Differences in Outcomes by Gender for Peer Mentors Participating in a STEM Persistence Program for First-Year Students

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Abstract

While the majority of STEM persistence has focused on outcomes for first-year students there has been little investigation into the outcomes for peer mentors and no investigation into whether peer mentors perceive the experience differently based on gender, ethnicity or other relevant variables. The purpose of this study was to examine an archival dataset containing perceptions of peer mentors to determine if there were differences in perceptions of the mentoring experience. An archival data set containing the responses of 309 peer mentors who mentored first-year undergraduate students enrolled in gateway STEM courses (Calculus 1, Chemistry 1, and Physics 1) were examined. A principal analysis component (PCA) was conducted and four factors were identified: Academic Scholarship, Academic Fit, Academic Professionalism, and Academic Relationships. Following this, a MANOVA by gender was performed across the four factors. Significant gender differences were found for two factors: Academic Professionalism and Academic Relationships, with females noting that as a result of participating in the mentoring program they believed they gained in these areas more than their male counterparts.

STEM students leaving the field early on in their college program has clearly become a national epidemic (Dagley, Georgiopoulos, Reece, & Young, 2016; Seymour & Hewitt, 1997). In fact, national studies have shown a dropout rate for this population to be as high as 60% (Hayes, 2007; Schneider, Bickel, & Morrison-Shetlar, 2015). In the mission to address this mass exodus many institutions have been focusing their efforts on the retention of first-year STEM students. There has also been an emphasis on supporting underrepresented students pursuing a STEM education (e.g. women, African Americans, Hispanics/Latinx, etc.) (Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013; Xu, 2018).

First coined by Berryman (1983), the term STEM pipeline has been noted in the literature on retention to being "leaky," especially when it comes to women and other traditionally underrepresented individuals entering and pursuing STEM disciplines and eventually careers (Goulden, Mason, & Frasch, 2011; Redmond-Sanogo, Angle, & Davis, 2016). At one time institutions did little other than recruitment and admittance into STEM programs as an attempt to address this issue (Bruffee, 1999). Now, faced with this on-going dilemma, they have focused heavily on retention efforts (Blackburn, 2017). Retention efforts have included: counseling support services, undergraduate research experiences, academic tutoring and peer mentoring (Bahr & Norton, 2006). Tutoring and peer mentoring have been noted to be quite effective at retaining students in STEM, particularly women (Toven-Lindsey, Lewis-Fitzgerald, Barber, & Hasson, 2015).

Graham, et al. (2013) discuss the importance of developing a "persistence framework" to address underrepresented students exiting STEM disciplines (pg. 1455). They identify three components to commonly successful programs: gateway courses that involve active learning, opportunities for involvement in research early on and involvement in experiences that encourage working with other science scholars in the community. These types of opportunities offer underrepresented students places to develop a professional identity as a scientist and acquire knowledge about their respective fields. Mentoring represents an example of the development of a learning community (Wilson, et al. 2012; Philipp, Tretter, & Rich, 2016; Drane, Micari & Light, 2014)

According to Packard, Marciano, Payne, Bledzki and Woodward (2014) peer mentoring has been defined as a process where an older, more experienced person in the field or practice facilitates "emotional, academic or career growth for a new person (e.g. a student) through their shared activities" (p. 434). Despite the focus on peer-based mentoring in STEM to increase STEM persistence, the majority of research has focused on the outcomes of first-year students (mentees) and has paid little attention to possible benefits for the student mentors (Page & Hanna, 2008).

Research on Mentoring

According to Amaral and Vala (2009), most of the research conducted on the outcome for mentors has been "haphazard" with little in the way of organized methodology. Previous studies have found that peer-based mentors in STEM have changed their epistemological beliefs about teaching and learning, as well as improved their communication, organization, and leadership skills; however, it has also been noted that these studies have typically used small samples of mentors (Amaral & Vala, 2009). In addition, data collection and overall methodologies for many of the studies reporting outcomes for mentors have been somewhat relaxed and in many cases considered "add-ons" or "additional" findings to investigating the retention of first-year STEM students (Amaral & Vala, 2009). Mentoring provides a different experience for students to learn and grow for both mentees and peer mentors (Crisp, Baker, Griffin, Lunford, & Pifer, 2017; Stigmar, 2016).

Research that has been conducted on the outcomes of peer mentoring examined various aspects of the experience. (e.g. Budny, Paul & Newborg, 2010; Cutright & Evans, 2016; Drane, et al. 2014, Philipp et al. 2016, Russomanno, et. al 2010; Schneider, et al. 2015; Streiwieser & Light, 2010). Studies that have examined the benefits for peer-based mentors at the undergraduate level have focused on traditional outcomes such as GPA, as well as a wide variety of skills. These skills range from improving time management, to relationships, to a better sense of self and a better understanding the content being taught. For example, Drane, et al. (2014) examined the grades (GPA) of peer mentors for five disciplines and seven classes over 10 years. The data suggested that mentor grades in five of the seven courses saw a positive impact. This impact was also seen with four classes that were part of a set of sequenced courses. The authors also noted an impact on mentors regardless of ethnicity or gender, even though effect sizes were larger for students in underrepresented groups.

In addition to changes in perceptions of teaching and learning, studies have also examined the various types of skills peer mentors have developed as a result of their mentoring practices. These skills have included communication, presentation, time management, life, and leadership (Jacobi, 1991). For example, Cutright and Evans (2016) found seniors who served as peer mentors for first-year students had received several key benefits from the overall experience. In this study, seniors were provided a one-credit class in order to share their experiences with first-year engineering, mathematics and science undergraduates each week. Mentors had rich discussions with first-year students about that week's class topic/skill and how they used that topic/skill throughout their college career. In addition to finding it a rewarding experience, mentors also noted they would recommend the experience to other students. While some studies have identified skills and outcomes developed by those who serve as STEM mentors, there has been little investigation as to what benefits and outcomes students associate with the mentor experience and whether or not females and males perceive the value of this opportunity to be the same.

Morganson, Major, Streets, Litano, and Myers (2015) in a qualitative study examined why students persist in STEM majors. Approximately half of the students in their focus groups were women (47.6%). The focus groups were stratified by gender to make room for students to potentially bring up the subject of gender. They found in the focus groups with men, gender did not come up as a topic but in the groups with women it did emerge. Ultimately, their findings indicated that for women students it was important for them to be a role model to other women and that they took pride in being a woman in science. These were not themes that came up for men in their study. This study supports findings by Seemiller and Grace (2016) about what motivates women in generation z. In Seemiller and Grace's work they describe generation z women as being motivated by "relationally focused" outcomes as compared to their male counterparts who were motivated by more "individually focused" outcomes (p. 16).

Purpose

The purpose of this study was twofold: first, it was to determine if the items used to measure peer mentor perceptions as to the benefits of serving as a mentor could be clustered differently than the original survey instrument used; and second, to determine if there were differences on key variables (e.g. mentor's gender) and the perception of these experiences.

A research-intensive (R1) university with a total undergraduate enrollment of ~6,400 students located in the northeast recognized the need to better support first-year students. The institution in 2014 secured a five-year grant for $1.2 million from the Howard Hughes Medical Institutes (HHMI) to design and implement an *Integrative Program for Education, Research and Support Involving Science and Technology* (I-PERSIST). The purpose of this learning community program was to provide all first-year students enrolled in one or more of the introductory STEM courses (i.e. Calculus I, Chemistry I, or Physics I) with weekly small group, tutoring-support sessions run by a peer mentor. The main objectives of I-PERSIST were to: improve student experiences in these three "gatekeeper" courses, help incoming STEM students develop key study and social skills shown in the literature to help students improve student academic achievement, and increase the percentage of first-year STEM students continuing at the institution. The long-term goal of I-PERSIST was to increase student retention in STEM fields. Retention of first-year students has continued to remain stable at the university even though the numbers of incoming students has increased.

Recruitment of Mentors

To provide enough peer mentors for the incoming 1,000 first-year students, an average of 124 mentors were recruited each year. Peer mentors were mostly second or third year undergraduates and they applied in January to serve as a mentor the subsequent fall semester. Applicants completed an extensive application that included information about the student's GPA, they need to have at least a B grade for the course which they were applying to mentor and an overall GPA > 3.0. The applicants also participated in a two-step interview process that included faculty from the respective disciplines and staff from the Office of Student Life. The program faced some challenges recruiting mentors in year one, and only 99 were available. However, in years two and three, 136 and 137 mentors were recruited respectively, with a third of the mentors returning from the previous year. This strategy provided a core of experienced mentors who provided guidance to first-time mentors. Mentoring became attractive as not only a way to give back to their college community, but also as a way to develop leadership skills, and as an activity they could use to build their resume for graduate school or for potential employers seeking the skills the program helped develop (e.g. increased communication skills, teamwork, collaboration).

Mentor Training

Mentor training was a key and required component of the I-PERSIST program. All mentors participated in extensive training prior to leading mentoring sessions. Training took places in three parts. In May, mentors were given an introduction and overview of the I-PERSIST program, its goals and objectives, how the program functioned, and their roles and obligations. Towards the end of the summer, mentors participated in a three-day intensive training to learn how to run mentor sessions and help mentees develop study skills, time management skills, and problem-solving. Mentors also participated in mock simulations with staff to better understand how to address first-year students' concerns and perspectives, particularly around skill-building exercises. Another training session occurred in the fall before the start of classes. Topics covered during training included: working with first-year students, understanding issues surrounding diversity and inclusion, engaging in a variety of approaches to learning, creating an engaging classroom, and working with international students. Underrepresented minoritized (URM) students were assigned whenever possible to a mentor who also identified as an URM or a mentee group with another URM. Any mentee who was potentially at-risk was not placed alone in a mentoring group with overachieving students.

Although mentors were paid a stipend for their participation in the three-day summer training, the stipend was not available once the grant had expired. However, it was anticipated that this would not pose adverse effects since mentoring had become a popular activity amongst the student body. During the fall semester, the mentors did not receive financial compensation for their participation, but instead received course credits by registering in a mentoring course specifically designed for the program. Thus, the mentoring program was very cost-effective to the institution.

Overview of Mentoring Sessions

Each mentor was assigned two groups of eight to 10 students and held weekly one-hour sessions with each group. These small group sessions were mostly held in classrooms and meeting rooms throughout campus. During the weekly sessions, mentors worked with their mentees to reinforce material and concepts taught during weekly course lectures. Mentors also taught first-year transitional content (study skills, time management, test taking strategies, etc.), similar to subjects found in traditional first-year seminar courses. In addition to weekly mentoring sessions, mentors were required to hold two hour-long office sessions per week to provide students with individual time to ask content related questions.

During the academic-year mentors received "just in time" professional development. Mentors met weekly with faculty from their subject area, as well as staff from the Office of Student Life. During these supervisory meetings, mentors received information about upcoming lesson plans and reported back on the progress and outcomes of their sessions. Mentors provided faculty and staff with feedback about students who were absent, appeared unengaged, or seemed to be struggling. This allowed staff the opportunity to follow up with these targeted students to get them back on track. An electronic form was also created so mentors could report at-risk students in a timely manner.

Method

Sample

This study is a secondary analysis of the university's archival peer-mentor data set. While 372 peer mentors participated in the program across the three years, 309 mentors completed the survey (an 83% response rate). In all, 20% of mentors served two years as a peer mentor, 58% were female and 42% were male. A majority (67%) of mentors were White, 13% were Asian American, 7% identified as Hispanic/Latinx, 1% African American and 7% Other or Multi Race (see Table 1).

Instrumentation

Data for the study were originally gathered by institutional research using a mentor survey. This survey con-

Demographics	Mentor	Institution
Gender		
Male	131 (42%)	1157 (68%)
Female	178 (58%)	534 (32%)
Total	309*	1,691**
Ethnicity		
American Indian	0	2 (.12%)
Asian American	40 (12.9%)	222 (13%)
Black/AA	4 (1.4%)	68 (4%)
Hispanic/Latinx	21 (6.8%)	170 (11)
Other or Multi-race	21 (6.8%)	107 (6.3%)
Native Hawaii/PI	1 (.3%)	1 (.05%)
Non-citizen	14 (4.5%)	193 (11.4%)
Unknown	2 (.6%)	26 (1.5%)
White	206 (66.7%)	902 (53%)
Total	309	1,691

*All mentors from 2015-2018 who completed survey. Approximately one-third of first time mentors continue for another year; therefore, their data is included in the demographics for the 309 total mentors.
**2016 enrollment figures for first-year class.

Table 1. Mentor Demographics Compared to Institutional Demographics

Item	Factor 1	Factor 2	Factor 3	Factor 4
I learned how to improve my own study skills.	.760			
I am better able to stay on top of my coursework.	.758			
I feel better prepared for my own exams	.753			
I completed my homework on a more consistent basis	.719			
I am better able to cope with stress.	.688			
I feel better able to meet my own academic goals.	.687			
I improve my time management skills.	.649			
I have greater motivation to be successful.	.604			
I formed my own study group(s).	.510			
Overall college experience.		.853		
Overall academic experience.		.823		
Overall sense of community among students.		.804		
Increased my leadership skills.			.834	
Increased my presentation skills.			.815	
Increased my knowledge of the subject			.489	
I feel more comfortable approaching my TAs in other courses.				.823
I feel more comfortable approaching faculty.				.789

Table 2. Factor Loadings Rotated Component Matrix

tained some initial demographic data (e.g. what courses did you serve as a mentor for? did you mentor last year? and gender), along with 19 closed-ended, Likert-based agreement items designed to gather mentor perceptions of outcomes. Likert scale for this instrument was a six-point scale (1=Strongly Disagree, 2=Disagree, 3=Slightly Disagree, 4=Slightly Agree, 5=Agree, 6=Strongly Agree). Originally, the 19 items were grouped into three clusters: Skills, Areas Improved, and Overall Satisfaction with Institution. The cluster questions were developed through a collaborative effort, by the director of the STEM persistence program, faculty who taught key gateway courses and served on the advisory committee, members from institutional research and the external program evaluator.

Procedure

From 2015 to 2017 institutional research administered an electronic survey each fall to all mentors participating in the program. Program administrators, to modify and improve the overall mentor experience used the survey information regularly. In the spring of 2018, a request to access the archival database was made and following IRB approval a secondary quantitative analysis was conducted.

Results

A principal component analysis (PCA) was executed on the 19 original items using orthogonal rotation (VARIMAX). Sampling adequacy was supported by examining the Kaiser-Meyer-Olkin, (KMO=.862). A KMO level between .8 and .9 is considered excellent (Hutcheson & Sofronious, 1999). Bartlett's test of sphericity (d.f. 136) =1619.441 $p<.001$, indicated that correlations between items were sufficiently large for PCA (Fields, 2009). Eigenvalues were run for each variable and only factors with an eigenvalue 1 or greater were retained. In addition, scree plots suggested four factors before inflexions (Cattell, 1966). Two items, #11) "I have developed a positive relationship with other students" and #14) "I feel that [the institution] is a friendlier place" were extracted due to low loading factors. Based on this, four factors were identified after orthogonal varimax rotation (see Table 2).

The original survey contained three factors. The PCA revealed a fourth factor. Based on this the three original factors were renamed, and a new name was given to the fourth factor. Factor 1 (Skills Developed) was renamed *Academic Scholarship* and consisted of nine items with factor loadings that ranged between .760 to .510. Factor 2 (Areas Improved) was renamed *Academic Fit* and contained three items with factor loadings ranging from .853 to .804. Factor 3 (Student Overall Satisfaction with Institution) was renamed *Academic Professionalism* with loadings that included .834 to .489. Factor 4 was a new factor that emerged as a result of this process and was

Factors	Mean		SD	
	M	F	M	F
Academic Scholarship (Factor 1)	37.3	39.3	8.0	8.2
Academic Fit (Factor 2)	10.6	10.8	1.8	1.9
Academic Professionalism (Factor 3)	15.0	16.0	2.2	2.1
Academic Relationships (Factor 4)	9.6	10.3	2.1	1.8

Table 3. Factor Means and SD by Gender

Factors	f	Sig.
Academic Scholarship (Factor 1)	3.53	.061
Academic Fit (Factor 2)	.77	.380
Academic Professionalism (Factor 3)	11.51	.001*
Academic Relationships (Factor 4)	10.17	.002*

*p <.05

Table 4. Univariate Test for Gender by Factor Subscores

named *Academic Relationship*. It contained two items that loaded at .823 and .789 respectively. Originally, the two items that comprised this new factor were included with items in Factor 3.

The principal component analysis factor scores were calculated for all mentors across the four factors. To examine research question number two, the data was then delineated by gender, male versus female. Presented in Table 3 are the means and standard deviations for the four newly identified factors by gender. Results from this analysis revealed that females reported greater agreement on all four factors. In order to determine if these mean differences were statistically significant a MANOVA was performed. A MANOVA was conducted with gender as the independent variable and the four subscores for factors as the dependent variables. A significant effect was found Lambda(4, 291) = .950, p = .005. Follow-up univariate ANOVAs indicated that Factor 3 Academic Professionalism was significant by gender (F(1,294), = 11.51, p = .001. Factor 4 Academic Relationship was also found to be significant by gender (F(1,294) =10.17, p = .002 (see Table 4)

Discussion

Mentoring certainly changed the instructional paradigm. The very act of mentoring another individual or small group of individuals required one to build relationships with others, interact on a weekly basis in small group discussions, share ideas and opinions, understand how people have come to construct knowledge, and share strategies for improving one's soft skills associated with academic success. These were not typical skills or experiences that a student obtains from traditional large lecture halls or even smaller seminar-type settings. It was this new personal learning experience for the mentors called "mentoring" that provided an opportunity for students to develop not only as students but as future new professionals in their respective fields.

In addition to skills and new opportunities, mentoring also provided unique learning experiences for those who have traditionally been underrepresented in STEM. The lack of underrepresented students (e.g. *women*, African Americans, Hispanics/Latinx) pursuing a STEM education in the United States has been well documented (Xu, 2018). While there has been a wide range of actions taken by colleges and universities to address this dilemma, the gap, as many refer to it, still remains very much in existence today. A prime example of this would be in the demographics for the incoming first-year class at the institution in this study. The demographics speak for themselves with 32% female; however, it should be noted that perhaps a possible outcome of the mentoring program may be in the disproportion of females who serve as mentors. Females outnumber males serving as mentors 58% to 42% in an institution that is 32% female and 68% male.

The literature points to many reasons why this gap still remains for women: department and classroom climates that do not encourage women, lack of interest in key content areas, influence of support systems, lack of role models, unsure that as women they can make it (Morganson, et al. 2015; National Academy of the Sciences, Engineering, and Medicine, 2018). In addition to these deficiencies that keep women from joining the STEM higher education learning force, there has also been gender discrimination (National Academy of the Sciences, 2007a), as well instructional approaches that have been recognized for lending themselves to supporting traits associated with one gender over another. Large, informal, didactic lecture centers where students are rewarded for risk taking, with little interaction with others and where faculty are the disseminators of knowledge (and students as sponges, soaking up that knowledge) has been the approach that many introductory STEM classes have traditionally taken. This approach to learning has been associated with playing into the strengths of how males tend to learn best and not environments in which females have tended to flourish academically (National Academy of the Sciences, 2007a).

While it was uncertain to know exactly why such a large proportion of females volunteered to be mentors in this program, it is clear that females saw a value in being a mentor, as well as many different outcomes. It was also clear that females associate these outcomes with mentoring more than their male counterparts. Being a mentor allowed women to grow in confidence in completing the actual classwork, supporting that they have the drive and will to succeed in the sciences (National Academy of the Sciences, 2007a).

Females reported higher agreement with *Academic Professionalism* than males in the study. No doubt, that leading weekly group sessions and working with first-year students through problem-based learning provided females an opportunity that they found more valuable than males. Similarly, the peer mentoring opportunity increased mentors' presentation skills, as well as their own understanding of the material. Again, it appears that females reported they found this more of an outcome than males. The difference in men and women "valuing" the mentoring experience and the outcomes associated with this experience may be due in part to how gender plays a role in learning, motivation and engagement. In addition, the act of mentoring may to some degree support generation z's need to learn in a hands-on manner, while making a difference and gaining real world experiences (Seemiller & Grace, 2016). Potentially, the mentor experience prepared them to become better role models, leaders, and teachers in the fields of science in the future (Phillpp, et al. 2016).

In addition to the above findings, the factor analysis allowed for a new construct in this study, *Academic Relationships* to emerge. The female mentors reported that the experience of being a mentor helped them to feel more confident in their relationships with TAs and faculty. For women in the sciences it has been historically shown that they may likely experience a sense of isolation and discrimination in the STEM classroom, laboratories and the field of science and engineering in general (Espinosa, & Nellum, 2015; National Academy of the Sciences, 2007a). Data from the National Science Foundation (2017) indicated that women have met parity in a number of the science fields (e.g. psychology, sociology, mathematics, etc.) but there is still a proportionally lower rate in physics, engineering, and computer science. This has created a lack of women role models for students and perpetuates the question for women about their fit in the STEM field as a place to see themselves doing the work of a scientist. (Graham, et al. 2013). Possibly, being a mentor has helped these female students to gain confidence in their skills as they negotiate the STEM environment.

Conclusion

Overall both men and women mentors felt they gained from the mentoring experience improvement in their ability to be successful scholars and growth in *academic scholarship*. They both also felt a sense of *academic fit* within the institution by being mentors. Where the experience diverged for women was in *academic professionalism*, where women felt more strongly that they gained more depth of the subject matter, leadership and presentation skills. Women also reported they felt that the mentor experience more strongly assisted them in increasing their sense of *academic relationship* with faculty and teaching assistants. This research may help STEM educators to gain more information about the benefits of the mentor experience.

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