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Strategies for Efficacy and Belongingness towards Foundational STEM Skills for At-Promise Graduate Students: The QMER Learning Community

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Abstract: Increasing representation of first-generation, low-income, and students of color has been considered critical in developing an inclusive and competitive future workforce. However, research has noted significant difficulties with continued engagement and persistence for those engaged in STEM-based activities, with literature showing at-promise students face difficulties in two areas: (1) lack of basic exposure to processes and norms undergirding advanced material, and (2) low self-conception surrounding issues of efficacy and belongingness. This paper reports on the findings of implementing a STEM-focused learning community in a flagship Southeastern university to improve graduate student research efficacy and social belongingness. The learning community program was aimed at (1) broadly supporting foundational STEM skills through supplementary and specialized curriculum; and (2) providing social and professional supports geared towards at-promise students. Survey and interview results demonstrate that graduate students participating in the learning community reported high senses of self-efficacy and belongingness. In addition, low-income, first-generation, and Black graduate students reported higher levels of self-efficacy and belongingness on average. This paper concludes that the learning community approach can be highly beneficial in developing research efficacy across the board, but at-promise students specifically benefit from professional skills development to undergird and contextualize their research confidence.

Keywords: Graduate STEM, Graduate Efficacy, Graduate Belongingness, At-Promise, Learning Community.

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Strategies for Efficacy and Belongingness towards Foundational STEM Skills for At-Promise Graduate Students: The QMER Learning Community

It has become increasingly clear that preparing students with skills germane to science, technology, engineering, and math (STEM) careers is a central thrust of postsecondary education and critical for the future development of the workforce. It is also clear that strategies to support engagement and persistence for low-income, racially minoritized, and first-generation (at-promise students[1]) are needed to ensure advancement and broader participation in this workforce (National Science Foundation, 2022). Research has broadly shown that much of the difficulty for at-promise students stems from two areas: (1) lack of basic *self-efficacy* regarding tools, norms, and processes undergirding advanced work (e.g., graduate norms, software skills), and (2) an uncertain sense of *belongingness* in a program, field, or university (e.g., Graham et al., 2013; Hurtado et al., 2010). While investigation on strategies to improve either *efficacy* or *belongingness* has increased, research explicitly dealing with both in tandem have been "sorely understudied" (Kitchen et al., 2021, p. 1) despite the notion that they are mutually reinforcing (Feldon et al., 2016; Preuss et al., 2020). As a result, the goal of this research is to explore new ways to facilitate high-quality educational practices that advance students' research capacity whilst supporting both efficacy and belongingness, as well as add to the body of literature on supporting at-promise student success.

There is an extensive body of work documenting the learning community format as a means to improve student engagement and persistence in graduate work (Jiang & Koo, 2020; Romsdahl & Hill, 2012), as well as improve the experiences of at-promise students (Culver et al., 2021; Russell, 2017). Although there are several iterations, learning communities have been defined as cohort-based, curricular-centric groups that use a horizontal co-learning model rather than a hierarchical teacher-student structure (Brower et al., 2007). Given that research at the intersection of graduate school pedagogy, STEM career skill attainment, and at-promise student experiences is still developing (NSF, 2020), the learning community format may offer a promising means to advance both high-level and inclusive learning for at-promise students in the areas of efficacy and belongingness.

Given the possibility of learning communities as a means to simultaneously support two critical areas to at-promise graduate student success, this research describes the exploratory approach of a graduate, research-focused learning community developed over a period of four

[1] We use the term at-promise to shift the focus toward the strengths and potentialities of students who may face structural economic, social, or cultural challenges in higher education institutions. We differ from prior use of the term in that we separate out racial identification from this category (Culver et al., 2021), not to deemphasize the structural economic, social, or cultural challenges, but to deal with them in a more granular way.

years at a flagship Southeastern university, called the Quantitative Methods Education for Research (QMER) learning community. QMER was based on an understanding of the literature on learning communities, the desire to advance graduate skills foundational to STEM, faculty observations of at-promise student needs, and a vision to create a more inclusive environment for student growth. Through a combination of collaborative workshops and extracurricular support groups, the QMER learning community has focused on improving access to, and attainment of: (1) academic professional skills and competencies; and (2) foundational STEM skills and advanced research methods. More specifically, the QMER learning community has sought to explore the extent to which a targeted learning community model might simultaneously address issues of efficacy and belongingness for at-promise students—and as such become a model for other programs and schools.

Below, we describe the QMER learning community's pedagogical structure and curricular design. Next, we use an exploratory sequential mixed methods approach (Creswell & Clark, 2018) to assess the program thus far in terms of the following research questions: (1) To what extent has QMER's learning community approach impacted perceptions of academic self-efficacy and sense of belonging, specifically for at-promise graduate students?; and (2) How do aspects of QMER's learning community approach foster or detract from students' self-efficacy and belongingness? We then present results from a survey of participants that includes scales of academic self-efficacy and sense of belonging. These results suggest that at-promise participants in QMER felt an increased sense of self-efficacy, inclusivity, and belongingness. Next, we present follow-up interviews, where students noted that the programmatic aspects of supplementary support, focus on academic 'soft skills,' development of interdisciplinary connections, opportunities for validation, and a low-risk learning environment contributed to feeling more academically confident and like a welcome member of the university. Finally, we conclude with a discussion of how specific aspects of the learning community may help support at-promise students more broadly and delimit areas of future investigation.

The QMER Learning Community Model

The QMER learning community was started by a pair of assistant professors at a flagship Southeastern university under the observation that graduate students in Education pursuing advanced-level quantitative, empirical research tended not to be from diverse backgrounds. At the same time, there was a desire to enhance methodological options for students beyond the standard three-course graduate sequence to better support and improve what we call *foundational STEM skills*—skills that include data literacy, analysis, coding, statistical reasoning, and reproducible research techniques (Gibson & Mourad, 2018; National Science Foundation, 2020). QMER was thereby developed under the guiding mission: "*To improve the rigor, quality, and inclusivity of quantitative research in Alabama and beyond*," and its core values were: (1) *collegiality and collaboration*; (2) *distinction in scholarship and preparation*; (3) *open access and open science*; (4) *continuous improvement*. Over the course of five years, participation in QMER has grown rapidly, hosting 70+ learning community workshops, two research teams, and multiple other gatherings. It has retained a highly diverse group and hosted students from virtually every academic discipline on campus. Below we detail the pedagogical model and curricular design.

Pedagogical Structure

QMER was designed on the learning community model, with specific consideration of the barriers that students often face when engaging in advanced quantitative research and thought. Given that at-promise students have often shown great benefit from approaches that emphasize personal value, contribution, group belonging, and academic-self efficacy (Buckley & Park, 2019; Murphy & Destin, 2016), the learning community model's structural focus on community, non-hierarchy, diversity, relatedness, and engagement (Dost & Mazzoli Smith, 2023; Lenning et al., 2013) offered an ideal format.

Specifically, QMER sought to directly address resource inequalities common to at-promise students engaging in foundational STEM learning. While the research is growing in this area, at-promise students are often overrepresented in schools less able to prepare students for graduate-level work (Ghose et al., 2018). This preparation may also not provide exposure to the technology and tools common to STEM and quantitative research (Estrada et al., 2016), provide familiarization with the specific disciplines, specializations, and institutional supports (Johnson, 2016), or model social and professional norms common to the institutional culture and expectations of graduate programs (Okahana et al., 2018). Moreover, lower levels of representation of at-promise students often result in fewer role models with similar backgrounds, including smaller peer groups (Estrada et al., 2016) and fewer representative mentors (Griffin et al., 2020).

To facilitate QMER's mission of inclusivity, the learning community was designed as a voluntary, supplementary organization that operates independently of students' coursework. It provides topical learning sessions where all graduate students are invited to attend as many or as few events as needed. In general, QMER offers two content-based learning community workshops a month in the evenings and orientation sessions at the beginning of each semester. Learning community workshops average about 12 participants but have ranged from 4 to 38. Some foundational workshops are repeated given academic year (e.g., how to be efficient & effective in graduate school) while most are determined by student input (e.g., data visualization in R).

At the beginning of each event, a statement is given that this is a learning community where there is no hierarchy of knower-learner, there are no grades and therefore no risk of failure, everyone is at a different place in their academic development, no prior knowledge is expected, and all questions are welcome (Culver et al., 2021; Lenning et al., 2013; Parker, 2009). After the announcement, the facilitator begins with questions and conversation around a particular topic (e.g., graphics in R), and solicits learning objectives to be agreed upon amongst the group with the question "What should I walk out with?" A facilitator (student and/or faculty, depending on the topic) will then begin guiding the discussion and present a lesson, walkthrough, or strategy. The lesson is followed by inquiry time where learners apply or explore the topic along a series of questions developed in the discussion (e.g., how can ggplot2 tell the story of my research?). Facilitators offer individualized attention during this time, and throughout learners are encouraged to contribute with collaborative experience-sharing (e.g., how they approached a task), along with personal stories, anecdotes, and concrete examples. At the end of the session, input on what to address in the next session is discussed, students are encouraged to explore and prepare for the upcoming topic, and volunteers to facilitate or contribute next time are solicited. Finally, a survey for self-reflection is given.

Given the aforementioned issues surrounding academic and technological exposure, QMER has followed the Open Science and Open Educational Resources models whereby all

resources, including manuals, articles, software, and computer access are free and available before & after events (Nipa & Kermanshachi, 2020). To ensure transportation or scheduling are not problems, events are held in a common campus room and hosted online. Workshops are recorded and posted for free at a non-public hosting site meeting university accessibility criteria. This includes a posted space online to ask questions and maintain discussion asynchronously (Jiang & Koo, 2020; Nipa & Kermanshachi, 2020). These techniques have been used to address the needs of at-promise students while removing identified barriers to research participation and persistence in graduate and STEM programs (Estrada et al., 2016; Griffin et al., 2020).

Curricular Design

Topics are co-designed between graduate students and faculty as part of a group visioning session that occurs each semester, with continuous feedback from participant students. In the visioning session, which is part of a larger student orientation, students are asked to identify their career goals and identify learning needs, gaps, and uncertainties. These topics are discussed and refined. Some students volunteer to facilitate sessions and curriculum is coordinated with a faculty member.

QMER focuses on two tracks of topics that are discussed in the learning community: (1) academic professional skills and competencies, and (2) foundational STEM skills and advanced research methods. Given the research on inequities in socialization and expectations (Johnson, 2016; Okahana et al., 2018), the professional skills workshops emphasize the academic norms, expectations, and social elements of higher education. Topics have included: professional identity development, publication process, interview skills, and more. Second, the research skills track emphasizes skills foundational for—but not isolated to—STEM research competencies including complex modeling and data science (Gibson & Mourad, 2018). Topics include specific skills such as data cleaning, visualization, coding, or techniques for reproducible research. Other workshops focus on advanced techniques outside of the normal statistical course sequence such as multilevel/mixed effect modeling or time-series analysis. Table 1 provides a sample schedule of topics to serve as an example from the 22-23 academic year.

Table 1.

QMER Sample Schedule of Topics

	Fall Meetings		*Spring Meetings*
1	Welcome: Goalsetting & orientation	1	Job market preparation: CV development
2	Integrating coursework, dissertation, and professional development into your schedule	2	Job market preparation: Interviewing
3	Working with your advisor and finding mentors	3	Clean Code 1: Loops
4	Introduction to statistical software	4	Clean Code 2: Branching & Commits with GitHub
5	Basics of coding and syntax: Python & R	5	Research and publication workflow

6	Finding conferences and writing proposals	6	Identifying and writing for external grant funding
7	Conference presentations & networking	7	Multilevel/mixed-effects modeling
8	Data cleaning techniques with R	8	Multilevel structural equation modeling
9	Data visualization techniques with ggplot2	9	Open session: Lessons learned in grad school

The curriculum and design of each workshop emphasize an integrated set of techniques aimed at promoting the type of thinking and problem-solving aligned with foundational STEM skills (Gibson & Mourad, 2018; National Science Foundation, 2020). Workshops center around a problem to be addressed, and are discussed using the design thinking process (empathize, define, ideate, prototype, test) (Li et al., 2019; Simeon et al., 2020). Workshops focusing on research skills model problem-solving with a combination of computational thinking or statistical reasoning processes, and learners are encouraged to use these processes when engaging in inquiry and sharing their experiences. For computational thinking, the process of decomposition, abstraction, algorithmic representation, and pattern recognition are used (Lyon & J. Magana, 2020). Statistical reasoning emphasizes concepts of aggregation, distribution, randomness, variation, and trend-seeking are based on practicing connections from a problem-based standpoint (Son et al., 2021). These models (design, computational, and statistical reasoning) are aimed at offering the metacognitive structures to pursue success in advanced research that are often not overtly integrated into postsecondary education (Lyon & J. Magana, 2020).

Overall, QMER has sought to improve the research efficacy and belongingness of graduate students—specifically at-promise students—through participation in a learning community focused on (1) academic professional skills and competencies, and (2) foundational STEM skills and advanced research methods. Given this approach, we aim to assess to what extent the program has been successful by assessing two main research questions: (1) *To what extent has QMER's learning community approach impacted perceptions of academic self-efficacy and sense of belonging, specifically for at-promise graduate students?*; and (2) *How do aspects of QMER's learning community approach foster or detract from students' self-efficacy and belongingness?* Below we detail our method for addressing these questions.

Method

To address our research questions, we utilize both survey data and participant interviews as part of an explanatory sequential mixed methods approach (Creswell & Clark, 2018). This consists of two sequential phases to gain a broad swath of data necessary to identify QMER's potential impact on student academic self-efficacy and belongingness. In the first quantitative phase—aligned with research question one—we assess the degree of impact of QMER on student experiences using a participant survey with scales for academic self-efficacy and belongingness. In the second qualitative phase—aligned with research question two—we used survey responses and results to inform semi-structured follow-up interview questions. The rationale for this approach is that the first stage aims to establish the magnitude of QMER's potential impact on participants, and the second stage helps to explain such results and inform the mechanisms by which they operate (Creswell & Clark, 2018).

Data

To assess the impact of the QMER learning community approach, in the first stage we collected data from a participant survey sent at the end of the academic year to every student who engaged with QMER over a four-year period. In the second stage, we conducted in-depth follow-up interviews with students who were involved in the learning community for at least an academic year, asking about which features helped or hindered students' sense of confidence in their research, and feelings of belongingness. The survey and interviews were both designed to assess perceptions of two main aspects of the learning community: *academic self-efficacy* and *sense of belonging*. Below, we outline our first stage survey measures and sample, followed by our second stage qualitative interview strategy.

First Stage Survey

Academic Self-Efficacy. For our survey, we included questions regarding academic self-efficacy, which can be defined as students' beliefs about their ability to manage research demands, preserve during difficult times in their studies, or handle challenges (Cheng et al., 2019). As noted by Bartimore-Aufflick et al. (2016) "Perhaps the single most important (and reliable) predictor of university student achievement in recent decades is self-efficacy" (p. 1918). Academic self-efficacy has been linked with improved academic performance, resilience, and persistence (Chemers et al., 2001; Cheng et al., 2019). Adapting questions from Cheng et al. (2019), we included two scales of academic self-efficacy, *self-efficacy of graduate studies* (*SEG*) and *self-efficacy of research* (*SER*). *SEG* included questions surrounding a student's confidence in comprehending graduate school concepts and performance (e.g., "I am confident I can take more advanced courses"). *SER* included questions aimed at evaluating a student's confidence in being an independent scholar (e.g., "I'm confident I can develop my own research").

Sense of Belonging. We next included questions regarding sense of belonging, which refers to students' general sense of value, acceptance, inclusion, connectedness, care, respect, and importance in a group or among others on campus (Strayhorn, 2018). Research has found that belongingness is associated with important educational outcomes such as academic self-concept, academic success, motivation, persistence, and self-efficacy (Hausmann et al., 2007; Ostrove et al., 2011; Strayhorn, 2018). Specifically, graduate student belongingness is positively influenced by factors such as professional relationships, mentoring, and microaffirmations (Kirby & Thomas, 2022; O'Meara et al., 2017). Moreover, socialization with diverse groups and displays of inclusive goals have been shown to improve feelings of belongingness (Maestas et al., 2007).

Considering the literature surrounding the importance of a sense of belonging, specifically for at-promise students, we adapted two scales: perceptions of *inclusivity*, and perceptions *of belongingness*, developed and validated by Maestras et al., (2007). *Inclusivity* deals with perceptions of the social inclusiveness of the learning community itself (e.g., "I feel that the learning community values and respects all students' voices and opinions"). *Belongingness* addresses a student's sense of personal acceptance into the community (e.g., "I feel like I can share my thoughts freely with others").

Scale Items and Qualitative Questions

Each question for academic self-efficacy and belongingness was based on 5-point Likert-type scales ranging from "strongly disagree" to "strongly agree." Table 2 presents each statement along with Cronbach's Alpha (α) for reliability, which is similar to the original validation studies (SEG α 0.69; SER α 0.87; Inclusivity α 0.76; Belongingness α 0.90). The survey also included two open-ended response questions: (1) "*What about QMER has been helpful to you?*" (2) "*Are there other ways where QMER could better support you as a graduate student?*" These open-ended responses were then coded for themes and will be presented in the results below.

Table 2.

Scale items and reliability

Scale/Question	Measure	Alpha
Scale: Self-Efficacy of Graduate Studies		*0.845*
Prompt: Has participation in QMER supported you in the following aspects?		
SEG1	"Succeeding in my future methods coursework"	
SEG2	"Understanding basic statistical concepts"	
SEG3	"Understanding advances statistical concepts"	
SEG4	"Being successful in my program"	
SEG5	"Taking more advanced courses"	
SEG6	"Working with statistical software"	
SEG7	"Having an advantage in my own program"	
Scale: Self-Efficacy of Research		*0.720*
Prompt: Has participation in QMER supported you in the following aspects?		
SER1	"Thinking more like a researcher"	
SER2	"Develop my own research"	
SER3	"Understand and critique research"	
SER4	"Applying learning to my own projects"	
SER5	"Having an advantage on the job market"	
Scale: Inclusivity		*0.712*
Prompt: "Do you think QMER…"		
INC1	"Helps work cooperatively with diverse people"	
INC2	"Supports tolerance of others with different beliefs"	
INC3	"Values and respects all students' opinions"	
INC4	"Shows openness to different/challenging viewpoints"	
INC5	"Allows space to see from different perspectives"	
INC6	"Operates with awareness of cultural backgrounds & needs"	
Scale: Belongingness		*0.845*
Prompt: "Has participation in QMER made you feel.."		
BEL1	"Like I am part of the university community"	
BEL2	"Like I have things in common with others"	
BEL3	"More comfortable being myself"	
BEL4	"Like I can share my thoughts freely"	
BEL5	"Like there are others like me around"	
BEL6	"Like my contributions and ideas are valued"	

BEL7	"Like I belong to the group"

Second Stage Interviews

Using open-form responses from participants and in-depth, semi-structured follow-up interviews, we provide further information on how the program has been viewed by students. Interviews lasted between 15-25 minutes, and students were asked which aspects of QMER were most helpful to them, as well as aspects that were not so helpful. Follow-up questions aimed to narrow in on those features that helped or hindered students' sense of confidence in their research, as well as features that helped or hindered feelings of being included and belonging at the university. In total, we interviewed 15 students who had been involved in QMER for a year or more, with interview sample characteristics shown in Table 2.

Sample

As noted above, the survey was sent to each student who had participated in a QMER event over the past four years. Every graduate student at the university was invited to QMER workshops through a graduate student listserv, and interested students could register for any workshop using a Qualtrics registration link. Since workshops were held virtually over Zoom, emails of students attending workshops were compiled from Zoom reports. From this list, emails were sent to each student who had attended a workshop. Five, 15-dollar gift certificates were raffled off to incentivize participation in the email survey invitation. Of the 160 registered participants, 59 completed the survey, resulting in a 37% response rate. Table 3 provides the compositional characteristics of the sample, and also includes interview sample characteristics.

Table 3.

Survey & Interview Sample Characteristics

	Survey		*Interviews*	
	Sample	# Events	Participants	# Events
Female	55%	4.03	8	6
Male	45%	4.19	7	5
Asian	26%	4.39	4	5.5
Black	23%	4.79	4	5.75
Latinx	9%	6.08	1	6
White	36%	2.00	5	4
Other	6%	3.39	1	4
First Generation Student	38%	4.95	6	4.83
Low-Income Background	43%	4.95	7	6.5
# of Participants	59		15	
# of QMER Events Attended	4.19		5.29	
# of Years in Grad School	3.16		2.86	

Notably, our survey sample includes a relatively high proportion of Asian (26%) and Black (23%) students, considering the graduate student population at the host university is roughly 3% Asian, 8% Black 4% Latinx, and 65% White. Much of the sample is comprised of first-generation and low-income students, the latter of whom make up roughly 17% of the

graduate student population but represent 43% of the sample.[2] Given that those indicators are not mutually exclusive, 72% of the sample identified themselves as being at-promise in one or more dimensions. Respondents also came from all across the university, including agriculture, architecture, biosystems engineering, forestry, mechanical engineering, political science, and more. However, given that QMER's faculty are from the College of Education, the majority of participants were from education-related fields. Overall, respondents attended just over 4 events and were in their 3rd year of graduate school. However, it is notable that on average White students attended relatively fewer events (2) compared to Latinx (6) and Black (4.8) students. In addition, first-generation and low-income students attended nearly 5 events each.

Analysis & Limitations

The goal of this analysis is to gain an understanding of the value of the learning community approach for students in terms of self-efficacy and belongingness, as well as to see what differences may exist between student groups, particularly at-promise students. We therefore present descriptive statistics to demonstrate broad trends and group differences, supported by qualitative responses to help explain these trends.

To present our survey data, we constructed scores for each scale using STATA's `alpha` function which complies items into a single scale variable and standardizes to a set length. In this manner, each scale score is reported on a continuum of 1-5, with 1 representing a low agreement score ("strongly disagree") on SEG, SER, Inclusivity, or Belongingness, and 5 representing a "strongly agree" score on the respective scale. This is followed by a series of themes presented from our open-ended questionnaire and interviews. Responses to questions on how students felt about their self-efficacy and belongingness were independently coded, cross-checked, and reconciled by the researchers until certain themes developed. Themes were member-checked with interview participants. These themes are presented following the descriptive section.

It should be noted that our sample is not random nor necessarily representative of students attending QMER. While the authors can anecdotally note that the demographic makeup of the sample does seem to align with observations, we do not collect information on students participating in QMER events as we do not want self-identification to be a barrier to participating. Given the low number of observations (59) and non-random sample design, the representation of sub-groups is limited and power is low. For this reason, while we report independent sample t-test results to demonstrate sample group differences, these are not to be considered representative of all participants. In addition, selection bias is a concern, and it is possible that, for example, certain types of students are more likely to take surveys or be motivated by financial incentives. Moreover, our goal is not to actively posit that the QMER learning community causes overall improvements in student perceptions—we do not have the resources at present for a proper control sample or repeated measures design. Rather, we intend to make an introductory case that the QMER approach may show initial effectiveness and that this may serve as grounds for future research into how programs may better engage at-promise students in STEM learning.

[2] As a limitation, it should be noted that we do not have information on the composition of graduate students pursuing advanced quantitative research, which may be differently distributed amongst graduate students at the university.

Results

The results of our exploratory sequential mixed methods investigations are presented below. We begin by presenting overall trends from our survey regarding academic self-efficacy and belongingness. Next, we present qualitative results that enrich our understanding of the survey results and address factors that foster or detract from students' self-efficacy and belongingness.

RQ1: To what extent has QMER impacted perceptions of research self-efficacy and sense of belonging?

Table 4 presents the mean and median for each of our four scales: SEG, SER, Inclusivity, and Belongingness. These are then decomposed by respondent-identified gender, race, first-generation, low-income, and first-generation status. Independent samples two-tailed t-tests are included to illustrate group differences, with a group being compared to the non-group mean. For example, the mean of Asian respondents is compared to all non-Asian respondents. Given the number of group comparisons, we present these results as box plots in Figure 1 to more clearly illustrate trends and response distributions. For reasons of parsimony, we will only focus on the main trends here.

Table 4.

Scale Score Means of QMER Survey Respondents

	SEG		SER		Inclusivity		Belongingness	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
All Respondents	4.34	4.43	4.42	4.4	4.68	5	4.33	4.43
	(0.56)		(0.52)		(0.46)		(0.62)	
Female	4.34	4.43	4.42	4.6	4.61	5	4.29	4.43
	(0.72)		(0.57)		(0.52)		(0.66)	
Male	4.34	4.29	4.43	4.4	4.74	5	4.35	4.43
	(0.4)		(0.49)		(0.41)		(0.59)	
Asian	4.49	4.5	4.5	4.7	4.71	5	4.31	4.5
	(0.44)		(0.63)		(0.37)		(0.79)	
Black	4.76*	4.79	4.75*	4.8	4.94*	5	4.75*	4.86
	(0.21)		(0.3)		(0.16)		(0.32)	
Latinx	4.37	4.43	4.16	4.4	4.85	5	4.49	4.71
	(0.3)		(0.36)		(0.22)		(0.54)	
White	4.85	4	4.30	4.3	4.53	4.75	4.12	4
	(0.67)		(0.48)		(0.55)		(0.49)	
Other	3.95	4	3.93	4	4.17	4	3.81	4
	(0.08)		(0.5)		(0.76)		(0.73)	
First Generation	4.54	4.57	4.48*	4.4	4.84	5	4.59*	4.71
	(0.38)		(0.45)		(0.37)		(0.55)	
Low Income	4.61*	4.71	4.58*	4.7	4.84	5	4.48*	4.79
	(0.36)		(0.47)		(0.29)		(0.69)	

Note: *p<0.05 on independent samples two-tailed t-test against non-inclusive group mean. Standard deviation in parentheses

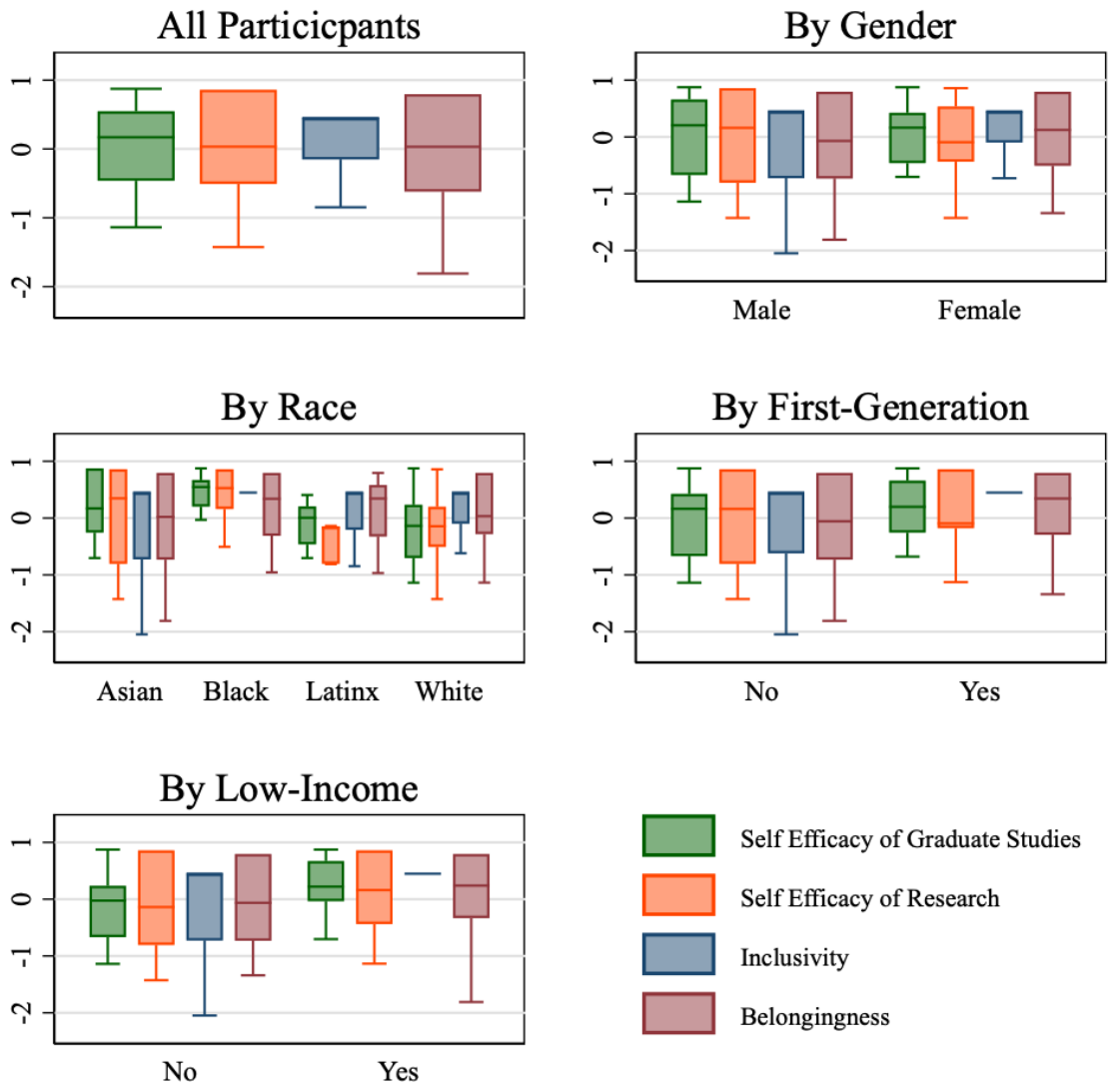
Row 1 of Table 3 shows that, on average, students perceived *Inclusivity* as the strongest component of QMER (mean = 4.68, median = 5), followed by *Self-Efficacy in Research* (mean = 4.42, median = 4.4), *Self-Efficacy in Graduate Studies* (mean = 4.34, median = 4.43), and *Belongingness* (mean = 4.33, median = 4.43).

When looking at participant-identified gender, we see roughly similar trends for both females and males, with females having slightly lower scores on SER and slightly higher on Belongingness. When looking at participant-identified race, Black graduate students reported the highest average levels of agreement for each scale, being statistically higher than the non-Black group mean. Notably, the high agreement with *Inclusivity* was shared across each racial sub-group, while *Belongingness* is most strongly agreed with by Black and Latinx students.

Slightly different trends show up across first-generation and low-income students. Notably, from Figure 1, we see that first-generation and low-income students all had a generally higher agreement with self-efficacy, inclusivity, and belongingness than the non-first-generation or low-income student groups. In particular, first-generation and low-income students all had a statistically higher agreement for SEG. Moreover, first-generation and low-income students had higher feelings of belongingness from QMER.

Figure 1.

SEG, SER, Inclusivity, and Belongingness Scales by Student Characteristics



Note: Higher scores represent stronger average agreement with the scale.

RQ2: How do aspects fo QMER's learning community approach foster or detract from students' self-efficacy and belongingness?

Given the above results reporting that QMER participation has improved students' sense of academic self-efficacy and belongingness—particularly for at-promise and Black students—we now turn to provide a deeper sense of ways in which the program has been viewed as part of the second stage of our explanatory sequential mixed methods approach.

Practical and Supplementary Approach

Several participants noted that they experienced improved mastery of statistical software, as well as translating it into coursework and research. This was often attributed to the emphasis on supplementary practical skills that did not repeat what was in the normal coursework sequence. In response to a question on what was helpful about participating in QMER, one student noted:

> Overall, QMER equipped me with the motivation and confidence to be an independent graduate student and a future researcher. I have been exposed to the requisite research skills and tools to initiate and complete a research project on my own. *–First-generation, low-income, international, Black, male, Educational Leadership student*.

Some students noted the opportunities to "slow down" and "process" much of the material, noting that "…the information is valuable and more personable than regular classes." As noted by one student:

> Essentially [QMER is] a place to apply practically the knowledge we are learning in Grad School. To be frank, this is the most needed practical experience that is not taught in Grad School. *– First-generation, low-income, Black, male, Adult Education student*.

Other students noted the importance of simply introducing the software that is used in coursework (such as R), while others emphasized the practical and developmental nature of the curriculum:

> QMER helped me in different stages of my program. It helped me with getting familiar with statistical methods, software usage [R, STATA], and research workflow in the first year of my Ph.D. program. It helped me to navigate the process of journals and conferences as I started manuscript writing when I was in the second year of my program. *–First-generation, low-income, international, Asian, female, Educational Psychology student*.

Focus on Academic Soft Skills

A second theme that developed under the area of improving academic self-efficacy was an emphasis on the soft skills surrounding academic research, which has shown to be particularly difficult for underrepresented and at-promise students (Estrada et al., 2016; Okahana et al., 2018). Several at-promise and underrepresented students emphasized the importance of "hearing the personal experiences of professors," as well as an emphasis on "professional development […] and assistance with preparing [my] work to align with my goals." Others emphasized the treatment of soft skills such as job market preparation, resume building, networking, "communication with my advisor," and "learning how grad school works in general." One student noted:

> I truly enjoyed the workshops on succeeding in our graduate programs. I found learning about the doctoral journey […] leading towards dissertation necessary and helpful. *–First-generation, low-income, Black, female, Higher Education Administration student*

Connecting Students Outside of Programs

Several students noted the importance of meeting with others outside of their programs, supporting the notion that graduate student's sense of belongingness is found to be positively influenced by factors such as socialization with diverse groups (Maestas et al., 2007) and professional relationships (O'Meara et al., 2017). For example, a fourth-year doctoral student stated that participating in QMER gave her:

> …the opportunity to feel connected. I have been done with my coursework for some time now and there is very little within the program that created a similar sense of graduate student community once coursework is completed…it is a relief that there are student peers and faculty who are willing and available to answer your questions or help you problem solve…-*White, female, Adult Education student*

A student from Human Development and Family Studies noted: "Often it's too easy in the later years of graduate school to become siloed, and QMER offers some connections." Another noted that "…joining [QMER] taught me different perspectives and approaches to research that I now use myself in my daily work."

Validation Through Contribution

Several students noted that the learning community format "offered a chance to be heard" and "a sense of contribution." For some students, not being able to share and contribute to learning led to a sense of detachment and invisibility. As one student noted:

> Yeah, there was this sense that once I was asked to share out how I was looking at [the topic], I was kind of 'part of things.' And I guess I had always kind of felt that no one needed to hear anything from me and I guess that made me feel, like, separate, you know? So it was crazy it was like, once I contributed [the learning strategy] to the group it was like, yeah I'm actually here and I'm real and I'm part of this. – *First-generation, Black, male, Agrisciences student*

Contribution activities such as collective goalsetting, experience-sharing, or facilitating the learning community format appeared to offer support for a sense of belonging (O'Meara et al., 2017), as well as interpersonal validation (S. Anderson & Blankenberger, 2023). Noting that research has long noted that many at-promise students feel a sense of alienation in graduate programs (Loo & Rolison, 2016), offering chances for students to voice themselves and contribute to the community may help improve the sense of connection and validation.

Removing Risk

Finally, students noted that since the learning community existed outside of the traditional class setting it did not have the normal teacher-student hierarchy and had no grades or assessments attached. This allowed for learning to take place in a low-risk environment. As one at-promise student in Counseling Psychology stated, "It feels very open. I don't feel judged." This low-stakes environment allowed for better overall connections as well:

> I was able to connect with students and faculty members more easily in this setting, and able to learn things that were not dealt with during the class or

> things that I wanted to learn in-depth—*Low-income, Asian, female, Adult Education student*.

Following the abovementioned barriers to at-promise students in higher education, such as unfamiliarity with academic norms, feelings of inadequacy, or fear of failure (Estrada et al., 2016; Maestas et al., 2007; O'Meara et al., 2017), operating in a low-risk environment appears to support further learning in spaces that might otherwise be prohibitive.

Discussion & Conclusion

The goal of this paper has been to describe and evaluate the QMER learning community model in terms of its effect on academic self-efficacy and belongingness for graduate students. The model of supporting foundational STEM skills through a supplementary, interdisciplinary, and professional-skills-oriented learning community format has shown that (1) generally students felt QMER supported self-efficacy in research, self-efficacy in graduate studies, inclusivity, and belongingness; (2) Black, first-generation, and low-income students reported higher perceptions of self-efficacy in research and belongingness than their peers; and (3) the supplementary approach, soft-skill focus, interdisciplinary connections, opportunity for voice and contribution, and low-risk environment were aspects of the QMER learning community model that stood out to students.

This work supports prior literature regarding three key implications for institutions looking to simultaneously improve students' experience and capacity. Most notably, it serves to demonstrate how efforts to improve self-efficacy and belongingness for at-promise graduate students can be combined into a comprehensive program. First, instructional structures that operate outside of the traditional methods sequence may be increasingly important as more specialized and differentiated research expertise is needed in many areas of the workforce (Tytler, 2020), and high student-to-faculty ratios in many programs make socioemotional support and communication more difficult to foster (Crocker et al., 2014). Second and related, explicit attention to professional norms (e.g., what to put on a CV), soft skills (e.g., networking at conferences), and baseline competencies (e.g., file structuring, coding) surrounding foundational STEM skills may offer a means to further support underrepresented and at-promise students who have less exposure and mentorship within their respective field (Estrada et al., 2016). Whether addressed within the traditional class structure or not, students noted that these supplementary skills were needed. Third, offering a format for students to interact across disciplines and actively contribute to inclusive academic goals may help foster notions of shared identity, community, and interpersonal validation that serve to advance both goals of research equity and excellence (S. Anderson & Blankenberger, 2023; Culver et al., 2021). As some students felt 'siloed' or 'invisible' in their programs, this supplemental learning community format offers a 'third space' that suspends organizational hierarchies and expectations for the development of wider personal and professional relationships and informal mentoring, as well as low-risk opportunities for experience-sharing, validation, and microaffirmations essential to belongingness (Elliot et al., 2016; Maestas et al., 2007). These features may help students feel a greater sense of shared belonging as well as prepare them to engage in collaborative and interdisciplinary research (National Science Foundation, 2022; O'Meara et al., 2017; Stachl & Baranger, 2020; Thornton et al., 2020).

Given that this learning community has multiple facets, it is difficult to pinpoint specific aspects that had the greatest contribution to the success of the program. However, it was clear that QMER's structure operated best alongside regular coursework, rather than in lieu of it.

Students reported that much of its importance was in offering a 'different perspective' on the same skills, furthering the understanding and context needed for learning (Hilliard, 2012). To gain a better understanding of just which aspects are most important, it will be important to continue with research on which specific learning outcomes have resulted from the program—which is a limitation of the current study. While the present study has focused on self-efficacy and sense of belonging, it is unclear to what extent such an approach may impact other aspects of success including persistence, time to completion, and placement. Moreover, it will be important to assess the capability of scaling the program. As participation has more than tripled in the past two years, maintaining personal and individual connections will become more difficult, and administration of the program may become more complex. However, these preliminary results do offer a promising start to the QMER learning community as a model that may create a more asset-based, inclusive environment for students while simultaneously pushing their research capabilities to advance the future workforce.

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