Examining Professional Engineering Societies' Systemic Inclusion of Transgender, Nonbinary, and Sexual Minoritized Undergraduates

Dr. Rebecca Campbell-Montalvo, University of Connecticut

Dr. Rebecca Campbell-Montalvo is a cultural anthropologist who focuses on understanding how a range of people (including women, historically excluded racial/ethnic groups, and LGBTQIA+ students) are served in undergraduate STEM contexts, with an emphasis on engineering and biology. She is a postdoctoral research associate in the Neag School of Education in the Department of Curriculum and Instruction at the University of Connecticut. In addition, Campbell-Montalvo is Co-PI on a $500,000 NSF grant that seeks to improve inclusion in biology education and biology education research through the Inclusive Environments and Metrics in Biology Education and Research network. Prior to her current role, Dr. Campbell-Montalvo was the Program Assistant for the National Institute of Health's Maximizing Access to Research Careers Undergraduate Student Training in Academic Research program in the Department of Chemical and Biomedical Engineering at the University of South Florida.

Mrs. Hannah Cooke, University of Connecticut

Hannah Cooke is a doctoral student in Curriculum and Instruction with a focus on Science Education at the University of Connecticut. Her research interests include critical, antiracist science teaching that works to dismantle systems of oppression. Currently, she is a research assistant on the DRK12 project COVID Connects Us: Nurturing Novice Teachers' Justice Science Teaching Identities, which uses design-based research to develop justice-centered ambitious science teaching practices with in-service science teachers. She also works on NSF projects that aim to improve equity in undergraduate STEM education, especially for students with LGBTQ+ identities. In addition, she is working in the Education Leadership department exploring student activism around issues of racial equity. Her former role as a high school science teacher and facilitator of the school's Green Team led her to grapple with the role science educators play in advancing environmental justice. She holds a MA in Curriculum and Instruction and a BS in Biological Sciences from the University of Connecticut.

Dr. Chrystal Smith, National Science Foundation

Chrystal A. S. Smith, Ph.D., is a cultural anthropologist with expertise in diversity, equity, and inclusion in STEM education. Her research uses social science theoretical frameworks to examine how implicit factors such as culture and social capital influence the persistence of students belonging to groups historically underrepresented in STEM education. Currently, she is a Program Officer in the Division of Equity for Excellence in STEM, Directorate for STEM Education, National Science Foundation.

Dr. Ellen Puccia, Beta Research Associates, Inc.

Ellen Puccia, Ph.D., is an applied anthropologist with expertise in mixed methods data collection and analysis. In addition to her work in healthcare access, she also focuses on diversity, equity, and inclusion in STEM education. Specifically, she looks at the influence of social capital on the persistence of underrepresented groups in STEM. Currently, she is the owner and Executive Director of Beta Research Associates, Inc.

Dr. Michelle Hughes Miller, University of South Florida

Michelle Hughes Miller is Professor in the Department of Women's and Gender Studies. As a feminist criminologist with a PhD in Sociology, Dr. Hughes Miller works to improve diversity in STEM, analyzes the problem of gendered violence, and deconstructs policy representations of bad mothers. She has published three co-edited books: Addressing Violence Against Women on College Campuses (Temple, 2017), Bad Mothers: Representations, Regulations and Resistance (Demeter, 2017), and Alliances for Advancing Academic Women: Guidelines for Collaborating in STEM (Sense, 2014). Her current collaborative project is to learn more about the development of STEM students' ethical identities (NSF, PI=Centeno and Reeves).

John Skvoretz, University of South Florida

John Skvoretz is Distinguished University Professor in the Department of Sociology & Interdisciplinary Social Sciences and, by courtesy, Distinguished University Professor in the Department of Computer Science and Engineering at the University of South Florida. A Fellow of the American Association for the Advancement of Science and a recipient of the James Coleman Distinguished Career Award from the Mathematical Sociology Section of the American Sociological Association, his current research projects analyze social network data from various sources.

Hesborn Wao

Hesborn Wao, Ph.D., uses mixed methods research to investigate the implicit factors associated with the underrepresentation of women and minorities in STEM education. He strives to improve K-20 STEM learning experiences and degree attainment. He received his Ph.D. in Measurement & Evaluation and M.Ed. in Curriculum & Instruction both from the University of South Florida, and his B. Ed in Mathematics from the University of Nairobi, Kenya.

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Introduction

Research shows the general STEM climate is less welcoming for sexual minority (SM, e.g., lesbian, gay) students, and is particularly harrowing for gender minority (GM, e.g., transgender, gender nonbinary) students [1]–[8]. The STEM climate is important to address due to its likely impact on the lower persistence of sexual and gender minority (SGM) students [9]–[12].

Professional STEM societies provide students with a range of resources that help them persist in STEM [13]. Specific societies created to serve LGBTQIA+ STEM students, such as oSTEM, have been shown to help students manage their identities in STEM in the face of unwelcoming STEM climates. At the same time, these societies may offer less professional and academic resources and prioritize identity management [4], [14], [15]. Because the impacts of professional society participation may be different for gender minority students than for gender majority students, an examination of participation and impacts by group is warranted.

The objective of this research is to identify whether there are differences between how GM students (some of whom have an SM identity in this study) and gender majority students (all of whom have an SM identity in this study) access resources important in STEM persistence. The society resources we focus on include: sense of community, social networking, professional resources, leadership skills, academic resources, declining isolation related to identities, and feeling that societies in which they may participate are helpful to them in their degree progress. This study offers an analysis of data from a one-time survey of 477 sexual and/or gender minority STEM undergraduates (n=364 engineering majors) relating to their participation in STEM professional societies.

Theoretical Framework

We aim to understand how different society-types (i.e., identity-focused vs. non-identity focused) may support SGM students, with an emphasis on GM students. We nest our study within the concept of social capital—the advice and resources gained from others. We focus on a specific type of social capital, participatory social capital—the resources and networks individuals gain by participating in organizations that help members expand their access to capital that will help them succeed [16]. This capital may include academic and professional resources, including building leadership skills, as well promoting as a sense of community in STEM [16]. We also focus on the extent to which the societies help students fit in STEM by reducing isolation they may experience due to others' reactions to their marginalized identities [15].

In addition, too often sexual and gender minority students are lumped together (e.g., LGBTQIA+ as a monolithic group) in analyses of their experiences in STEM, a flaw given the overlapping *but also* differing experiences of sexual minority and gender minority students. To advance theorization of how identities articulate in STEM and how the environments of a range of professional society-types intersect with them to support or not support their persistence in STEM, we analyze the findings of a first of its kind survey with 477 SGM STEM students. The survey measured student identities and STEM experiences, including student access to social capital and social networks, such as those accessed through professional societies. The research questions driving this work focused on how students reported that societies impacted them when

it came to the types of social capital offered, how the society impacted any isolation they may have experienced related to particular identities, and how participation in the society affected their degree progress. The research questions include:

1. How did GM and gender majority students report experiencing non-identity focused professional STEM societies?
2. How did GM and gender majority students report experiencing identity focused professional STEM societies?

Methods

The data for this study come from a survey of 477 SGM STEM undergraduates recruited through several professional STEM organizations. In the survey, participants indicated the societies and organizations that they were a part of and the extent of their participation. There were open-ended follow-up questions about each of the societies/organizations in which they participated. For this analysis, we focused on the survey item "Please describe how your participation in _____ society has contributed to your progress as you pursue your STEM degree." The blank was filled in based on the specific societies or general society types that the respondent had indicated participating in on an earlier survey item.

There were 66 respondents who indicated a gender other than man, woman, and/or cisgender. These 66 GM respondents selected one or more of the following identities outside of the binary (but may have also included selection of the three previous identities listed): agender, multigender, gender non-conforming/genderqueer, and transgender (one also wrote in 'questioning'). Comparing the responses of these 66 students to those who claimed majority gender identities shows how various societies may cultivate differential experiences and resource access for students. We note that we take at face value that those who reported a binary gender (woman/man) are not claiming a minority gender. The reader is directed to Campbell-Montalvo et al. [15] for a table showing the racial/ethnic, sexual, and gender identities of participants in all of the professional societies in which respondents participated as well as tables depicting the racial/ethnic identity, the sexual identity, and the gender identity of the whole sample and in the identity-focused societies.

The responses were reviewed by two initial coders using a codebook developed by a team of four co-authors and ground in the data and previous research. Then, two other research team members reviewed and negotiated the data coded by the first two team members. The five social capital codes that are reported in this research include: sense of community, social networking, professional resources, leadership skills, and academic resources. The codes relating to isolation that are reported here include: cisgender isolation reduction (e.g., helping women feel they fit into STEM), sexual identity isolation reduction, unspecified identity isolation reduction, racial/ethnic identity isolation reduction, and gender minority identity isolation reduction. Finally, when it came to the impact of the society on the student's degree progress, we utilized codes including: has not impacted them, student did not spend enough time in it, student felt unwelcome, or negatively impacted student's degree progress.

This analysis was limited by the generally small sample of GM students by society type (a range of 9-20 students participated in the various societies) as compared to gender majority students (43-410), as comparisons between smaller and larger groups is difficult. When making the comparisons using simple statistics, we were conservative in denoting something as a difference. For example, we reported differences when percentages were ten or more percentage points higher in one group and when at least one group had more than 3 people with a response

that was applied a certain code. While we acknowledge limitations of this sample size, we note that research with SGM STEM populations, particularly those with GM has not typically benefitted from large sample sizes, therefore, this work has added value.

Results

Identity-focused societies. As shown in Tables 1 and 2, the main differences in social capital amongst oSTEM (Out in Science, Technology, Engineering, and Mathematics) participants were that GM members less often reported experiencing community (56%) and social networking (6%) than gender majority members did (74%; 22%). Both groups similarly reported benefitting from professional resources, leadership skills, and academic resources. For reducing isolation, GM students slightly more frequently reported a reduction in the isolation of an unspecified identity (38%), though this was similarly reported amongst gender majority students (29%). oSTEM was generally not reported as reducing isolation of other identities for either group. In terms of the impact of oSTEM on participants, nearly a third of GM students said it had not impacted their progress in their STEM degree program (31%), while this was 16% amongst gender majority students. There were not differences in reporting rates when it came to students spending enough time to get benefits from oSTEM, nor in feelings of being unwelcomed or facing negative impacts.

Tables 3 and 4 show that for NSBE (National Society of Black Engineers), the main differences in capital were that GM members less often reported experiencing community (33%) and professional resources (11%) than gender majority members did (59%; 34%). Both groups similarly reported benefitting from social networking (44% GM; 48% gender majority), as well as leadership skills (0%; 5%) and academic resources (22%; 16%). For reducing isolation, both groups reported similar reductions in racial/ethnic isolation (33%; 25%) and did not often report reduction of isolation for other identities. Neither group commonly wrote about its impacts on degree persistence.

In Tables 5 and 6, GM students reported accessing professional resources in the society half as often (14%) as gender majority students (33%) in SHPE (Society of Hispanic Professional Engineers). There were not marked differences in the other forms of capital. When it came to reducing isolation, GM students far more often reported a reduction in racial/ethnic isolation (43%) compared to 12% of gender majority students. Other forms of isolation reduction were not commonly reported in either group. GM students were more likely to indicate that SHPE had not been helpful in their degree program (29%) compared to gender majority students (12%), while gender majority students more often reported than GM students that they did not spend enough time in SHPE to reap its benefits (0% GM; 9% gender majority).

As depicted in Tables 7 and 8, when it comes to social capital, SWE's (Society for Women Engineers) GM members less often reported benefitting from community (35%) and social networking (25%) compared to gender majority members (56%; 35%). However, GM students had similar percentages of reporting professional resource access (40%), leadership skills (15%), and academic resources (10%) compared to gender majority students (31%; 9%; 8%). In addition, GM students (perhaps because they do not necessarily hold such an identity) less frequently reported a reduction in cisgender identity isolation (20%) compared to gender majority students (34%). In neither group did participants often (more than 1%) report a reduction in isolation related to other identities. In terms of the impact of SWE on participants' degree progress, three times as many GM students said it was not helpful in advancing their STEM degree progress (30%) compared to gender majority students (9%). There were not

marked differences in the other codes in the section.

Non-identity-focused scientific societies. In Tables 9 and 10, for any industry and discipline specific societies (e.g., Institute of Electrical and Electronics Engineers [IEEE]) and their impact on capital, GM members less often reported feeling a sense of community (6%) and accessing academic resources (6%) compared to gender majority members (31%; 17%). There were not pronounced differences in the other forms of capital. While GM students reported no reduction in isolation related to any identities, gender majority students reported a reduction in cisgender isolation 5% of the time. GM students were also more likely to say such societies were unhelpful in their degree progress (19%), compared to gender majority students (9%). The other impacts in the section did not have marked differences.

As seen in Tables 11 and 12, for science chapters (e.g., the American Chemical Society [ACS]) at universities, there were not marked differences between GM and gender majority students' access of capital. There were also no differences in reducing isolation or impacting degree persistence.

Summary of findings. At oSTEM, GM students may not be benefitting to the same extent as gender majority students when it comes to feeling in community with other members and having opportunities for social networking. However, GM students may benefit more from a reduction in isolation related to their identities. As well, GM students more often noted that they had not benefitted from oSTEM when it came to degree progress. In NSBE, GM students may also not be benefitting the same in community nor accessing professional resources as gender majority students do. In SHPE, while GM students accessed professional resources less frequently than gender majority students did, they also more often experienced a reduction of racial/ethnic isolation. In SWE, GM students less often benefitted from community and social networking in comparison to gender majority students. GM students also less often reported a reduction in cisgender identity isolation in SWE. Yet, the absence of other identity isolation reduction is noted. Importantly, a greater percentage of GM students indicated that SWE was not helpful to their degree progress. In industry and discipline-based societies, GM students benefitted from community and academic resources less often than gender majority students—accordingly they indicated that such societies were helpful in their degree progress less often. Gender majority students also reported a reduction in cisgender identity isolation, while GM students did not report isolation reduction. There were no observed differences in participant responses in science chapters.

Conclusion

Understanding the effects of professional STEM societies on undergraduates and their STEM persistence is of utmost importance given the less welcoming STEM climate for gender minority and sexual minority students (e.g., LGBTQIA+) and the likely impact of climate on persistence. Professional societies may be focused on helping students negotiate their identities and/or may have a focus on more academic subject matter. Understanding the differences in such social capital afforded to students by different types of societies can be valuable to increasing fit in STEM programs, and therefore students' persistence.

Importantly, we find differences in how societies provided a sense of community to GM students—this trend was seen across oSTEM, NSBE, SWE, and industry/discipline societies, which less often provided GM members with sense of community. Only SHPE and science chapters offered similar or higher rates of sense of community to GM members. At the same time, in some cases, GM students had less access to social networking (oSTEM; SWE),

professional resources (NSBE; SHPE), and academic resources (industry/discipline societies). These trends are likely connected to lower rates of reporting that the societies were useful to GM students' degree progress (found in oSTEM, SWE, and industry/discipline societies). At the same time, for GM students, oSTEM more frequently reduced isolation related to unspecified identities (likely those related to gender minority identities but not explicitly mentioned in the responses), and SHPE more often reduced racial/ethnic isolation.

More data must be gathered to help determine to what extent these findings hold up to inferential statistics with a larger sample and to more robustly qualitatively explain findings in order to bring forward the social mechanisms that might be at play. However, based upon previous qualitative work, we conject that it is likely that many of these societies may reproduce exclusionary cultures for GM students as evidenced by the pattern in the less frequent reports of community in four of the six society types. Also highlighting important differences in social effects of the societies were the reduced access to social networking in two of the societies, though differential access to professional resources in two societies and academic resources in one society was also important. oSTEM's reduction of identity isolation for GM students coincides with previous qualitative research [4], [14], [15], though the current study builds on this previous research by comparing GM and gender majority students in this regard.

This work has implications for societies when enacting policies to cultivate more inclusive community environments, and buttressing potentially unequal access to social networking as well as professional and academic resources. Further, right now, participants suggest that only oSTEM helps reduce isolation related to unspecified but like GM identities, leaving room in other societies' programming to promote inclusion in this regard. Program changes based on this evidence could help improve the social capital and resource access of GM students, which in turn could increase persistence in STEM.

Acknowledgment
This material is based upon work supported by the National Science Foundation under Award No. 1747580.

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Tables 1 and 2. oSTEM Gender Minority (n=16) and Gender Majority (n=69) Responses

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/16)**
Capital Gained		
Community	9	56%
Social networking	1	6%
Professional resources	2	13%
Leadership skills	0	0%
Academic resources	1	6%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/16)**
Reduce cisgender isolation	0	0%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	6	38%
Reduce racial/ethnic isolation	0	0%
Reduce gender minority isolation	0	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/16)**
Has not	5	31%
Didn't spend enough time	2	13%
Student felt unwelcome	0	0%
Negatively impacted students	0	0%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/16)**
N/A	0	0%
MISSING	0	0%
?	0	0%
Grand Total	26	-

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/69)**
Capital Gained		
Community	51	74%
Social networking	15	22%
Professional resources	9	13%
Leadership skills	1	1%
Academic resources	0	0%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/69)**
Reduce cisgender isolation	0	0%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	20	29%
Reduce racial/ethnic isolation	0	0%
Reduce gender minority isolation	1	1%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/69)**
Has not	11	16%
Didn't spend enough time	8	12%
Student felt unwelcome	0	0%
Negatively impacted students	0	0%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/88)**
N/A	3	3%
MISSING	0	0%
?	0	0%
Grand Total	119	-

Tables 3 and 4. NSBE Gender Minority (n=9) and Gender Majority (n=56) Responses

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/9)**
Capital Gained		
Community	3	33%
Social networking	4	44%
Professional resources	1	11%
Leadership skills	0	0%
Academic resources	2	22%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/9)**
Reduce cisgender isolation	0	0%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	0	0%
Reduce racial/ethnic isolation	3	33%
Reduce gender minority isolation	0	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/9)**
Has not	0	0%
Didn't spend enough time	1	11%
Student felt unwelcome	1	11%
Negatively impacted students	1	11%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/10)**
N/A	1	10%
MISSING	0	0%
?	0	0%
Grand Total	17	-

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/56)**
Capital Gained		
Community	33	59%
Social networking	27	48%
Professional resources	19	34%
Leadership skills	3	5%
Academic resources	9	16%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/56)**
Reduce cisgender isolation	0	0%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	1	2%
Reduce racial/ethnic isolation	14	25%
Reduce gender minority isolation	1	2%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/56)**
Has not	2	4%
Didn't spend enough time	2	4%
Student felt unwelcome	0	0%
Negatively impacted students	0	0%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/57)**
N/A	0	0%
MISSING	0	0%
?	0	0%
Grand Total	111	-

Tables 5 and 6. SHPE Gender Minority (n=7) and Gender Majority (n=43) Responses

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/7)**
Capital Gained		
Community	2	29%
Social networking	2	29%
Professional resources	1	14%
Leadership skills	1	14%
Academic resources	1	14%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/7)**
Reduce cisgender isolation	0	0%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	0	0%
Reduce racial/ethnic isolation	3	43%
Reduce gender minority isolation	0	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/7)**
Has not	2	29%
Didn't spend enough time	0	0%
Student felt unwelcome	0	0%
Negatively impacted students	0	0%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/7)**
N/A	0	0%
MISSING	0	0%
?	0	0%
Grand Total	77	-

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/43)**
Capital Gained		
Community	14	33%
Social networking	14	33%
Professional resources	14	33%
Leadership skills	3	7%
Academic resources	3	7%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/43)**
Reduce cisgender isolation	1	2%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	2	5%
Reduce racial/ethnic isolation	5	12%
Reduce gender minority isolation	0	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/43)**
Has not	5	12%
Didn't spend enough time	4	9%
Student felt unwelcome	0	0%
Negatively impacted students	0	0%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/43)**
N/A	0	0%
MISSING	0	0%
?	0	0%
Grand Total	77	-

Tables 7 and 8. SWE Gender Minority (n=20) and Gender Majority (n=377) Responses

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/20)**
Capital Gained		
Community	7	35%
Social networking	5	25%
Professional resources	8	40%
Leadership skills	3	15%
Academic resources	2	10%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/20)**
Reduce cisgender isolation	4	20%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	0	0%
Reduce racial/ethnic isolation	0	0%
Reduce gender minority isolation	0	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/20)**
Has not	6	30%
Didn't spend enough time	2	10%
Student felt unwelcome	0	0%
Negatively impacted students	0	0%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/20)**
N/A	0	0%
MISSING	0	0%
?	0	0%
Grand Total	37	-

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/377)**
Capital Gained		
Community	212	56%
Social networking	132	35%
Professional resources	116	31%
Leadership skills	34	9%
Academic resources	32	8%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/377)**
Reduce cisgender isolation	127	34%
Reduce sexual identity isolation	5	1%
Reduce unspecified identity	2	1%
Reduce racial/ethnic isolation	2	1%
Reduce gender minority isolation	1	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/377)**
Has not	34	9%
Didn't spend enough time	20	5%
Student felt unwelcome	6	2%
Negatively impacted students	3	1%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/410)**
N/A	9	2%
MISSING	2	0%
?	2	0%
Grand Total	738	-

Tables 9 and 10. Industry and Discipline Societies Gender Minority (n=16) and Gender Majority (n=103) Responses

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/16)**
Capital Gained		
Community	1	6%
Social networking	9	56%
Professional resources	4	25%
Leadership skills	2	13%
Academic resources	1	6%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/16)**
Reduce cisgender isolation	0	0%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	0	0%
Reduce racial/ethnic isolation	0	0%
Reduce gender minority isolation	0	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/16)**
Has not	3	19%
Didn't spend enough time	0	0%
Student felt unwelcome	3	19%
Negatively impacted students	1	6%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/17)**
N/A	0	0%
MISSING	1	6%
?	0	0%
Grand Total	25	-

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/103)**
Capital Gained		
Community	32	31%
Social networking	69	67%
Professional resources	34	33%
Leadership skills	12	12%
Academic resources	17	17%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/103)**
Reduce cisgender isolation	5	5%
Reduce sexual identity isolation	1	1%
Reduce unspecified identity	1	1%
Reduce racial/ethnic isolation	0	0%
Reduce gender minority isolation	0	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/103)**
Has not	9	9%
Didn't spend enough time	3	3%
Student felt unwelcome	2	2%
Negatively impacted students	2	2%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/110)**
N/A	3	3%
MISSING	1	1%
?	3	3%
Grand Total	189	-

Tables 11 and 12. Science Chapters Gender Minority (n=9) and Gender Majority (n=51) Responses

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/9)**
Capital Gained		
Community	4	44%
Social networking	6	67%
Professional resources	2	22%
Leadership skills	2	22%
Academic resources	0	0%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/9)**
Reduce cisgender isolation	0	0%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	1	11%
Reduce racial/ethnic isolation	1	11%
Reduce gender minority isolation	0	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/9)**
Has not	1	11%
Didn't spend enough time	0	0%
Student felt unwelcome	0	0%
Negatively impacted students	0	0%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/9)**
N/A	0	0%
MISSING	0	0%
?	0	0%
Grand Total	96	-

Type of Coding	**Count of Codes**	**Percentage of valid responses (n/51)**
Capital Gained		
Community	23	45%
Social networking	38	75%
Professional resources	14	27%
Leadership skills	3	6%
Academic resources	5	10%
Type of Isolation Reduced	**Count of Codes**	**Percentage of valid responses (n/51)**
Reduce cisgender isolation	0	0%
Reduce sexual identity isolation	0	0%
Reduce unspecified identity	1	2%
Reduce racial/ethnic isolation	0	0%
Reduce gender minority isolation	0	0%
Ill or no impact on persistence	**Count of Codes**	**Percentage of valid responses (n/51)**
Has not	3	6%
Didn't spend enough time	1	2%
Student felt unwelcome	1	2%
Negatively impacted students	1	2%
Non-usable responses	**Count of Codes**	**Percentage of total responses (n/57)**
N/A	4	7%
MISSING	2	4%
?	0	0%
Grand Total	17	-