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Long Term Benefits for Women in a Science, Technology, Engineering, and Mathematics Living-Learning Community

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Abstract
Science, technology, engineering and math (STEM) degrees provide opportunities for economic mobility. Yet women, underrepresented minority (URM), and first-generation college students remain disproportionately underrepresented in STEM fields. This study examined the effectiveness of a living-learning community (LLC) for URM and first-generation first-year women interested in STEM. The authors utilized a matched sample post-hoc analysis to examine undergraduate and graduate degree attainment in science related fields for women who participated in the Women in Science Residence Program (WISERP) LLC compared to matched controls. The control group was matched on twelve characteristics that are associated with retention in STEM. First-generation college students in the LLC were significantly more likely to receive an undergraduate degree in science; URM students were more likely to receive an undergraduate degree in a science related field, nearly three times as likely to receive a master's degree in science and more than three times as likely to receive a graduate degree in science compared to their matched controls. The results indicate that a one-year intervention can meaningfully impact persistence of at-risk populations in attaining STEM bachelor's degrees and in enrolling in STEM graduate programs and invite further investigation into the factors contributing to the beneficial impact of LLCs.

Keywords
STEM, first-generation, underrepresented minority, women, living-learning

Cover Page Footnote
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Background

Pursuing a degree in a science, technology, engineering and math (STEM) field provides students opportunities for economic mobility. This can be particularly important for students who are in disadvantaged populations, such as those who are the first in their family to attend college or those from underrepresented minority groups. Over the last decade, the supply of qualified candidates to fill job openings in STEM fields has not met the growing demand from employers for skilled STEM workers (Langdon, McKittrick, Beede, Kahn, & Doms, 2011; Change the Equation, 2015). Not only is the number of STEM job openings plentiful and increasing but workers in STEM earn higher salaries and are less likely to be unemployed (Langdon et al., 2011). Earning a STEM degree therefore offers first-generation college students and students from underrepresented minority groups a potential path to economic success.

While colleges and universities acknowledge the need to attract women and underrepresented minority and first-generation college students to STEM disciplines, representation from these groups in STEM degrees remains very low. Black, Hispanic, and Native American women are particularly underrepresented in STEM fields, accounting for only 11% of STEM bachelor's degrees and 6% of enrollees in STEM graduate programs in 2012 (National Science Foundation, 2015a; National Science Foundation, 2015b). Prior research has described the challenges of recruiting and retaining women and minorities in STEM majors and careers, for instance, that aspiring female scientists and engineers feel isolated, interact with few role models, and experience a hostile climate in the classroom (Gayles & Ampaw, 2011; Clewell & Campbell, 2002; Johnson, 2011).

In addition, students who are first-generation in college face a variety of unique challenges in accessing and persisting in degree programs generally and are at much higher risk for failing to earn a degree. Only 28% of students who are the first in their family to attend college earned a bachelor’s degree in 4 years, compared with 42% of students who have at least one parent who attended college (DeAngelo, Franke, Hurtado, Pryor, & Tran, 2011). First-generation college students are also underrepresented in STEM majors and graduates (Engle & Tinto, 2008). Financial struggles, lack of parental guidance, and less rigorous high school preparation all contribute to the low retention rates for first-generation students (Pascarella, Pierson, Wolniak, & Terenzini, 2004).

Living-learning Communities

As colleges and universities search for strategies to increase representation of women from marginalized groups (first-generation college students and underrepresented minority students) in STEM fields, Living-Learning

Communities (LLCs) represent a promising approach. LLCs offer college students an environment that supports their social, academic, and career interests. Much of the prior research on LLCs originated with the National Survey on Living-Learning Programs (NSLLP), which defines LLCs as "programs in which undergraduate students live together in a discrete portion of a residence hall (or the entire hall) and participate in academic and/or extracurricular programming designed especially for them" (Inkelas, Szelenyi, Soldner, & Brower, 2007).

Most LLCs serve first-year students and work to support those students in their transition to college. Students who participate in LLCs experience positive impacts on their transition to college, campus engagement and academic performance (Inkelas et al., 2007). Participation in an LLC also leads to increased sense of belonging, particularly for students in STEM fields. (Hausmann, Schofield, & Woods, 2007; Spanierman et al., 2013). Spanierman et al. (2013) found that students who participated in LLCs felt a greater sense of belonging in their residence hall, as compared with non-participants. Specifically, women in a STEM-focused LLC had the greatest sense of belonging, which they attributed to feeling socially and academically supported by other women in STEM. In particular, students who identify as underrepresented minorities (Black, Hispanic or Native American) and students who are the first in their families to attend college demonstrate increased benefits from participation in a living-learning program. The demonstrated positive impacts of LLCs on the student experience have led colleges and universities to include LLCs as one component in their efforts to improve student retention and graduation.

Research on LLCs has generally focused on short term outcomes, often measured at the end of the year a student participated in the program, typically the end of their first year in college. There is strong evidence that participation in LLCs produces a myriad of positive outcomes for students at the end of their first year, including smoother academic transitions to college and higher levels of engagement with academics and the institution (Inkelas & Weisman, 2003; Inkelas et al., 2007). In turn, researchers have found connections between students' sense of belonging to their institution and their persistence in college (Hausmann et al., 2007; Hurtado & Carter, 1997). Living-learning programs have also demonstrated a positive impact on the quality of peer interactions and students' sense of social support (Soldner, Rowan-Kenyan, Inkelas, & Garvey, 2012). The literature on retention of women in STEM degrees suggests that frequent interaction with faculty and peers, career exploration and planning, and sustained engagement with faculty and professional role models are associated with retention in STEM majors (Astin & Astin, 1992; Buck, Clark, Leslie-Pelecky, Lu, & Cerda-Lizarraga, 2008; Seymour & Hewitt, 1997). Academic conversations with peers also lead to greater interest in pursuing a STEM career (Soldner et al., 2012). Additionally, research on retention of first-generation college students has found engagement with the institution and

peers and participation in extracurricular activities are beneficial for first-generation students (Pascarella et al., 2004). Taken together, these bodies of research suggest that participation in an LLC has the potential to increase retention for women, underrepresented minorities, and first-generation college students pursuing STEM majors. However, no direct evidence yet exists to establish this relationship.

The most relevant prior research is an investigation of participation in a STEM-focused LLC on women's plans to attend graduate school. Szelenyi and Inkelas (2011) analyzed data from the 2004-2007 NSLLP, a longitudinal study of living-learning programs at multiple institutions. NSLLP data were collected from students at 16 institutions during their first (2004) and fourth (2007) years. Women pursuing STEM majors lived in one of four residential settings as first-year students: (1) a female-only STEM LLC, (2) a coeducational STEM LLC, (3) a non-STEM LLC, or (4) a traditional residence hall. The study compared the female students pursuing STEM majors across these four residential experiences and found that women who participated in a female-only STEM LLC were significantly more likely than any other group to report an intention to attend graduate school in STEM fields.

Our study aims to build on the findings of Szelenyi and Inkelas (2011) by going beyond intention and investigating the impact of participation in an LLC on attainment of STEM bachelor's degrees and enrollment into STEM graduate programs. Examining the outcomes for students who participated in the Women in Science and Engineering Residence Program (WISE RP) at the University of Michigan, allowed us to explore the long-term impact of LLC participation, particularly for the students least likely to persist in a STEM field—women who are first generation and/or from underrepresented minority groups.

The Women in Science and Engineering Residence Program

The Women in Science and Engineering Residence Program (WISE RP) was implemented at the University of Michigan in 1993, with the goal of supporting and retaining women in STEM fields. WISE RP is a residential community for first-year students with an expressed interest in pursuing a STEM degree. Initial evaluation of the impact of WISE RP found the program had positive short-term outcomes for the women it served (Davis & Hummel, 1996; Hathaway, Sharp, & Davis, 2001). The impact of participation in the program on long-term outcomes, including retention in STEM majors and persistence to graduate school in STEM, has not been previously measured.

WISE RP is one of six LLCs at Michigan focused on first-year students. An assessment effort involving these programs in 2013 and 2014 confirmed that students participating in one of these first-year LLCs at Michigan reported gains in learning outcomes and achieved higher GPAs than those students who lived in

University Housing but did not participate in an LLC. Participants who identified as underrepresented minority students and/or first-generation college students demonstrated stronger benefits than the participants as a whole. These findings were consistent with prior research on LLCs.

Program Components

While program components have changed over time, the foundation of the program has remained consistent: a supportive peer community, academic and career resources, mentoring, and community building activities. Students in WISE RP live together on the same floor(s) of a residence hall, providing participants with a supportive community of other women with similar academic and career goals. The women in WISE RP are enrolled in similar introductory STEM courses and thus share the experiences of completing academically demanding and time-consuming courses. Participants also interact with a critical mass of women in STEM majors, helping to combat the isolation women may feel in predominantly male courses. Having a supportive peer community of women in STEM majors as neighbors, study partners, and friends is a key element of the WISE RP.

Academic and career support is also a vital asset to WISE RP students. WISE RP offers formal peer-facilitated study groups for all introductory STEM courses. These study groups meet in the residence hall where WISE RP women live and are scheduled around the availability of women interested in attending the group. Beyond the formal study groups, women in WISE RP form their own informal study groups that meet both regularly and on an ad-hoc basis in lounges and student rooms. For students who need additional support, WISE RP also offers individual tutors for STEM courses. WISE RP hosts a mix of required and optional career workshops, company visits, and talks by women working in STEM fields in the residence hall. These events allow WISE RP members to meet female role models working in STEM fields, explore possible careers, and learn from the paths other women have taken. The combination of formal and informal study groups, tutoring, and career events creates a strong academic environment in the residence hall community.

Both professional and student staff support students in WISE RP. The half-time Program Director assumes leadership for the program, including instructing the common course, holding office hours, and providing informal academic advising and counseling for program participants. The full-time Associate Director manages the day-to-day operations of the program and meets individually with every program participant each semester to discuss academic, social, and transition goals and to connect the student with appropriate resources. Five residence advisors (RAs), former participants in WISE RP, live and work with WISE RP students. The WISE RP RAs provide support beyond that of a traditional RA, including meeting individually for a minimum thirty minutes with each resident each semester and

offering programming focused on issues relevant to women in STEM fields. Finally, approximately thirty WISE RP students who continue in the program as sophomores serve as Peer Mentors. Each Peer Mentor supports three to four first-year students in WISE RP, from their initial transition to college through their last final exam of the year.

WISE RP students benefit from robust relationships with their peers and a strong identification with the WISE RP community. Student leaders and staff plan community building activities to strengthen bonds between participants and enhance the network of social support. These include a few required community-wide events, such as a low-ropes course during the first weekend of the academic year, an event aimed at team building as well as improving leadership and communication skills. In addition, many optional social and community service events are planned by student leaders throughout the year. Examples of community building activities that are offered in the residence hall include game nights, ice cream socials, and making cards for veterans. At least one community building activity is available to WISE RP students each week; these are well attended by program participants. The community building activities in WISE RP supplement the STEM-focused programming, strengthen relationships among participants, and build connections to the community.

The program structure and content have evolved over time to include more focused and structured academic support. One recent addition to the program is a required course for all first-year students. Beginning in Fall 2008, in addition to their other courses, the approximately 100 first-year students in WISE RP enrolled in a one-semester common course, “STEM Challenges/STEM Successes,” taught by the Program Director. The course was expanded to two semesters beginning in Winter 2012. These one-credit courses allow women to explore factors that influence persistence of women in STEM and to develop personal strategies for combating challenges to their persistence. In addition, the course exposes WISE RP members to female role models working as faculty, graduate students, and professionals in STEM fields.

Research Question

The purpose of this study was to examine whether or not there were long-term benefits to participation in WISE RP for students who identify as underrepresented minority students and/or first-generation college students. Specifically, the study investigates whether underrepresented minority and first-generation women who participate in a female-only STEM LLC received more STEM undergraduate and STEM graduate degrees. Participants were compared to matched controls from the same institution.

Methodology

The University of Michigan is a large, primarily residential, public institution. The Carnegie Classification of Institutions of Higher Education (2015) identifies it as a full-time, four-year selective research university with a high graduate student coexistence and a very high research activity. In 2014, the total student population of 43,625 was comprised of 28,395 undergraduate, and 15,230 graduate and professional students (University of Michigan Almanac, 2015). In 2004, 21,293 students applied for first-year admissions; 13, 304 admissions offers were made, with a first-year enrollment class of 6040. Approximately 5 to 6% of first-year students are first-generation college students, and 21% are an ethnic or racial minority. Approximately 50% of students who receive a bachelor's degree are enrolled in a graduate or professional school within four years of graduation (University of Michigan Almanac, 2015).

For this study, our goal was to create matched controls between WISE RP students and similar students who were not participating in the LLC. We considered both pre-college and in-college attributes as we designed the study. Pre-college and college demographics were obtained for all undergraduate students at the University of Michigan from 2004 to 2010 from the University Data Warehouse. The University Data Warehouse contains pre-college and college data from Student Records and can be queried by University of Michigan faculty. We chose 12 attributes to use to create the matched controls. These 12 attributes included pre-college factors such as race, gender, ACT score, parental income, and parental education levels as well as college factors such as participation in the Honors Program and the Undergraduate Research Opportunity Program (UROP). (See Table 1 for a description of each of the 12 attributes.) Students were considered first-generation college students if they reported that their parents did not attain at least a bachelor's degree. Students whose parent or parents received associate degrees were included as first-generation college students. Students were considered an underrepresented minority (URM) if they reported their race to be Black, Native American, or Hispanic.

In order to assess interest in majoring in a science-related field, we utilized data from two sources. The College of Literature, Science, and the Arts (LSA) is the largest of the colleges at the University, and all LSA students are required to complete an Academic and Planning Interest survey at the beginning of their first-year. In this survey, students identify up to four areas in which they are interested in majoring. Consensus decision making was employed between the authors to identify 25 majors as being science-related. For the purposes of our analysis, Social Science majors were not considered science-related. Selecting any of the 25 majors was used as a proxy of interest in majoring in a science program and became an additional attribute that was used to create matches to the WISE RP students. In

addition, students in the College of Engineering were matched to controls also in the College of Engineering.

The general method used was a matched sample post-hoc analysis. In general, this method compares a sample of interest that has engaged in a "treatment" to a quasi-control sample that has similar attributes but did not engage in the treatment (e.g., was not enrolled in a learning community of interest) (Brooks, Chavez, Tritz, & Teasley, 2015). This method is different from—but similar to—propensity score matching: in propensity score matching, the attributes that describe a learner are reduced to a unitary value describing the propensity at which a learner might engage in the treatment. In a matched sample analysis, each attribute is considered independently, and best matches for a treatment learner (a learning community student) and a non-treatment learner (a non-learning community student) are made without replacement. The end result is a list of pairs of students who can be compared using pairwise methods such as paired t-tests. We used the toolkit described in Brooks et al. (2015) for the matching process. For each WISE RP student, we generated a matched control student who was enrolled in the same academic year as the WISE RP student. Matching was done across the variables described in Table 1 and, while matching across this number of attributes is unlikely to be perfect, we measured the quality of the matched control using the Kolmogoroff-Smirnov test statistic.

Table 1:
Description of Attributes Used to Match WISE RP and Control Group Students

Attribute	Values	First Generation		URM	
		WISE RP	Matched Control	WISE RP	Matched Control
General					
Sex (self-reported)	Female	81	78	69	67
	Male	0	3	0	2
Ethnic Group (self-reported)	Asian	1	1	0	0
	Black	13	15	40	42
	Hispanic	5	1	27	26
	Native American	1	0	2	1
	Other	4	3	0	0
	White	57	61	0	0
Citizenship Status (self-reported)	US Citizen	77	78	67	67
	US Permanent Resident	2	1	2	2
	Non Resident	2	2	0	0

Parental Education (self-reported)	High School Diploma	28	27	8	6
	Associate	31	30	6	3
	Some College	22	24	5	5
	Nursing Diploma	0	0	0	0
	Bachelor	0	0	19	22
	Masters			15	19
	Doctorate	0	0	10	7
	Prof Doc	0	0	6	5
	Post doc	0	0		1
	Don't know	0	0	0	0
	No value given	0	0	0	1
Parental Income (self-report Likert scale)	<25,000	7	7	7	7
	$25,000 - $50,000	17	17	7	6
	$50,000 - $75,000	18	20	10	8
	$75,000 - $100,000	13	12	2	4
	> $100,000	10	7	16	18
	No value given	12	14	21	23
	Don't know	4	4	6	3
Pre-college attributes					
Credit Hours Achieved: The number of pre-college credit hours a student has at the time of enrollment*		6.69 ±7.49	5.44 ±7.70	8.52 ±9.38	7.33 ±8.63
ACT Score: ACT score of the student. If the student took the SAT, this score was converted to an equivalent ACT score using the formula described at www.act.org/solutions/college-career-readiness/compare-act-sat/.*		28.20 ±3.24	27.50 ±2.40	26.41 ±3.29	26.23 ±3.53
Summer Bridge Program: Participation in the pre-matriculation summer bridge program at the University of Michigan. This is a summer program for under-prepared students, identified as being at-risk for success at the University. (see www.lsa.umich.edu/csp/studentprograms/summerbridgeprogram).	Yes	7	7	9	10
	No	74	74	60	59

College attributes					
Academic College: The academic college the student had enrolled in	College of Literature, Science and Arts	40	45	33	42
	College of Engineering	39	34	35	23
	Kinesiology	2	2	0	1
	Nursing	0	0	1	1
	Art and Design	0	0	0	1
Participation in the Undergraduate Research Opportunity Program (UROP): The UROP program creates research partnerships between undergraduate students and researchers at the University. Students apply for this program.	Yes	26	20	23	22
	No	55	61	46	47
Honors Program Enrollment: Whether the student is enrolled in the LS&A Honors program (see www.lsa.umich.edu/honors).	Yes	2	1	1	1
	No	79	80	68	68
Comprehensive Studies Program (CSP) Enrollment: Participation in this program intended to provide academic guidance in order to retain students. All students who participated in the Summer Bridge Program are in CSP (see www.lsa.umich.edu/csp).	Yes	15	15	28	28
	No	66	66	41	41
LS&A Academic Planning and Interest Survey: All students in the College of LS&A are required to complete this survey prior to meeting with their academic advisor					
Student interest in majoring in science field: Students were asked to identify up to four different areas of interest from a list of 75 programs. Consensus decision making was employed between the authors and 25 programs were identified as being science-related. Social Science majors were not considered science-related. Selecting any number of these programs was used as a proxy of interest in majoring in a Science program.	Yes	26	26	16	16
	No No response includes students who did not complete the survey (e.g. because they were a student in the College of Engineering, rather than LSA)	55	55	53	53

* data reported as mean ± standard deviation

Undergraduate degree attainment in general and, more specifically, students' attainment of an undergraduate degree in a science-related field were obtained from the University Data Warehouse at the University of Michigan. Information about graduate school enrollment and graduation was obtained from National Student Clearinghouse data, a service that provides transcript history of learners across institutions. Participants in this service include 3600 colleges and universities enrolling 98% of students in public and private US institutions. This data warehouse includes data on graduate and professional degree program enrollment and degree attainment (National Student Clearinghouse, 2015). We investigated whether students in our study received a graduate degree in a science-related field and whether the student received a Master of Science. Statistical analysis was performed with paired two-tailed t-tests. IRB exemption was obtained from the University of Michigan for all aspects of this study.

Results

Of the total of 664 students who participated in WISE-RP from 2004 to 2010, National Student Clearinghouse Data was available for 568 (85%). Matched controls were made for these 568 students. The quality of the matches across a given attribute was tested using the Kolmogoroff-Smirnov test statistic. This statistic describes the difference between two distributions for each attribute (e.g., the ACT scores of the learners who were in the learning community and the ACT scores of the matched control). None of the matched controls were found to be statistically significant from the WISE RP students at the $p=0.05$ level.[1]

First, we performed an analysis that compared all of the 658 WISE RP students to their matched controls. In terms of completing an undergraduate degree in science, Masters in science, or graduate degree in science, there were no statistically significant differences between the whole WISE RP population and the matched population. We then examined the URM and first-generation subset of students within the 658 WISE RP students. Sixty-nine of the WISE RP students (12%) self-identified as URM and 81 (14%) as first-generation college students. First-generation college students in WISE-RP were significantly more likely to receive an undergraduate degree in science. Sixty-three of the 81 first-generation WISE RP students (77.8%) received an undergraduate degree in science compared to 45 of the 81 (55.6%) matched controls ($p=0.001$). However, first-generation

[1] In particular, applying the Kolomogoroph Smirnov test on a year-by-year basis, comparing the students in the learning community to those who were not enrolled in the learning community, did not produce any statistically significant deviations for any of the attributes listed in Table 1. Thus, the distributions for each attribute (e.g. gender, ethnicity, ACT score) are similar between our population of interest (the learning community students) and the post-hoc matched sample (students who did not enroll in the learning community). This suggests that the matches are, as far as the attributes described in Table 1, an appropriate comparison population.

WISE RP students did not receive more Masters or graduate degrees in science than their matched controls did. In contrast to the first-generation college students, URM students in WISE-RP received significantly more undergraduate degrees in science; they also received more Masters of Science and graduate degrees in Science than their matched controls. Most striking, 16 of the 69 URM students in WISE RP received a graduate degree in Science compared to 5 of the 69 matched control students. These 16 graduate degrees included three Masters of Science in Engineering, three Masters of Sciences, two Masters of Public Health, one medical degree, and one doctor of pharmacy.

Table 2:
Undergraduate and Graduate School Degree Attainment for URM Women in WISE-RP, from 2004 through 2010 Compared to Matched Controls.

	First Generation Students			URM Students		
	WISE RP n=81 (%)	Matched Controls n=81 (%)	p	WISE RP n=69 (%)	Matched Controls n=69 (%)	p
Undergraduate Degree In Science	63(78%)	45 (55%)	0.0016*	57 (82%)	35 (51%)	<0.0001*
Master's Degree in Science	15 (19%)	10 (12%)	0.2274	12 (17%)	4 (6%)	0.0447*
Graduate Degree in Science	18 (22%)	13 (16%)	0.278	16 (23%)	5 (7%)	0.0106*

*indicates significance at a 0.05 level

Discussion

This study presents compelling evidence of long-term benefits for first-generation and URM women who participated in a first-year STEM LLC. First-generation students who participated in WISE RP were more likely to receive an undergraduate degree in a science-related field than their matched controls. Furthermore, URM students who participated in WISE RP were more likely to receive an undergraduate degree in a science-related field, nearly three times as likely to receive a master's degree in science, and more than three times as likely to receive a graduate degree in science compared to their matched controls. This study adds to the existing literature by demonstrating significant long-term impacts for students in a first-year LLC.

As highlighted earlier, the primary interventions of WISE RP during this period were co-curricular in nature: providing a supportive peer community, academic and career resources, and mentoring. We postulate that each element of the WISE RP intervention, as well as the overall environment offered by the

community, had positive influences on the URM and first-generation women's persistence. In particular, the study supports the importance of the peer and residential support offered by WISE RP and, importantly, demonstrates that the benefits continue past their undergraduate experience. As one alumna from the program explained:

> I can honestly say living in WISE RP had a very positive influence on my time in college and set me up for success after college. Starting off in college was not an easy transition for me, but living with other women who were in the same STEM courses and dealing with the same issues as me helped to make the transition easier.

Another student's comment illustrates the importance of the social supports:

> I always knew I had a "safe haven" to turn to at the end of the day. Caring supports were always accessible. It was nice to be among other women with similar goals, drive, and passion. We uplifted each other and learned from each other in a variety ways.

These two representative quotes illustrate the importance of peer support for academic success for women in the program.

Taken together, these co-curricular interventions build a supportive environment that contributes to students' sense of belonging and formation of scientific self-identity. Prior research has linked a sense of belonging to successful adjustment and persistence in college students (Hausmann et al., 2007; Ostrove & Long, 2007). Similarly, the growth of a scientific self-identity has been proposed to have a positive effect on achievement for URM students in STEM (Hernandez et al., 2013). WISE RP women are able to identify themselves as members of a science and engineering community at the onset of the undergraduate experience, enhancing their sense of belonging at the institution and supporting the early development of a scientific self-identity. In addition, the WISE RP experience exposed students to role models, both at the peer and faculty levels, which likely also helped foster connections to the institution and strengthen the growth of their self-identities.

Since women in STEM fields are at risk of experiencing stereotype threat (Shapiro & Williams, 2012), access to a supportive single sex environment may also have contributed to our findings. Women in WISE RP took STEM courses that enrolled both men and women and were not composed of predominantly URM students, thus heightening the opportunities for experiencing the negative effects of stereotype threat. Participation in WISE RP may have been a protective factor against the potentially negative impact of these environments. In addition, education on stereotype threat, which has been shown to mitigate its impact, was included in the common course offered to WISE RP students in the later years of this study.

It is striking that we were able to demonstrate our results at a large selective institution with a high research expenditure and a high ratio of graduate to undergraduate students because these two factors have been shown to be negatively associated with women and minority students' persistence in STEM fields (Griffith, 2010). In addition, our study design controlled for multiple factors that have been demonstrated to be favorable for persistence in STEM fields, such as high school preparation and prior educational experience (Kokkelenberg & Sinha, 2010) and involvement in research (Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013). It is also important to note that the primary interventions were co-curricular rather than the curricular Learning Communities promoted as high-impact practices (Kuh, 2008). The results suggest that without redesigning curriculum or academic offerings, colleges and universities can significantly influence persistence in STEM degrees for first-generation and URM students by curating a supportive environment for a cohort of STEM women.

It is important to recognize that the same long-term gains were not seen for the entire group of students in WISE RP. Given that we are examining the long-term effect of only one first-year experience on a student's scholarly career, we would expect direct effects for most students to be small. Our data suggests that the first-generation and URM students gained more from participation in WISE RP. There were likely gains for the other students; however, the gains were not as large as for these higher risks groups. This suggests that the students who benefit the most from participation in a community like WISE RP are those who are least likely to already be connected to university resources and a strong academic support network. While we are cautious to attribute all of the impact to WISE RP participation, our findings provide clear evidence of the additional benefit of LLCs for higher risk undergraduate students.

Furthermore, our study illustrates the great potential of further long-term investigations with the growing availability of large data warehouses. In this study, the use of these data warehouses eliminated the self-reporting and selection biases that are inherent in survey design studies and allowed us to go beyond measuring aspirations by demonstrating increased degree attainment for URM and first generation college students. With the use of data warehouses, post-hoc studies (quasi-experimental methods) can compare learners who have engaged in a program (or treatment) that may include selection bias (including self-selection) to those learners who are similar in a variety of ways but did not engage in the treatment. Using matched sampling, as we did here, allows for an "apples-to-apples" comparison strategy, increasing confidence in any effects found. Through this, we have demonstrated the concrete benefits of a STEM LLC for first generation and URM women.

There are multiple limitations to our study. First, the study was conducted on one LLC at a large research institution, and thus it warrants caution when

generalizing the results to other settings. In addition, there is a competitive selection process for admission into WISE RP, which requires students to complete a short application. Although WISE RP does not consider academic performance in admissions and although we did match our controls on multiple variables such as incoming ACT score and number of credit hours, within the WISE-RP student population there may be an inherent bias toward students who were motivated and able to learn about and apply to the program. It is important to note that during the WISE-RP selection process, students who are perceived to have the potential for highest benefit from participation in the community are preferably viewed for admission. We tried to control for the potential self-selection bias for WISE-RP participants by creating matched controls. Future inquiry is needed about how best to weigh these different factors. Focus group discussions or individual interviews that focused on these factors could potentially provide qualitative data that could help to illuminate our quantitative findings.

Despite these limitations, our study demonstrates promising long term benefits for URM and first-generation college women who participated in a STEM LLC. This study fills a gap in the literature by demonstrating that LLCs can provide crucial support for first generation and URM female students, particularly in STEM fields. The benefits lasted through their undergraduate experiences and extended into their graduate education. The results of our study have great potential impact as colleges and universities work to increase diversity initiatives and evaluate the effectiveness of their current diversity programming.

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