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# "Please Stop Bringing up Family Life, We're Here to Talk about Science": Engaging Undergraduate Women and Women of Color in STEM through a Participatory Action Research Project

Batsheva R. Guy
*University of Cincinnati*, batsheva.guy@gmail.com

Tziporah Feldman
thserota@gmail.com

# "Please Stop Bringing Up Family Life; We're Here to Talk about Science": Engaging Undergraduate Women in STEM through a Participatory Action Research Project

Batsheva R. Guy and Tziporah Feldman

*University of Cincinnati*

**Abstract**

Stark underrepresentation exists of undergraduate women enrolled in science, technology, engineering, and mathematics (STEM) degree programs. Although women have outnumbered men in undergraduate enrollment for over 30 years, these numbers do not apply to the sciences. Previous research shows that low self-efficacy is a barrier and high self-confidence is a strength for women in STEM. Participatory Action Research (PAR) addresses both sides of this issue by (1) answering the questions that exist about women in STEM and undergraduate research and (2) providing women in STEM with research experience. Thus, PAR not only helps solve the problem of self-efficacy that affects women in STEM, but also aids with self-esteem issues and other barriers they face daily. The current study is a PAR research project that uses group-level assessment, a participatory qualitative research method. In collaboration with female undergraduate coresearchers, the purpose of this PAR research project is to explore the experience of women conducting and/or seeking STEM undergraduate research experiences to inform program development at the university level.

**Keywords:** women in STEM, Participatory Action Research, participatory methods, group-level assessment

## Introduction

Stark underrepresentation exists of undergraduate women enrolled in science, technology, engineering, and mathematics (STEM) degree programs. Although women have outnumbered men

in undergraduate enrollment for over 30 years, these numbers do not apply to the sciences (Simmonds et al., 2021; Bloodhart et al., 2020; Witherspoon et al., 2019; Cole & Espinoza, 2011; Hill et al., 2010). According to Kokkelenberg and Sinha (2010), undergraduate women are particularly underrepresented in the field of engineering, which coincides with data from Hill et al. (2010), indicating a mere 2.5% of women compared to 14.5% of men intend to major in engineering. Women also enroll in physical science courses less frequently than men—a statistic that has persisted for over 40 years (Pryor et al., 2007). Not only do men outnumber women in STEM majors, but men are also more likely to receive degrees in STEM—over 138 thousand men as opposed to less than 90 thousand women (Hill et al., 2010).

According the "Characteristics of Excellence in Undergraduate Research (COEUR)" report (Rowlett et al., 2012), undergraduate research ideally involves institutional and administrative support, the commitment of scholarly faculty, accessible opportunities in multiple fields, and funding. For the purposes of this study, undergraduate research involves undergraduate students in any field of study conducting research with a faculty mentor, which can encompass any field or type of research, scholarly activities, or creative practice within various settings. While both formal, university-established undergraduate research programs (URPs) and informal mentored research experiences exist, these can be compiled into the single category of undergraduate research experiences (UREs).

Studies that examine the impact or effectiveness of various UREs each specify at least one type of benefit that UREs provide for undergraduate students of various demographics, and implementing programs and programmatic factors have been shown to positively impact women in STEM in various ways (Dewey et al., 2022; Duboue et al., 2022; Werth et al., 2022; Ghebreyessus et al., 2021; Samad et al., 2021; Starr et al., 2020; Jones et al., 2019; Krim et al., 2019; Ramsey et al., 2013; Inkelas, 2011; Ong et al., 2011; Rosenthal et al., 2011). For instance, women in STEM are susceptible to feeling a low sense of belonging (Thoman et al., 2014), and UREs have been demonstrated to positively impact a sense of belonging (Rosenthal et al., 2011).

Several positive academic outcomes have been found through participating in UREs, both in the classroom and in relation to persistence. For example, studies have found that grade point average (GPA) increases following URE participation (Fechheimer et al., 2011; Maton et al., 2000). In addition, retention and graduation rates improve for students who have engaged in UREs (Jones et al., 2010; Eagan et al., 2013; Barlow & Villajero, 2004). Undergraduates who participate in UREs are also more likely to improve their cognition and problem-solving skills. Hunter et al. (2006) found evidence for "cognitive growth," and Zhan (2014) discovered that students were more prepared and able to solve real-world problems on account of UREs. Most notably, several studies show that research skills improved considerably (Odera et al., 2015; Adedokun et al., 2013; Tigno et al., 2009; Campbell & Skoog, 2004; Kardash, 2000). Students' inspiration to seek research-related and science-centered careers increased after participation in UREs (Odera et al., 2015; Adedokun et al., 2013; Russell et al., 2007). Interest in, preparation for, and likeliness to attend graduate school also increased (Barnes, 2015; Carter et al., 2009; Russell et al., 2007; Barlow & Villajero, 2004; Maton et al., 2000). UREs were found to impact self-efficacy

(Adedokun et al., 2013), which is a variable that stimulates the persistence of women in STEM (Cole & Espinoza, 2011; Heilbronner, 2012). Campbell and Skoog (2004) found that a particular URE experience increased students' confidence and motivation. UREs were also found to enhance student engagement and belonging (Fechheimer et al., 2011; Rosenthal et al., 2011).

The outcomes of UREs can be related to the barriers and strengths of women in STEM and, as a result, can be used to encourage the persistence of these groups. For example, UREs require faculty mentors (Rowlett et al., 2012), and UREs with a strong mentorship component are particularly effective (Campbell & Skoog, 2004). Women in STEM especially benefit from mentors who are supportive (Kim et al., 2011). Furthermore, UREs can decrease implicit stereotype endorsement (Ramsey et al., 2012).

The impact of UREs on women in STEM is not fully considered in the literature; therefore, women in STEM are excluded from these conversations related to program development in higher education. The inclusion of multiple perspectives from various groups is important from both an equity-based and an economic standpoint (Espinosa, 2011; Ong et al., 2011), so including a variety of perspectives is essential when discussing both the persistence of women in STEM and the development of inclusive and accessible UREs, which can be accomplished through Participatory Action Research (PAR). PAR essentially puts the power in the hands of the participants (McIntyre, 2008), and these projects have been shown to lead to empowerment, buy-in, and enhanced research quality (Guy & Arthur, 2021; Jacquez et al., 2013; Anderson et al., 2007; Goodhart et al., 2006; Williams & Lykes, 2003).

Previous research demonstrates that low self-efficacy is a barrier and high self-confidence is a strength for women in STEM (Almasri, 2022; Wofford, 2020; Thoman et al., 2014; Heilbronner, 2012; Cole & Espinoza, 2011). PAR addresses both sides of this issue by (1) answering the questions that exist about women in STEM and undergraduate research and (2) providing women in STEM with research experience. Thus, PAR not only helps solve the problem of low-efficacy that affects women in STEM but also aids with self-esteem issues and other barriers they face daily. The current study is a PAR research project that uses group-level assessment (GLA), a participatory qualitative research method**.** In collaboration with female undergraduate coresearchers, the purpose of this PAR research project is to explore the experience of women conducting and/or seeking STEM UREs to inform program development at the university level. Research questions include:

1. What are the barriers to STEM and research participation for women?
2. What are the support factors for STEM and research participation for women?
3. What future programming should be considered at the university level to support women's STEM and research participation?

## Authors' Positionalities

We, the authors, are both white, cisgender, straight, able-bodied women, and we acknowledge the privilege and power that comes with those identities.

### Author One Positionality

At the time of this study, I was the doctoral student co-creator and facilitator of the Participatory Opportunity for Women Emerging Researchers (POWER) in STEM group. I chose this topical area as a result of my experiences as an undergraduate female researcher in STEM. I was frequently told by my professors not to pursue an advanced degree in STEM since I planned on marrying and having children; this advice was not given to my male peers. The microaggressions I faced daily from my male peers and professors were both frustrating and defeating, but they led me to become passionate about seeking equitable opportunities for women and other underrepresented groups in STEM. The second reason for my interest in this topic involves the context of my previous position working as an assistant program coordinator and student worker for my university's undergraduate research office. I held this position for four years, and throughout my employment, I gained experience working with both undergraduate students who were doing research and those seeking research opportunities. While we served a diverse group of students, we used the same interventions and programs for everyone. Many of the students valued the programs our office offered, but there were no opportunities to address specifically the retention and success of women in STEM. While we worked closely with the Women in Science and Engineering (WISE) undergraduate research program, this program does not serve all women in STEM seeking research, as there is a rigorous application process. My goal is to develop a holistic program to help all women, regardless of their GPA and test scores.

### Author Two Positionality

At the time of this study, I was an undergraduate at a large public R1 university and had just left home. I began as a coresearcher in the POWER group starting the first semester of college and felt totally unaware of and unprepared for the path of higher education that lay ahead. I was unsure of what classes I should be taking, how much time I should be spending on research, how to get into graduate school, and what appropriate conduct was. Thus, my views at the onset of this project were shaped by overall confusion with how higher education works, frustrations with the lack of clarity and guidance from my department, and a feeling that I had no role or purpose within the university. Likewise, as a woman who had many health problems, had to work part-time outside of school, and aimed to get into graduate school, I felt alienated by the highly competitive nature within STEM and frequently felt I was unable to have a life outside of school. As I progressed in my degree and became more involved in research, I was not only able to understand the process better, but also better understand the issues of the higher education system. This understanding of

the issues in STEM led me to become invested in this study so that future generations of women can have better experiences than I did.

## Methods

PAR is a research framework that regards participants as coresearchers involved in every step of the research process (McIntyre, 2008). As such, PAR is an iterative process guided by the expertise and interests of the coresearchers. Below we detail the context of the study, including the coresearchers, as well as the methodology used.

### Partners and Study Context

POWER in STEM is a PAR group of six undergraduate women in STEM at a large midwestern R1 university. The group was formed in the fall 2016; Table 1 below includes coresearcher demographics ($n$ = 6) and their undergraduate year in school upon the initiation of the group. The current study involved these women as coresearchers throughout the project as both the designers of and participants in participatory data collection and analysis. Informed by initial findings with participants, the POWER in STEM coresearchers chose to conduct a self-study of their own experiences seeking and participating in STEM research.

Table 1
*Coresearcher Demographics*

| Coresearcher | Year in school | Major | Race/Ethnicity |
|---|---|---|---|
| 1 | 1 | Biological Sciences | White |
| 2 | 2 | Education, Psychology minor | White |
| 3 | 2 | Chemical Engineering | Black |
| 4 | 3 | Biological Sciences | White |
| 5 | 4 | Biomedical Engineering | White |
| 6 | 4 | Psychology | Appalachian |

*Notes.* Year in school indicates each coresearcher's undergraduate year upon onset of POWER.

#### *Recruitment*

I (author one) sought to be intentional about recruiting a diverse group of coresearchers. Scholarly literature indicates that recruiting women of color to participate in research studies is a challenging endeavor (Carter-Sowell & Zimmerman, 2015; Joseph et al., 2007; Ong, 2005). In the context of the current study, the anticipated difficulty in recruiting a diverse group of women could be attributed to the low numbers of women of color in STEM fields (Ong, 2005). Targeted efforts

were carried out to recruit a diverse group of women for the current study. I have outlined my process below.

I initiated the formation of the POWER in STEM group by recruiting students through the list of presenters at the university's spring 2016 Undergraduate Research Conference, which includes about one thousand student presenters. Through my assistant program coordinator and student worker position for the university's undergraduate research office, one of my main duties was recruiting for and organizing this conference. To recruit women of color for the current project, I visited some of the ten McNair students who were presenting at the conference and personally spoke to them about PAR. The McNair Scholars program is a national program meant to increase the number of underrepresented minority students in doctoral programs, with a particular focus on STEM fields (Barnes, 2015). Targeted efforts to recruit women of color were achieved with assistance from the McNair Scholars Program and the university's Office of Equity and Inclusion. Through contacts that I developed through my work at the undergraduate research office, I was able to personally reach out to coordinators and directors of these programs and offices. To recruit additional participants for the PAR project, the POWER in STEM team also conducted participant recruitment by advertising to their STEM labs and classes.

### *Training*

Before data collection was performed, the group's initial meetings were spent training POWER coresearchers on action research approaches and participatory methods. As POWER began to explore specific participatory methods, training for how to apply these tools was conducted in the weeks before the implementation of each method. During the first semester of POWER, biweekly meetings were devoted to reading about and discussing action research concepts, such as participation, collaboration, and the action research cycle. For example, one of our first meetings was spent examining the article "Why Action Research?" (Brydon-Miller et al., 2003), which led to the group conversing about why action research is appealing and meaningful to them, with one coresearcher reflecting, "In traditional research the acting part is very small; you don't really take any action." These meetings were also spent reading and discussing literature surrounding women and specifically women of color in STEM and undergraduate research. As we began choosing the methods we would use, we spent time deliberating and examining qualitative versus quantitative research methods.

## Protection of Vulnerable Populations

The current project received a Non-Human Subjects Designation (NHSD) from the university's IRB, meaning the submitted proposal did not meet the federal definition of research. In other words, POWER research initiatives are meant to inform program development at the current university and are, therefore, not generalizable. Because I (author one), and not the IRB, had ethical oversight of activities performed in this study, aside from the NHSD, I did several things to ensure

ethical procedures were followed. First and foremost, POWER coresearchers consented to each research activity and were made aware that they could separate from the group or from the research at any time.

The purpose of a structured ethical reflection is for coresearchers to identify values that inform the research at hand (Brydon-Miller et al., 2015). According to Brydon-Miller and Maguire (2008), the nature of PAR requires more in-depth ethical considerations on the part of the participants and coresearchers that extend beyond IRB determinations. I facilitated a structured ethical reflection with the POWER in STEM coresearchers to identify our values as a collective group. I modified the process of creating a structured ethical reflection to make it participatory within the group. Each coresearcher individually identified her most salient values on separate sticky notes (Figure 1). Next, coresearchers combined their sticky notes on a whiteboard and grouped them thematically. The POWER in STEM team grouped their values into three distinct categories: community, commitment, and character.

1. Community: inclusivity, mutual respect, equality, democratic practice, social responsibility, responsibility, and community spirit
2. Commitment: opportunity, flexibility, passion, and critical thinking
3. Character: patience, self-confidence, authenticity, humor, leadership, and objectivity


*Figure 1.* Structured Ethical Reflection Creation

Following this modified engaging version of creating a structured ethical reflection, the coresearchers and I transferred the values onto the traditional grid. The POWER in STEM coresearchers and I referred to our values throughout the research planning and data collection.

**Data Collection**

Data collection involved conducting a GLA. Participants in the GLA, which was facilitated by the POWER in STEM coresearcher team, involved female participants who were conducting or seeking STEM undergraduate research at the university ($n$ = 17).

A GLA is a participatory research method that involves collecting a large amount of qualitative data from groups of stakeholders to solve a problem in a community or organization (Guy & Arthur, 2021; Guy & Arthur, 2022; Vaughn & Lohmueller, 2014; Vaughn & Lohmueller, 1998).

A GLA is an inclusive method that allows all participants to have their voices heard in individual, small-group, and large-group settings (Vaughn & DeJonckheere, 2019; Vaughn et al., 2011). The purpose of a GLA is to consolidate themes from the process *with* participants in order to develop a timely and realistic action plan. GLA has been used successfully to implement programming in a variety of contexts in higher education, including with STEM faculty in the classroom to promote the use of active learning (Guy, 2017), with biomedical informatics faculty and students to improve graduate programming (Guy, 2020), with graduate women in psychology to enrich their experiences (Guy & Boards, 2019), and with undergraduate women in engineering to enhance programming (Arthur & Guy, 2020).

The GLA method involves a seven-step process of (1) climate setting, (2) generating, (3) appreciating, (4) reflecting, (5) understanding, (6) selecting, and (7) action. The GLA process as implemented in the current study is described in subsequent sections.

### *Preparation*

Planning for the GLA occurred during POWER in STEM biweekly meetings. As the facilitator of these sessions, I (author one) provided literature on the GLA method for members to read and take notes on prior to meetings and encouraged them to come with questions and insights to prepare for discussion. As a group, we discussed the method, including the advantages and disadvantages of GLA in the context of our research questions. The POWER in STEM coresearchers concluded that facilitating a GLA could serve as an ideal way to engage their peers in conversation regarding their lived experiences as women in STEM and gather a large amount of qualitative data in a relatively short period of time. We worked during meetings and between meetings in an online, shared password-protected document to write up and edit GLA prompts.

### *GLA Participants*

Participants were recruited via email using targeted recruitment strategies as discussed previously; a random drawing for an Amazon.com gift card and refreshments during the GLA were provided as incentive to attend and participate. Table 2 contains demographics of the GLA participants ($n$ = 17). Among the GLA participants, five of the women identified as Black, one as Black and Hispanic, and three identified as Asian, making more than half of the participants women of color. Four participants were engineering students, three were biochemistry, and five were neuroscience, among an assortment of others, which demonstrates the diversity of degrees sought as well. Five participants were conducting STEM research at the time of the GLA.

Table 2
*GLA Participant Demographics*

| Participant | Year in school | Major | Race/Ethnicity | Currently Conducting STEM Research |
|---|---|---|---|---|
| 1 | | Biology | Black | X |
| 2 | 4 | Biochemistry | Black | X |
| 3 | 2 | Neuroscience | Black | |
| 4 | 2 | Neuroscience | White | |
| 5 | 2 | Neurobiology | White | |
| 6 | | Medical Sciences | Asian | |
| 7 | 1 | Biochemistry | White | |
| 8 | | Neuroscience | Asian | X |
| 9 | | Neuroscience | White | |
| 10 | 4 | Psychology | White | X |
| 11 | | Biomedical Engineering | White | |
| 12 | | Biochemistry | Asian | |
| 13 | | Environmental Science/ Math | Black | |
| 14 | 2 | Engineering | Black, Hispanic | |
| 15 | | Actuarial Science | Black | |
| 16 | 3 | Engineering | White | |
| 17 | 3 | Engineering | White | X |

***Process***

The GLA was fully facilitated by the POWER in STEM team and followed the steps outlined by Vaughn and Lohmueller (2014)—climate setting, generating, appreciating, reflecting, understanding, selecting, and action. Before the participants arrived, POWER coresearchers set up the classroom we reserved by forming a large circle with the classroom chairs and posting the large sticky notes with prompts (25 total prompts; see Appendix) around the room on the walls. Figure 2 includes an example of a GLA prompt with answers. Upon arrival, participants signed in and received a study information sheet, in which participants were made aware that their participation was voluntary. The study information sheet also informed participants of the study information, research goal, and the protection of their identifying information. Snacks and beverages were provided for the participants.

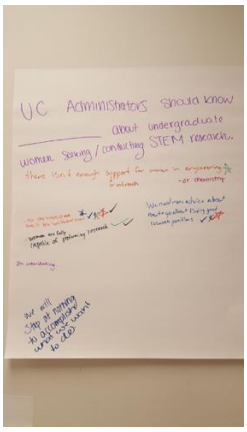


*Figure 2.* Example GLA Prompt

Once the participants arrived and settled in with food, the POWER coresearchers and I explained the GLA process and opened the floor to questions. First, we facilitated an icebreaker activity with participants for the purpose of climate setting and helping everyone feel comfortable engaging with one another. Next, a colored marker was distributed to each participant, and the generating phase began in which participants individually wrote responses to each prompt around the room. Following the generating phase, we instructed participants to take time to walk around and read the responses to each prompt in the appreciating portion. For the reflection phase, participants were given blank pieces of paper on which they could write or simply silently reflect upon the data. Following reflection, during the understanding portion of the GLA, participants were divided into smaller subgroups, were each given a set of three to four prompts to analyze, and were tasked to come up with three to four main themes they found across their assigned prompts. We then reconvened as a larger group, each subgroup shared their themes, and a few overarching themes were decided upon and discussed. Next, for the action step, the POWER in STEM team facilitated a discussion regarding how the experiences of women in STEM could be improved with program development; two coresearchers were assigned as notetakers during the open-ended discussion.

### *Qualitative Data Analysis*

Data analyzed from the GLA included the prompt responses, themes compiled by small groups and the whole group, as well as both my notes and those of the coresearchers taken during the discussion. Future Creating Workshop (FCW) data included written responses to the prompts, the themes uncovered in the group analysis phase, and notes on the discussion surrounding the creation of the hand-drawn pictures and diagram.

A first cycle coding of GLA data was conducted with the POWER in STEM group using Jackson's (2008) group analysis method, which utilizes thematic analysis techniques to code qualitative data on a collaborative group level. I compiled the textual data in a single document and cut out each distinct word/phrase/idea into a single line of text. I then increased the font size and cut out each individual line. As a group, POWER coresearchers spent an entire day sorting through this data

and conducting a thematic analysis. Coresearchers read the text on each strip of paper and began collaboratively sorting them into piles.

Once several piles were created, coresearchers consolidated some of them and came up with a name for each pile, writing these on small sticky notes, which became their themes. Next, coresearchers gathered their sticky notes with their themes and used them to create an image to demonstrate how the themes are related and interconnected (Figure 3). We then transferred the diagram onto a word processing document, which was used to create the first set of codes.

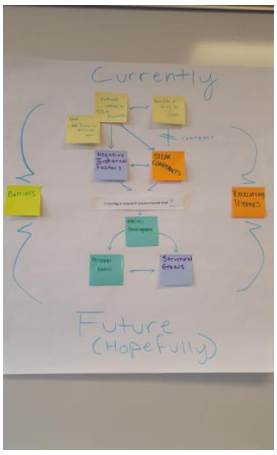


*Figure 3.* GLA Group Data Analysis

While the participatory group analysis technique was helpful for community participation and generated initial codes, additional time is needed for a more comprehensive coding of the data (Jackson, 2008). Therefore, I (author one) individually analyzed the data in a second cycle of coding using Dedoose, a qualitative coding software, using the six-phase technique for thematic analysis by Clark et al. (2015). I began by inputting the set of codes generated from the participatory analysis, and as I worked through the data, I updated and added to the initial set of codes as needed. The results of the second coding cycle were shared with the coresearchers to ensure trustworthiness in data reporting.

## Findings

Findings from the group data analysis included three overarching themes: (1) barriers to STEM and research participation, (2) support factors for STEM and research participation, and (3) desired future directions for programming. Table 3 includes a detailed categorization of themes, subthemes, and representative quotations.

Table 3
*Barriers, Support Factors, and Future Directions*

| Theme | Subtheme | Representative quote |
|---|---|---|
| Barriers to STEM and research participation | Social inequities | "Women work so much harder in classes in order to be equal to men." |
| | Lack of awareness | "I feel like I am not aware of all the research opportunities out there." |
| | Lack of diversity in STEM | "Most of my higher-ups are male." |
| | Lack of inclusivity | "Opportunities are created with the idea that they'll be given equally to men and women, but that's not what is." |
| Support factors for STEM and research participation | Passion for STEM and career goals | "I love learning about how the world works (and our bodies)." |
| | Perseverance | "We will stop at nothing to accomplish what we want to do." |
| | Research discovery and application | "I get to apply the things I learned in class in a practical way." |
| Desired future directions for programming | Research access and awareness | "Give us more accessible opportunities." |
| | Diverse mentors | "Mentors and students equal in diversity." |
| | Networking opportunities | "Seeing women weekly, teaching about the things I can do . . . I think I could actually get a job." |

## Barriers to STEM and Research Participation

The women indicated various barriers that impede their retention in STEM majors and participation in STEM research. These barriers include both internal and external pressures and can be broken down into the following four subthemes: (1) social inequities, (2) lack of awareness, (3) lack of diversity, and (4) lack of inclusivity.

### *Social Inequities*

The women described their experiences in STEM fields and in STEM research as being characterized by lack of support, on the part of their peers and professors alike. Some of the words the women described when interacting with their peers in STEM included "intimidating," "argumentative," and "frustrating." These challenges result in these women feeling an overwhelming "lack of support [from] classmates." The same sentiments were expressed in terms of lack of support from their professors, with one woman explaining that it was challenging "working with and under men that don't view [us women] as equal" and dealing with "not helpful professors." Another asserted that this lack of support results in struggles with "creating and maintaining relationships in a STEM field [with] professors, which is compounded with the issue of women viewing their teachers as "favoring male students" and giving their male peers more attention and support. Several of the women shared that professors had even discouraged them from pursuing STEM careers and research by "telling [us] not to do male stereotypical stuff."

There was a general sense among the women that while they are forced to fight for their place in STEM fields, men are simply expected to pursue STEM degrees. The women felt that males, particularly white males, are privileged in both STEM and higher education. The women explained that this privilege represented an innate double standard in STEM education, in which women feel as if they are "second-class citizens" and are treated as such. One of the GLA participants explained that because of her success in STEM, "People assume [I'm] male without [the] female name context." Another explained that "[men] can be ok by doing the bare minimum, but we have to do our best to be considered for the same opportunity."

In addition, the women expressed that they must work "twice as hard to try and be equal to men" and to succeed in STEM, just because of their gender; as one woman explained, "guys assume they can be okay and get opportunities; women know they have to be the best." Another woman stated, "sometimes it feels like girls have to step over people to get where you want to go," whereas men are simply handed these opportunities. During the GLA, when discussing whether it is possible to succeed in STEM as a woman, one participant suggested that "it is possible but as women we have to step over people and walk over people to get where we need to be," and another asserted that there is "nothing handed to us."

A consensus during the GLA discussion was that if women must work "twice as hard" to be successful in STEM, then minority women must work even harder to succeed because of their marginalization for both "gender and race." One of the GLA participants expressed that as a woman of color, she felt she had to prove herself more than her white female peers. Additionally, the issue of familial expectations for women in STEM frequently arose. One GLA participant described this feeling as "this endpoint that loom[s] over your career ending when you have kids." During the GLA, the participants listed off advice they were given by family, friends, colleagues, and professors throughout their pursuit of STEM degrees:

> "Oh, you can't be a doctor; how are you gonna start your family?"
> "If you don't have kids, you won't have fulfilled lives."
> "How are you going to raise kids? When are you going to start your family?"
> "How are you going to raise kids when you work in a hospital?"
> "This isn't a program where you can get married."

The women expressed frustration from hearing these pieces of advice, demanding, "chill about family life! Why is it always a family [or a] kids thing?" As one woman poignantly explained during the GLA discussion, "Please stop bringing up family life. We're here to talk about science."

### *Lack of Awareness*

The women also expressed a general lack of awareness that they and other women in STEM have, whether it be a lack of awareness about what they can do with a STEM degree, or a lack of awareness of research opportunities. One woman explained the "problem with research in general [is that] people don't know there is research in all fields." A GLA participant felt defeated because "[There] might be opportunities, [but] we don't know about them." In terms of seeking a job, a GLA participant expressed that many are unaware of the job possibilities that can be attained with a STEM degree:

> People are so unaware of the jobs you can get from STEM. You're always just finding stuff out, but you don't find out about it 'til you're here in college. And sometimes you find it too late.

Another woman pursuing a degree in psychology explained "people that go into psych have no idea what they can do other than clinical," which she felt contributes to "turnover" and "bad retention rates" of underclassmen in the major. The women observed an overall "lack of . . . knowledge [of opportunities]" available in both the research and job sectors. In general, the lack of awareness was attributed to the university's failure to disseminate information. Opportunities may exist but are "not highly advertised," and there is a consistent "lack of communication for opportunities" within individual STEM departments as well.

### *Lack of Diversity*

During the GLA discussion, one of the women asked the question, "Why is everyone male?" and another expressed feeling uncomfortable with "so few women" in her classes. By way of this discussion, the women expressed feeling isolated in an "unwelcoming environment with so many males" and explained this isolation led to a difficulty "feeling comfortable with so few women." Throughout the GLA, a marked lack of diversity in STEM was noted as a result of the women's experiences in their science courses and labs. During the GLA, a participant asserted that STEM is "a very patriarchal field," which caused several participants to explain that there is not only a lack of women in STEM, but that there are also "not many . . . minorities" both "in [our] classes, and in senior faculty." A few GLA participants pointed out that their identities as women of color led them to be subject to a greater amount of stereotyping than white women in STEM, and expressed the thought that "white straight guys with money have privilege. But you don't notice until you compare yourself to other people." These comments led to a discussion of privilege within the higher education system because, according to a GLA participant, "lack of diversity stems from privilege or lack thereof." Lack of diversity was a topic of conversation during the GLA as the participants delved deeper into the following "cycle"—a lack of diversity leads to fewer faculty mentors in higher education, which can negatively impact the retention and success of women and women of color in STEM majors.

### *Lack of Inclusivity*

The women cited the actual process of searching for research as a barrier in and of itself, especially in the lack of opportunity, inclusivity, and accessibility of UREs. Therefore, not only did the women feel there was a lack of knowledge of research opportunities as explained previously, but a "lack of opportunities for research" as well. Aside from a dearth of research opportunities available for undergraduates, women cited that the opportunities that do exist fail to be inclusive and accessible for women and women of color. The lack of inclusivity can partially be attributed to the idea that "research can be intimidating for women in STEM," but the women also felt that research opportunities are not made for women or women of color, and these "opportunities are created with the idea that they'll be given equally to men and women, but that's not what is." This absence of inclusivity also includes the types of research opportunities out there—one GLA participant expressed her frustration with "the lack of funding for research in 'literally insert any female condition here.'" Not only is it difficult to find research due to a marked absence of inclusive programs, but "access to opportunity" is also missing in current undergraduate research programs. One woman pleaded, "Give us more accessible opportunities!"

Lack of inclusivity also manifests itself in unrealistic expectations for women in STEM. The women felt they are faced with an unrealistic set of expectations in STEM, such as academic stressors, a competitive environment, and the burden of over-commitment, including their commitment to research. Concerning academic stressors, the women felt STEM classes are

portrayed as challenging with the perceived goal of "trying to get people to drop STEM." The women felt their academic course load is wrought with "difficulty and intimidation." Pressure from STEM fields being competitive is another source of stress for the women: "STEM in general is a very competitive field. Everyone is trying to better their resumes and gain valuable experience, but in turn is a very cut-throat field." Data analysis also revealed that over-commitment contributed to the unrealistic expectations women in STEM face, which includes a "push to be too involved [and] 'well-rounded'" in various activities, such as "school, work, [and] service." The pressure for involvement can lead to problems with time management and being stressed over not having enough time for all these commitments.

## Support Factors for STEM and Research Participation

The women identified several support factors that combat the aforementioned barriers. Participants indicated these factors positively impact their retention and success in STEM fields. These support factors can be broken down into the following three themes: (1) passion for STEM and career goals, (2) perseverance, and (3) research discovery and application.

## Passion for STEM and Career Goals

The women highlighted their interest in STEM and their future STEM-related goals being key support factors in their drive to pursue their degrees. During the GLA, the participants listed their motivation for participating in STEM, such as "My passion for biochemistry," "I am fascinated by the human brain," "I enjoy science as much as the next person," and "Science makes sense to me." Another woman explained, "I love learning about how the world works (and our bodies)." The consensus was "We have passion!"

In addition to passion for the sciences, the women cited career goals as another STEM motivator. Participants explained they desired a "promising career" and felt that pursuing STEM would lead to a career that is both "lifelong" and "fulfilling." One woman shared, "I want to apply my favorite subject to my career," and another agreed with her sentiments, explaining "I want to study and research it [science] for my future career." Another woman shared that she "wanted to be in a field where I will be able to work in different areas." Other participants described how they envisioned their future "practicing as a physician and conducting research," "helping others," and "being an insightful doctor helping as many people as I can." One woman enthusiastically exclaimed, "I want to make a difference!" and felt like she could accomplish this with a science career.

## Perseverance

"Proving [ones]self" was a main source of motivation, which could include "pursuing to make a difference in the world even when the world doesn't think you can!" In discussing perseverance

in STEM, participants explained that women "will stop at nothing to accomplish what we want to do" to begin "proving women can do just as good and/or better than men." Women in STEM do not hesitate to begin "putting [themselves] out there" to achieve their goals because "women are fully capable of performing research." One participant noted that "with experience, notice [that] women work much, much harder. Girls are present, they're engaged," while another asserted, "by sheer force of personality [women] can garner the same treatment from the bosses as they give to guys." GLA participants explained that "knowing I can do it" and "believing in myself" instilled confidence that helps them continue to be successful in STEM. They also offered advice to other women in STEM to help boost confidence: "never give up," "find your passion," "don't be afraid to make mistakes," and "don't be afraid to ask questions." A GLA participant explained that this perseverance leads to "[knowing] I am strong [and] smart enough," which makes her feel confident in herself and her abilities.

## Research Discovery and Application

While the process of searching for research opportunities is a barrier, participating in research acts as a support factor, with participants valuing an experience where they can "get a glimpse of research" currently happening in the field. Participants used words about "conducting research on topics that matter to me" that included "mind-opening," "enlightening," "fun," "exciting," and "stimulating." GLA participants valued the experience of gaining knowledge through research, with one woman explaining that research gives women the opportunity to "take in as much as you can, [to] learn and gain experience." A GLA participant felt that "women are finally crawling out [of] the hole, pursuing the knowledge, even though we already had the knowledge," and that research gives women the opportunity to "becom[e] knowledgeable in such an important field." The women also indicated that research helps them better understand the scientific world to "gain knowledge every day that helps me understand the world around me" and the chance to "learn . . . different things about the world."

One woman explained that conducting research has helped guide her in her STEM career path by "learning if research is what I really want to do." In addition to learning and building knowledge beyond their STEM coursework, the women also described themselves as being inspired by the opportunity to gain "tactile experience, hands-on" in research in the form of "apply[ing] the things I learned in class in a practical way." Participants stressed the importance of being able to "apply our knowledge [and] develop our skills." The women discussed the "possibility of hands-on learning" through research, which provides them with the chance to "apply the skills acquired in STEM to other areas" and engage in "experiences that can be used in the real world." One GLA participant expressed that research is enjoyable for her because it involves "seeing what I've learned [in classes] in action," with another agreeing that with research "I get to apply the things I learned in class in a practical way." The women agreed they "enjoy doing work that is hands-on."

## Desired Future Directions for Programming

The women expressed several desired directions and offered suggestions for future programming within the university as they considered both barriers and support factors. Recommended programming included four main types: (1) research access and awareness, (2) diverse mentors, and (3) networking opportunities.

### *Research Access and Awareness*

Given the importance of "having those resources and [research] opportunities available" to women and women of color in STEM, GLA participants gave some examples for how access to UREs could be improved. For example, implementing "a consistent website or newsletter from the university that could give a package of information for STEM" would allow everyone to have access to and find research opportunities. They also expressed needing access to a variety of opportunities, given the misconception that research must be in a lab. In particular, the women asked for "non-medical opportunities," "community-based research opportunities," and "encourage[ing] research in our community." "Give us more accessible opportunities," one of the GLA participants pleaded. Another GLA participant reflected that it is "not just access but awareness" of what research opportunities exist for undergraduates.

A GLA participant expressed her frustration with the lack of awareness: "We just want to know things, opportunities, conferences, jobs, knowing what you can do with your major. It just comes to knowledge." The women agreed that having other women who are professionals in the field connect them with opportunities would be an ideal program because "knowing that women are researching, that they and you are contributing, and knowing you can give back. Having a person to bridge us to opportunities would help you tremendously." Another participant described a program that could model "career day" in elementary school: "it feels like the things a kid [experiences] when your parents would come to your class, and someone's mom had really cool jobs. It suits, talking about what they did. It was eye-opening." The need to see model women in STEM leads directly into the next theme, a need for improved mentorship in undergraduate research programming.

### *Diverse Mentors*

The women agreed that the problem with current UREs is that "mentors are now being found by happenstance," and argued, "departments in STEM should designate an office or faculty members" to organize "one-on-one mentoring." They agreed that organizing mentorship should be departmental, with more "accountability in the departments to sign up for mentoring." A GLA participant envisioned a program as involving mentoring others themselves, where "we get mentored by professionals, then we mentor [high school] students. A trickle-down effect."

Not only do the women want individualized mentorship, but they also want mentors who represent diverse career status and demographics. The women came to a consensus that mentors should include professors, peers, and professionals in the field to encompass a diverse set of mentors: "Have women from all different fields. Have a network of mentors based on interests, paired with mentors with the end goal/career" that would involve "having women of higher positions that could mentor and give advice on how they got there," such as in education or business, as opposed to just academia or medicine. The women felt that it is "also [important] for mentors to not simply have graduate degrees; have mentors from all perspectives of degrees." They agreed: "mentors should be diverse, with different levels of education, even entry level [than] . . . way higher upper-level people," and "it is important to see older women especially, not ones who are just starting."

The women also want "mentors and students equal in diversity" because "you don't doubt you can do it when other people do it; it feeds into your knowledge." The value of having female mentors and female mentors of color means mentors are "easier to relate to . . . on a personal level" and leads to "the realization that woman can do this." One woman reflected that "you don't know it's there until you see someone [like you]" in the career you envision yourself in. Several of the GLA participants pointed out that while "female mentors can give you opportunities or outlook on their previous experiences," it is especially important for women of color to have mentors who are also underrepresented women. They felt that having mentors who are women of color would allow undergraduate women to "get advice about adversity," including "warn[ing] me about potential pitfalls," and learn "about their experiences" as a woman and "as a minority." The women agreed that having "women to look up to" helps with networking in the workforce because "learning how to market yourself as a woman . . . is completely different than marketing yourself as a man."

### *Networking Opportunities*

A diverse set of mentors "connecting me with people like me in my field" is an ideal networking opportunity for "getting your foot in the door, talking to other people" as it leads to "the realization that women can do this." A GLA participant expressed that "seeing someone else's passion, where they found passion, listening to other people with their passions, it's inspiring." Another GLA participant explained:

> Just seeing those women talking to you, it builds. Weekly, teaching you, investing in you, believing in you. Teambuilding, working together. Realizing our commonalities, helps understand what's going on in the field.

The women discussed that networking events could be in the form of mentored meetings in which professionals and professors "talk about different life skills" that could lead to job preparation: "seeing women weekly, teaching about the things I can do, and about myself, not only will I be confident in my classes, but I think I could actually get a job." The participants envisioned this networking potentially leading to opportunities in which "mentors send you opportunities that applies to your interests," such as "telling me about conferences or projects I can be a part of."

They felt that mentorship aids in the job search by "connecting you with potential employers" and "hav[ing] goals in mind," which could include resume building, teaching job skills, and explaining how to go about "putting yourself into the field."

## Conclusion

The current study explored the barriers and support factors for women regarding STEM and research participation, as well as programmatic changes that could be made to improve their participation. GLA participants indicated several barriers that impede their participation both in STEM and in undergraduate research. These barriers include a general lack of support from peers and professors, as well as being hindered by unrealistic expectations for women in STEM. The women indicated that not only do they feel a lack of awareness of research opportunities, but their search for existing research opportunities can also be difficult. Finally, both social inequalities and internal barriers serve as constraints for the retention of women in STEM and their participation in research.

GLA participants and POWER coresearchers felt that although there are several barriers that impede their STEM and research participation, several support factors are present as well, which encourage them to pursue STEM degrees. These support factors include their STEM motivation, including their interest in STEM and STEM- related goals. Internal strengths, such as confidence and self-efficacy, promote STEM retention. Finally, the actual act of participating in research is fulfilling and motivating.

Considering both barriers and support factors, participants highlighted several suggestions for future programming to support women in STEM at the university-level, such as improving pedagogical practices. Another suggestion for future programming surrounding undergraduate research involves participants wanting to see programs that are not only accessible but also advertised widely to promote undergraduate research awareness. Mentorship was also brought up as a key aspect of creating programming for undergraduate women and women of color in STEM.

The POWER in STEM team expressed interest to delve into their personal experiences in STEM. The POWER in STEM team chose to not only explore the experiences of GLA participants but also to study their own experiences as women in STEM. Coresearchers decided they would like to use the GLA findings to inform their own self-study and chose to use three participatory data collection methods: FCW, Photovoice, and collage inquiry. Other methodological options we discussed as a group that they did not choose included focus groups, interviews, and poetry. Findings from the GLA prompts and discussion informed the questions and problems explored in the three methods.

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## Appendix: Group-Level Assessment Materials

The following materials include the group-level assessment (GLA) recruitment email, prompts implemented during the GLA, and the study information sheet given to participants before the GLA process began.

### Group-Level Assessment Recruitment Email

Hello,

My name is [redacted], a doctoral student in the Educational and Community Based Action Research program, and I am emailing you on behalf of our participatory research team. We are conducting a research project looking at the experiences of undergraduate women conducting STEM (science, including social sciences, technology, engineering, and mathematics) research at the University of Cincinnati, with the hopes of using this data to develop future undergraduate research programming.

We are looking for participants to engage in a GLA (group-level assessment), a qualitative, participatory research method. GLA is a very fun and interactive process—you will get the opportunity to meet like-minded women, learn about a new research tool, and eat ***free food***! For those of you who participate, you will be entered into a drawing to win a **$25 Amazon gift card**.

If you are interested in participating, please fill out the following BRIEF survey: [redacted].

We are all very passionate about this research project and hope you will agree to assist us in gaining knowledge that could benefit YOU! If you agree to participate, we will follow back up with you about dates and times.

Thanks!
[redacted]

### Group-Level Assessment Prompts

1. What I love about conducting research in STEM:
2. What I hate about conducting research in STEM:
3. Being an undergraduate woman conducting research in STEM means . . .
4. Searching for research positions in STEM is _____.
5. If undergraduate women conducting STEM research had a spirit animal, it would be a . . .
6. The university needs to change _____ to support undergraduate women in our STEM research experience.

7. The university needs to stop doing _____ to support undergraduate women in our STEM research experience.
8. The university needs to keep doing _____ to continue to support undergraduate women in our STEM research experience.
9. I wish I had more _____ as an undergraduate woman seeking/conducting research in STEM.
10. I wish I had less _____ as an undergraduate woman seeking/conducting research in STEM.
11. What I envision about my future in STEM research:
12. If I could give other undergraduate women researchers in STEM one piece of advice, it would be_____.
13. If I could give undergraduate women who are seeking research opportunities in STEM one piece of advice, it would be_____.
14. Words that describe my encounters with my peers in STEM research settings are . . .
15. My research mentors can support me by_____
16. I chose an area of study/research in STEM because_____.
17. Something that almost prevented me from pursuing STEM research opportunities:
18. Something that motivated me to pursue STEM research opportunities:
19. Factors that support finding an undergraduate research position in STEM include . . .
20. Factors that inhibit finding an undergraduate research position in STEM include . . .
21. The most challenging part about being a woman conducting undergraduate research in STEM is . . .
22. The best part about being a woman conducting undergraduate research in STEM is . . .
23. A program for undergraduate women seeking research in STEM fields should include:
24. A program for undergraduate women conducting research in STEM fields should include:
25. Administrators at UC should know _____ about undergraduate women seeking/conducting research in STEM.

**Group-Level Assessment Study Information Sheet**

**STUDY INFORMATION SHEET**

*Group-Level Assessment (GLA) with Undergraduate STEM Women Researchers*

**INVESTIGATOR INFORMATION**:

| | | | |
|---|---|---|---|
| [Primary Investigator] | Jessica | Emma | Tracie |
| Alice | Molly | Natasha | |

**STUDY INFORMATION:** Qualitative data collection will be conducted via group-level assessment (GLA), a large group participatory method within Action Research. Action Research draws upon participatory and reflective practices to engage communities as active partners in identifying and investigating issues with the goal of achieving positive social change.

***Your participation and responses will remain anonymous.****

**RESEARCH GOAL:** We are working on a project exploring the experiences of undergraduate women conducting or seeking STEM research at the University of Cincinnati. Our research goal

is to identify and explore some of the success factors and barriers that exist so we can make recommendations to UC in order to improve future program development.

**DEMOGRAPHIC INFORMATION:** We are asking for demographic information on the sign-in sheet (i.e., which STEM field you are involved in). Identifying information will not be published and names/emails will not be used for any purposes other than contacting you for future studies, as well as to select a winner for the gift card raffle.

**PHOTOGRAPHY:** We will be taking photographs for the purposes of documenting our research and process via an e-portfolio. Your likeness will not be published, and we will take the photographs so they do not include faces. If you do not wish to be included in any photographs, please let us know.