only so much they can do in their allotted work time. Practitioners shared some thoughts on this: “I think it comes down to time, and just being one person, it's hard to stay on top of all of that. I think that’s the big hinderance honestly,” and “I think that the biggest barrier is a shortage of resources in terms of FTE in each of our respective centers. I truly believe that people would like to partner more collectively, but have only so many hours in the week and are focusing that effort as efficiently as they are able at the moment,” and “I also think the ways in which many of us are working with fewer resources, and fewer staff, and are expected to do more as part of the effort to revitalize, we have less time to nurture relationships or foster deeper ties beyond what currently exists.” All these different factors accumulate and make it harder for program coordinators and directors to collaborate. Even though collaborating on events and leaning on each other's expertise could potentially lower their individual loads.

Some program coordinators explicitly mentioned the siloed nature of their institutions, which in part leads to the duplication of services [13]. Some also commented on the institutional structural barriers and policies that hinder smooth collaboration. Staff indicate that units are siloed according to “department, specialization, or location,” and note, “Services for students are separated from faculty and staff. Undergrad and grad students also very separate, and separation between colleges and depts. Student clubs and organizations have too much red tape, bureaucracy, reporting and not enough help and support.” The visualizations show the separation between colleges and departments this staff member mentions through the distinction between the College of Engineering, the University EDI office, and units within the College of Arts and Sciences. This can lead to a disconnection with administration and sometimes low institutional support for the different programs on campus, especially those funded through grants.

Discussion

Overall, we find that the organizational structure of EDI initiatives at UW is dense and well-connected, with high levels of contact and information-sharing among organizations. This is somewhat surprising, given qualitative insights from program coordinators indicating that communication and information provide consistent barriers to collaboration. However, when it comes to collaboration, the structure is much less dense. While there are high levels of communication amongst organizations, other structural factors like funding requirements or practitioners being overworked may pose obstacles to collaboration. Organizations led and managed by students that are either specific to UW or chapters of national organizations appear to have more limited contact and collaboration with other programs on campus. This could be due to the smaller capacities of students who lead these organizations, less awareness of their existence on campus, or the yearly turnover of officers in charge. Despite this, student organizations exhibit a high degree of information sharing amongst themselves, likely facilitated by member overlap or more proficient use of social media platforms.

Our quantitative findings do not necessarily provide evidence of rigid siloing of individual EDI efforts, at least for this particular institution. However, we do identify distinct communities of efforts – in particular, efforts within the College of Engineering are somewhat disconnected from efforts within the College of Arts and Sciences, and EDI efforts serving the student body as a whole are somewhat disconnected from STEM academic advising. Our analysis reveals that, in general, programs and service centers embedded within the university's administrative structure communicate and share information the most, whereas the student organizations and advising offices are more on the outskirts of the network. Engineering-related organizations tend to collaborate more, possibly due to shared student populations or higher levels of institutional support that are not tied to grant deliverables.

While our SNA reveals less siloing than anticipated, qualitative insights suggest a desire for even more coordination and collaboration. Increased collaboration amongst efforts could lead to less duplication of services and lower the workload as practitioners can rely on each other's expertise. Shared planning and leveraging the variety of resources and knowledge across organizations could contribute to more impactful events and better outcomes for students. Increased knowledge and information-sharing across campus organizations serving similar

students or providing similar services could also support staff in providing students with the appropriate resources and information for their unique needs. While there are clear advantages to higher levels of collaboration amongst EDI initiatives, they must align with the practicalities of practitioners' daily tasks and unique missions.

We anticipate that investment in more centralized access to information about the resources and services available to support student success could support increased efficiency and efficacy of efforts to improve EDI in STEM. However, we recognize that there are some instances in which increased collaboration is not necessarily the goal. Silos in institutions of higher education exist for different reasons and on different scales, and siloing is not inherently harmful. Some siloing may be necessary in order for specific student populations to get the particular services they need.

Our preliminary findings from the SNA and qualitative experience of staff involved in EDI efforts presents important questions for further research. As we dive deeper into this project, we hope to examine how the communities we identified function and where there are areas for improved collaboration. Given how institutions are structured, is it realistic (or desirable) to completely eliminate silos? Are there other strategies that could be helpful for practitioners in the structures they currently work in? What can be done to translate the dense communication network into increased density in the collaboration network?

The next phase of our research will involve a deeper-dive into our SNA findings as part of a research-to-action forum. Researchers hope to gain more insights into how this study can be useful and valuable to practitioners. What are the practical insights and outcomes of this study? What are the types of collaborations that are missing from the organizational structure, and what level within the organization would be best situated to facilitate new/improved collaborations? How can this research be continued to further help program coordinators in their work with students? What other questions are important for us to explore?

Limitations

A key limitation of our study is that we did not receive responses from all organizations identified as important actors in this space. This limits our understanding of connections across organizations represented in the data. To handle missing responses we symmetrized the data,

which means that our data represent potentially weaker connections than in reality. Being one of the few student organizations that completed the survey, the importance of the student organization concerned with high school outreach could be inflated. For example, other student organizations could be highly connected for a previous year or term but lacked leadership while the survey was administered. While many other initiatives might be connected to that organization, their non-response could artificiality weaken its ties to the rest of the network. To account for this to the best that these data allow, we use the average symmetrization method to preserve any relationship suggested by other network members who did complete the survey.

LSAMP's central location within all of our analysis may be due, in part, to the fact that we created the survey based on the LSAMP coordinators' input. Therefore, most of the organizations in the survey were identified by the LSAMP coordinator as a collaborator or an organization they are in contact with. This could have an impact on how central LSAMP is in each of the social network visualizations. That said, while LSAMP seems central to each network considered, it lacks ties to many of the organizations included in our analysis.

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