FACTORS INFLUENCING FIRST YEAR UNDERGRADUATE SCIENCE AND ENGINEERING ACADEMIC CONFIDENCE

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Abstract—How to address the under-representation of women in science, mathematics, engineering, and technology-related (SMET) disciplines and careers remains one of the consistently pressing issues of higher education research and practice. Of considerable concern is the evidence that many undergraduate women in these disciplines appear to lose confidence in their abilities to do the work of these fields once they are enrolled. For women, their beliefs about whether they belong in SMET fields and possess the ability to do the coursework are significant predictors of their academic achievement and persistence. Using five years of survey data collected from a matched sample of undergraduate men and women in science and engineering fields, this research study examines what factors (including participation in a residential community designed for women in science and engineering) contribute to undergraduate women's confidence in their academic abilities and sense of self-efficacy or expectations for success in SMET fields..

Index Terms—academic self-confidence, self-efficacy, retention, college impact.

CONTEXT AND PURPOSE OF THE STUDY

How to address the under-representation of women in science, mathematics, engineering, and technology-related (SMET) disciplines and careers remains one of the consistently pressing issues of higher education research and practice. Of considerable concern is the evidence that many undergraduate women in these disciplines appear to lose confidence in their abilities to do the work of these fields once they are enrolled [1]-[2]. For women, their beliefs about whether they belong in SMET fields and possess the ability to do the coursework are significant predictors of their academic achievement and persistence [2]-[5]. Understanding what factors contribute to undergraduate women's confidence in their academic abilities and sense of self-efficacy or expectations for success in SMET fields is thus critical for retaining women in these fields.

We have ground our work on one of the central ideas of the college impact model. That is, the context or environment in which a student acts and learns figures prominently in such student educational outcomes as their academic self-confidence, academic achievement, and persistence [6]-[7]. The aim of this study is to examine the relationship among students' entering background and demographic characteristics, students' experiences with institutional academic and co-curricular structures, programs, and services, and students' confidence in their overall and SMET academic abilities. For this study we were particularly interested in determining how participation in a Women in Science and Engineering Residence Program (WISE-RP), which is expressly designed to provide confidence-building experiences, influences participants' academic confidence as compared to undergraduate male and female students, who did not participate in the program. In earlier studies we found that WISE-RP has been successful in retaining women students in science and engineering majors [8]. In this study we seek to identify possible reasons why this retention effect is found and whether and in what ways WISE-RP participation has an effect on participants' self confidence.

LITERATURE REVIEW

Because students' perceptions of their academic abilities (self-confidence) and students' beliefs that they can perform the activities related to SMET fields (self-efficacy) are so closely linked with girls and women's academic achievement and persistence in SMET fields, it is imperative that we fully understand what factors influence these perceptions and beliefs [5], [9]. Only with this knowledge can effective interventions be developed and refined.

Female students' perceptions of their SMET academic abilities and their confidence in their ability to do the work required of SMET fields is influenced and shaped by both the background characteristics and experiences they bring to the college environment and the experiences they have in the educational environment. In this study we consider the influence of a number of personal and institutional characteristics on students' sense of academic self-confidence and self-efficacy. We are particularly interested in understanding whether and how students' participation in a living-learning program, expressly designed to support the academic pursuits of women in SMET fields, positively impacts women's sense of academic self-confidence and sense of belonging.

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Student Background Characteristics

One's sense of one's ability and achievement in all fields, including SMET fields is closely associated with one's exposure, knowledge and confidence in the fields. There is evidence indicating that women who persist in SMET fields are more likely to come to college with stronger academic backgrounds than the women who drop out [3]. We also know that young women often come into college with less classroom exposure and out-of-classroom experience with SMET subjects [5], [10]. As a result some women may need greater exposure to the concepts and cognitive demands of the fields in order to gain confidence and believe that they can effectively meet the demands of these fields [11], [12]. The question then is what happens once students arrive on college campuses that might assist in their greater exposure to SMET knowledge and skills and contribute to their sense of confidence and skill.

University Environment

Goodman [1] suggests in a study of 20,000 college women enrolled in 53 undergraduate engineering schools that "a student's self-confidence increases when she feels that someone believes in her engineering abilities, cares about her, and wants her to be part of a community" (p. 10). What is it about a student's interaction with the university environment that might communicate this caring and foster the confidence of women SMET students?

Peers have been found to be among the strongest influences on women's commitment to staying in SMET fields through their college years [2], [13], [14]. Often first-year women in SMET lack contact with upper-class women who could understand what they are experiencing and help the new students make sense of classroom climate issues. New students' ability to develop friendship groups with other women (including and especially upper-class women) in SMET majors is critical to their sense of ability and belonging [2]. In these groups women gain support and insight that can help them make sense of what is going on around them, learn how to navigate obstacles and identify opportunities, and have the chance to collaborate in doing homework, make sense of lab work, and prepare for tests.

Participating in social enrichment activities, help-seeking behaviors, and research experiences are also positively associated with either positive change in self-confidence for women in engineering or persistence in STEM fields [1]. Social enrichment activities include participating in SMET-related field trips, hearing guest speakers, and attending engineering social and engineering society events. Help-seeking behaviors include the active participation in tutoring and mentoring opportunities. Research experiences that involve hands-on, ongoing research work with a faculty mentor have been found to be instrumental in keeping women in science and engineering fields [15]-[16].

Students' interactions with SMET faculty can be both positive and negative in terms of their influence on students' self-confidence and persistence in SMET fields. On some occasions faculty can and do act as role models and mentors such as in a research work relationship. Such positive interaction can provide both insight into these academic fields and encouragement, which is vital to girls and women in SMET fields feeling as though they belong and can do the work required of them in these domains [2], [17]-[18].

Faculty can also exhibit discriminatory behavior towards women SMET students and directly or indirectly contribute to hostile climates undermining women student's sense of belonging in the fields and their willingness and/or beliefs that they can do the work of these fields [1]-[2].

What these activities and relationships have in common is their ability to facilitate (or hinder) the integration of women into the academic culture of the SMET fields. In their peer and faculty interactions and by participating in SMET-focused social and help-seeking activities women have the opportunity to learn the language, skills, and knowledge of these academic domains and feel as though they belong in or fit into the academic culture.

Across the country there are intervention programs designed to provide a collective offering of peer and faculty interactions and support programs and opportunities whose purpose is to facilitate students sense of self-confidence and self-efficacy as related to SMET academic and career fields. Students in this study participated in one such program and it is described below.

Description of WISE Residence Program

The WISE-RP is one of several residential communities at the University of Michigan. At the time of this study the WISE-RP was comprised of 120 freshman and sophomore women majoring and/or pursuing careers in SMET-related fields. The community is typically split evenly among students enrolled in the College of Engineering (CoE) and the College of Literature, Science, and the Arts (LS&A), with 1 or 2 students each from the School of Nursing, the School of Natural Resources and the Environment, the School of Art and Design, and the College of Architecture. Throughout the history of the WISE-RP, approximately one-third of each class has been composed of women of color and two-thirds of Caucasian women.

The WISE-RP provides a residential community where women have access to services to support their academic and personal achievement. They live on the same floor with 119 other freshman and sophomore women who share similar academic majors, career interests, and aspirations. The WISE-RP provides a series of programs and supports to students. New students are paired with undergraduate and graduate mentors and can participate in an email mentoring program with SMET professionals. Ongoing academic and

career counseling is provided, as are both formal and informal study groups and SMET subject-matter tutoring. Students have the option to coenroll in a number of WISE-RP sections of introductory SMET classes that are predominately (and sometimes completely) female. By providing peer support, role models, and knowledge of how to negotiate the complex academic environments of the women's chosen disciplines, the program hopes to offset several of the obstacles women face in engineering and science fields.

METHODS

Data for this study come from an End-of-Year Survey (EOYS) sent to WISE-RP and non-WISE-RP participants during the last six weeks of their first-year experience in the 1997/98, 1998/99, 1999/2000, 2000/01, 2001/2002 academic years. The survey is designed to measure key aspects associated with students' university involvement, engagement, socialization, and integration. The survey consisted of 130 questions that asked about students' first-year experiences, including, but not limited to, satisfaction with faculty, staff, and student services; skill development; academic field development, campus resource use, campus climate perception, and intellectual self-confidence. Surveys were sent to students six weeks prior to the end of their first-year, and we sent two follow-up surveys, at two-week intervals, to students who did not return the surveys. Students who returned surveys were entered into a lottery for a $25.00 gift certificate.

The EOYS is one component of a comprehensive assessment and evaluation effort designed to identify and understand the impact of WISE-RP on student participants. In other research we have found that WISE-RP students, when compared to matched control students based on the criteria identified above, have significantly higher science retention compared to both male and female control students (Hathaway, Sharp, & Davis, 2001). In addition, we have found that WISE-RP white/asian students have significantly higher engineering retention than their white/asian female engineering counterparts [8]. In a qualitative focus group study findings indicate that WISE-RP students are more specific in identifying positive and/or negative aspects to their science or engineering undergraduate experiences than their female control counterparts. WISE-RP students indicate that the hands-on experiences in the laboratory settings are the most influential to their learning and cite academic counseling and advising as the least influential, even negative influence to their learning experiences. White/Asian and underrepresented minority students identify different benefits to WISE-RP participation. For example, underrepresented minority participants state that WISE-RP resource support (e.g., tutoring) is the strongest benefit to WISE-RP participation whereas White/Asian students draw the most benefit from the community support they receive from their fellow WISE-RP floormates. The survey on

which the following analyses are based is designed to better understand the process of the WISE-RP retention effect by investigating the development of students' sense of a "scientist" identity as measured by a research competence construct.

Sample

The sample consisted of 665 WISE-RP, female controls, and male controls enrolled during the five academic years between 1997 and 2002.

Matching

To develop the survey sample, we matched each WISE-RP participant to one female and one male control on several key variables: race/ethnicity, incoming major, high school grade point average (GPA), SAT score, ACT score, and high school type. The control group consists of science and engineering majors who did not participate in WISE-RP. We matched on high school GPA, in general, to within .20 points. For example, a WISE-RP student with a 3.7 high school GPA could have matched controls with GPA's ranging from 3.5-3.9. SAT scores we matched within 50 points, with most matches falling within the 30-point range. ACT scores were matched to within 3 points. In some cases a student would have either an SAT score or an ACT score. If a student only had an ACT score or an SAT score, we used a conversion scale in order for each student to have both scores. WISE-RP participant high school GPA, ACT, and SAT scores did not differ significantly from the control group -- thereby supporting that the matches were done accurately.

WISE-RP students were also matched, where possible, to female and male controls with the same intended major. Information on first year students' intended majors comes from students' applications for admission to the university.

Variables

Table 1 presents a summary of the variables we used in this study. 1st year, 2nd year, and 3rd year GPA served as the indicator of our key outcome variable, academic achievement. Given our interest in the influence of WISE-RP participation on academic achievement, we developed two factor variables (WISE Program Staff Support and WISE Student Support) that measured WISE-RP students' perception of the program environment. Academic confidence was measured by a composite variable that measured students' ability to handle and do will in college coursework. We controlled for several factors, students' incoming "ability" (SAT/ACT test scores), personality characteristics, general and specific first-year skill development, and university environment. Agency and control served as student personality indicators. Agency

measured students' sense that they were actively shaping their first-year college experiences and control measured how students respond to situations and/or problems that arise. We also controlled for students' academic identity, a measure of how closely linked academic performance and achievement is tied to students sense of self and identity. We controlled for university environment via two factor variables, faculty environment and student environment. Faculty environment measured students' perception of faculty supportiveness, and student environment measured students' perception of student supportiveness. Learning skills and research competence controlled for "out-of-class" personal development. Learning skills measured development of general skill development, such as critical thinking and problem-solving skills, and research competence measured socialization into their academic field of interest.

TABLE I
ANOVA ANALYSES COMPARING WISE-RP TO CONTROLS ON KEY VARIABLES

Variables Entered	WISE-RP (n=254)	Female Control (n=258)	Male Control (n=139)	F-statistic
1st Year GPA	3.11	3.13	3.21	1.626
2nd Year GPA (n=222,210,123)	3.10	3.15	3.07	.758
3rd Year GPA (n=177,177,92)	3.19	3.25	3.09	2.308
Academic Ability	2.56	2.51	3.03	26.339 ***
SAT	1252	1246	1278	2.757
Agency	3.65	3.61	3.75	2.481
Control	3.87	3.86	3.85	.078
Student Support	3.21	3.21	3.06	3.539*
Faculty Support	3.09	3.01	3.00	1.792
Academic Expectations	3.78	3.80	3.92	1.374
Academic Identity	4.33	4.31	4.24	1.152
Research Competence	2.11	2.03	2.15	1.517
Feedback	2.62	2.59	2.51	1.005
Learning Skills	2.80	2.77	2.71	.714
Course Satisfaction	3.53	3.68	3.82	6.495**

*p<.05, **p<.01, ***p<.001

FINDINGS

Table I presents an ANOVA analysis of the key variables. The three groups differ significantly on academic confidence and student support. Male students are more confident academically than WISE-RP and female students. However, WISE-RP and female students are similar in academic confidence. In contrast, WISE-RP and female students perceive fellow university students as significantly more supportive than their male counterparts. WISE-RP students are significantly less satisfied with their courses than Male students.

The three groups were not different in academic achievement: 1st year GPA, 2nd year GPA, and 3rd year GPA. In order to investigate contributing factors to academic achievement, a regression analysis was performed for 1st, 2nd, and 3rd year GPA. The results of these regressions are shown in Tables II, III and IV, respectively. Table II presents the results of the 1st year GPA regression. The findings indicate that student academic confidence positively influences first-year GPA; that is, students with stronger academic confidence have higher 1st year GPAs. The groups differed slightly in that Agency (indicator of student self-efficacy) did influence 1st year GPA for male and female students, but not for WISE-RP students. In other words, male students who were more active in shaping their first year experiences (Agency) had higher 1st year GPAs. WISE-RP students who perceive higher performance expectations are more likely to have higher 1st year GPAS. In addition, student ability to "handle" problems had a negative influence on 1st year GPAs for WISE-RP and female students, but not for male students. That is, for women students, in general, the ability to deal effectively with problems that arise had a negative influence on 1st year GPA. Or, conversely, women students who indicated an inability to deal with problems had better 1st year GPAs – such a relationship is not relevant for male students. Interestingly, for female students, being in a supportive student environment had a negative impact on 1st year GPA.

TABLE II
REGRESSION ANALYSIS ON FIRST YEAR GPA

Variables Entered	WISE-RP (n=236)	Female Control (n=254)	Male Control (n=137)
SAT	.447***	.329***	.341***
Agency	.118	.308***	.230**
Control	-.195**	-.178**	.016
Student Support	-.120	-.192***	-.045
Faculty Support	.086	.037	.158
Academic Expectations	.165**	.110	.069
Academic Identity	-.035	.048	-.117
Academic Ability	.146*	.205***	.242**
Research Competence	-.020	-.134*	-.081
Feedback	.065	.001	-.122
R-square (adj)	.319	.332	.360
F-statistic	12.001***	13.597***	8.641***

*p<.05, **p<.01, ***p<.001

Regression analysis on 2nd year GPA (Table III) indicates that academic confidence remains a significant influence on academic achievement. Students with higher academic confidence have higher academic achievement in their 2nd year. By the 2nd year, the influence of Control on academic achievement disappears for female students, but remains a negative influence on 2nd year GPA for WISE-RP students. Again, for WISE-RP students, those who deal more effectively with "problems" have lower 2nd year GPAs. Similarly, student support still has a negative influence on female student 2nd year academic achievement. By the 2nd year, expectations for academic performance do not have an influence on academic achievement for WISE-RP women, but this factor (academic expectations) does have an influence on 2nd year GPA for female students. In the first

year, expectations for academic performance did influence GPA for WISE-RP students, but not for male or female students. However, in the 2nd year, such expectations are irrelevant for WISE-RP students, but do become significantly relevant for female students.

TABLE III
REGRESSION ANALYSIS ON SECOND YEAR GPA

Variables Entered	WISE-RP (n=206)	Female Control (n=209)	Male Control (n=122)
SAT	.382***	.337***	.260**
Agency	.069	.121	.203*
Control	-.233**	-.129	-.043
Student Support	-.060	-.189**	-.189
Faculty Support	.034	-.088	.099
Academic Expectations	.072	.183**	.007
Academic Identity	-.056	-.029	.004
Academic Ability	.207*	.157*	.247**
Research Competence	-.059	-.023	.068
Feedback	.002	.059	-.063
R-square (adj)	.259	.229	.221
F-statistic	8.171***	7.180***	4.434***

*p<.05, **p<.01, ***p<.001

Regression analysis on 3rd year GPA continues to show the significant positive influence of academic confidence across all groups. By the third year, Control is no longer a negative influence on academic achievement for WISE-RP students. Agency remains significant for male students, as does the negative influence of student support for female students. In addition, academic identity is a negative influence on 3rd year GPA for WISE-RP students. In other words, WISE-RP students whose self-identity is connected to their academic performance have lower 3rd year GPAs.

TABLE IV
REGRESSION ANALYSIS ON THIRD YEAR GPA

Variables Entered	WISE-RP (n=162)	Female Control (n=176)	Male Control (n=91)
SAT	.280***	.277***	.210
Agency	-.065	.133	.280*
Control	-.158	-.003	-.138
Student Support	.040	-.211**	-.085
Faculty Support	.032	-.077	.134
Academic Expectations	-.006	.058	-.106
Academic Identity	-.182*	-.013	-.138
Academic Ability	.375***	.263**	.273*
Research Competence	-.087	-.142	.054
Feedback	.035	.099	.018
R-square (adj)	.242	.220	.165
F-statistic	6.133***	5.948***	2.779**

*p<.05, **p<.01, ***p<.001

Because academic confidence was a lasting contributor to GPA, we wanted to identify the factors that influence academic confidence. Table V shows the results of this analysis. SAT and Agency were significant positive influence on academic confidence. In other words, students with higher SAT scores and students who actively shaped their first-year experience exhibited higher levels of academic confidence. Satisfaction with first-year courses has a positive influence on academic confidence only for WISE-RP students. Hence, for WISE-RP students, there is a connection between their satisfaction and their academic confidence. The stronger their satisfaction, the more confident they are in their ability to handle course demands and do well in their courses. In addition, if WISE-RP students are not satisfied with their courses, this dissatisfaction has the effect of decreasing their overall academic confidence.

Table V also presents findings specific to the influence of the WISE-RP environment on academic confidence. WISE-RP does not have a direct influence on 1st, 2nd, or 3rd year GPA. We measured WISE-RP students' perceptions of program staff support and fellow student support and their influence on academic confidence. As can be seen, the WISE-RP program staff support significantly influences academic confidence. In contrast, and more difficult to interpret, a supportive WISE-RP student environment has a negative influence on academic confidence. The finding is counterintuitive taken at face value: A supportive student environment decreases academic confidence. However, we believe that this finding can be better explained: WISE-RP students with lower academic confidence perceive their fellow WISE-RP students as more supportive.

TABLE V
REGRESSION ANALYSIS ON ACADEMIC ABILITY (FACTOR)

Variables Entered	WISE-RP (n=233)	WISE-RP (n=203)	Female Control (n=256)	Male Control (n=138)
SAT	.263***	.259***	.265***	.226**
Agency	.490***	.453***	.248***	.201*
Control	.026	.021	.119	.005
Academic Identity	.043	.044	-.020	.165
Research Competence	.041	.048	.168**	.102
Learning Skills	-.079	-.100	-.030	-.082
Course Satisfaction	.181**	.231***	.056	.170
Student Support	-.132*		-.013	-.054
Faculty Support	.135*		.074	-.049
WISE Student Support		-.129*		
WISE Program Staff Support		.125*		
R-square (adj)	.428	.414	.254	.137
F-statistic	20.304***	16.856***	10.622***	3.416***

*p<.05, **p<.01, ***p<.001

DISCUSSION

Our findings indicate that WISE-RP participation does influence students' academic achievement, but does so indirectly by enhancing students' academic confidence. That is, WISE-RP facilitates women's academic confidence, and that academic confidence is a strong influence on 1st, 2nd, and 3rd GPA. Given that WISE-RP was developed with the premise that a supportive living-learning environment focused around science and engineering could positively influence women's confidence in their academic abilities, our findings show that WISE-RP does, indeed, enhance their academic confidence. This is an important finding given that we controlled for other factors that have the potential to influence academic confidence and academic achievement.

Some of the research findings are difficult to interpret. For WISE-RP students, their sense of control for their first and second years has a negative influence on their academic achievement. It is possible that those WISE-RP students who deal more effectively with problems that arise may direct their energy and focus from their academics, thus influencing their academic confidence. In contrast, those WISE-RP students who feel less able to control problems that arise may be better able to focus on their academics. Our findings also suggest that we need a better measure of the WISE-RP student environment given the negative influence on academic confidence found. It is highly unlikely that a positive and supportive student environment on the WISE-RP floor decreases participants' academic confidence. It is more likely that those students with less confidence in their academic ability view their fellow WISE-RP floormates as helpful and supportive of their academic pursuits.

Our findings provide strong support for the notion found in the literature that a supportive community setting may mitigate against those factors that have a detrimental effect on womens' SMET academic confidence. Given that research indicates that lack of confidence is a major contributor to womens' SMET attrition, this study provides insight into how a programmatic intervention can support womens' confidence – confidence that appears important to increasing academic achievement. Future research is needed to unravel the contribution of the WISE-RP influence given the contradictory findings related to WISE-RP staff and WISE-RP students. There is evidence of the influence of the environment on women's academic confidence and achievement. Examining in what ways and why the WISE-RP student environment is a negative contributor and the staff environment a positive contributor to academic confidence is important to understand both as research questions and for the purposes of program design and administration.

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