

Retention Rates and Differences between Leavers and Stayers

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Abstract—As part of a National Science Foundation grant (EEC-0234985), the University of Washington revised its longitudinal study of female students in science, technology, engineering and mathematics (STEM) in 2002. A primary revision of the study design included the development of measures to compare the retention rates of women who participate in the Women in Science and Engineering (WISE) program with those who do not. A Female Undergraduate Survey was developed to collect data on student preparation for studying engineering and their perceived self-confidence levels. This research paper combines the two sources of information to yield new findings about STEM leavers and stayers. The paper will also discuss the research findings in light of previous published work in this area.

Findings indicate that retention rates for WISE students are much higher than for non-WISE students. Additionally, WISE students are better prepared than non-WISE students, as evidenced by high school grades and SAT scores. Not surprisingly, students who stay in STEM are better prepared for their education than students who leave STEM, based on differences in SAT scores. In the analysis focusing only on WISE students, there were significant differences between UW leavers and STEM leavers, and also between STEM leavers and STEM stayers in years of physics preparation in high school. There were also significant differences between STEM leavers and STEM stayers in terms of years of physics and chemistry, and math confidence.

Introduction

Prior to the formation of WEPAN, formal Women in Engineering/Women in Science and Engineering (WIE/WISE) programs were rare on college and university campuses. In 1991, there were 26 formal WIE/WISE programs. Since that time, the number of formal programs has more than doubled, and a number of institutions have started informal support programs focused on increasing the recruitment, retention and success of female students pursuing STEM degrees (Anderson-Rowland et al, 1999; Goodman Research Group, 2002; Marra & Bogue 2004).

As programs have proliferated and matured, assessment focused on student outcomes has become more prevalent (Marra & Bogue, 2004). The WISE program at the University of Washington was among the first wave of programs established to focus on the recruitment, retention and success of female students in engineering. For more than ten years, the program conducted a longitudinal research project on female student experiences in engineering. Findings from that research project are an important part of the literature on gender equity in science and engineering (Brainard & Carlin, 1998; Brainard, Laurich-McIntyre, and Carlin, 1995; Brainard & Ailes-Sengers, 1994; Huang & Brainard, 2001).

In 2002, the UW program received a grant from the National Science Foundation, which led to a significant change in the focus of its research projects. One of the primary changes was the development of a control group, which allowed CWD to monitor outcomes for students who use WISE services AND for those who do not. Prior to 2002, the UW research project, known as the Freshman Intervention Program (FIP) recruited a cohort each year from the entering freshmen class. FIP students were surveyed intensively and interviewed every year to monitor their progress and retention in engineering. They were not, however, ever compared to a group of women who were not affiliated with the WISE program to determine if their retention rates were significantly different. Nor were their academic experiences in science and engineering gateway courses compared to a control group. In their comprehensive review of WIE/WISE programs, the Women's Experience in College Engineering Project, identified the lack of control groups as a major limitation of many of the retention projects they examined (Goodman Research Group, 2002). The revision to the UW research project addresses this limitation.

Each year, entering female students with an interest in science and engineering majors are recruited to participate in the WISE program. Identifying this initial pool of students is always an issue at UW since applicants are not required to declare a major until the end of their sophomore year. Less than 50% of all applicants indicate an intended major on the admission application. A collaboration with the Admissions Office in 2001 enabled WISE staff to better identify entering female students who intend to major in science and engineering. Admissions developed a system to supplement what is known about a student's intended major by merging multiple databases containing information about student interest. Since 2001, Admissions has used this new methodology to provide WISE with an annual extended list of entering female students with an interest in science and engineering that more accurately reflects the intended majors. It is this pool from which WISE students are recruited and from which the WISE control group is now randomly selected.

Every student using WISE services at the UW is required to complete a WISE registration form. At the time of registration, students are asked if they would like to participate in an undergraduate retention study. Regardless of their interest in the research study, WISE services are still available and special effort is made not to coerce students into participation. Students who agree to participate complete an initial survey known as the Female Undergraduate Survey (FUS) and their progress toward an engineering and science major is tracked in the same manner as in the FIP research project described above.

Literature Review

The research indicates that women's educational experiences differ considerably from men, even when they attend the same institutions and the same classes. Persistence rates in science, math and engineering majors vary from 39 to 61 percent for men and 30 to 46 percent for women, depending upon the type of institution (Astin & Astin, 1993; Strenta, 1993). According to the 1998 report, *Women and Men of the Engineering Path*, women and men earn similar grades in engineering courses, and the women who leave engineering have higher grades than the men who leave (Adelman, 1998). Women who leave engineering do not leave because of poor academic performance, though they do evidence a higher degree of academic dissatisfaction. A smaller percentage of women complete their engineering degrees (42%) compared to men (62%).

Research indicates that the largest dropout point for undergraduate college students occurs in the first two years of study (Brainard & Carlin, 1998; Tinto, 1987). Results from a ten-year longitudinal study conducted at the University of Washington suggest that while women begin their academic careers in science, math, and engineering with high levels of self-confidence in their abilities in these areas, by the end of their first year, their self-confidence levels have suffered sharp declines. Brainard and Carlin (1998) noted in their study of female undergraduates in science and engineering that at least 25% of the female persisters most frequently cited "lack of self-confidence" as a major barrier; this percentage increases to 44% by their senior year. Further, women who switch out of math, science, and engineering majors report even lower levels of self-confidence than women who persist.

Not surprisingly, the reasons for leaving are also the most frequently reported concerns or barriers to progress reported by women students who persist: losing interest, intimidation, lack of self-confidence, poor advising, and not being accepted in their department. Seymour and Hewitt suggest that, for many women, experiencing engineering education as a distinct minority automatically puts them at a psychological disadvantage with regard to confidence (1997). Grandy found that women who received engineering degrees found their courses more difficult and less enjoyable than did men (1994). In addition, women rated their study skills higher than did men, while the opposite was true in self-assessment of problem-solving skills and in self-image as future engineers.

As mentioned above, the Goodman Research Group (WECE Project) conducted a cross-institutional, longitudinal examination of undergraduate women's experiences and persistence in engineering majors (Goodman & Cunningham, 2002). The primary goal was to identify aspects of women's educational experiences that are critical to their retention and success in engineering and understand why they are successful. One of their primary findings of the individual level analysis was that women who participated more frequently in engineering support activities, particularly those combining social and academic interaction, were less likely to leave engineering majors. However, in an institutional-level comparison of universities with and without a WISE program, they found no statistical differences in the overall persistence rates of females. They hypothesize that the availability of any informal support programs for women, not just formal WISE programs, has a positive impact on individual women's retention, which is why there was no difference in women's retention at the institutional level.

In an institutional-level analysis at Rowan University, Hartman and Hartman (2006) conducted a longitudinal survey of engineering students, female and male, to determine characteristics of "stayers" and "leavers". Background characteristics of the stayers and leavers were similar. One difference between the two retention groups was in their level of involvement in student activities, both engineering and non-engineering related. Consistent with the Goodman & Cunningham (2002) findings, the leavers were less likely to be involved in discipline-specific professional societies, academic enrichment programs, and interactions with faculty. The leavers also reported less confidence in thinking that engineering was the right major for them. This study did not find gender differences in retention.

Measuring retention in college is fraught with difficulty. Students enroll and drop out and re-enroll frequently. Transfer students complicate this picture; they can mask the departures of other students if retention is not measured properly (Peter & Carroll, 2005; Porter, 2002). Additionally, tracking particular students is time consuming, although it is the only way to calculate a realistic measure of retention. For this reason, many measures of retention mistakenly do not look at particular students, but instead focus on cohort numbers and compare the final graduation numbers four or five years after the cohort entered the institution.

Inconsistencies in how retention is measured across institutions and studies make it difficult to understand what is meant when retention rates are discussed. Retention can mean one of the following:

- The percentage of students in an entering freshman cohort who re-enroll the fall of the sophomore year
- The percentage of students in an entering freshman cohort who re-enroll each fall quarter until exiting with a degree
- The percentage of students entering an institution in a given year, regardless of class standing, who graduate from that institution within a specific period of time (i.e. four, five or six years)
- The percentage of students entering college in a given year, regardless of class standing, who graduate from any institution within four, five or six years
- The percentage of students who enter college in a specific discipline, or with an intent to pursue a specific discipline who subsequently graduate with a degree in that discipline

In this paper, retention refers to the percentage of students indicating an interest in science or engineering, either prior to their entry to the university, or because of their interest in WISE, who in fall of 2005, are either currently enrolled or have graduated from a STEM major. Individual students are tracked.

Despite variation in how retention is measured, it alone is not sufficient for understanding why people leave engineering or other STEM disciplines. This study follows a group of students over time to measure retention and uses their responses on the Female Undergraduate Survey to assess why they might have been retained in STEM.

Methodology

The University of Washington Center for Workforce Development staff began tracking students who came to the Women in Science and Engineering (WISE) program for assistance in 2002. A majority of these students chose to participate in the Female Undergraduate Survey (FUS) as a part of the NSF funded research study, and completed the survey in 2003 and 2004. This paper uses the participants in the Female Undergraduate Survey as a group of students who utilized WISE services and compares them to a random sample of female students taken from the population of female students who enrolled in 2002 and indicated they were interested in science and engineering on their university admissions form, or on their standardized test (SAT /ACT). These students are the ‘Science and Engineering Interest’ population. For the purposes of this paper, the Female Undergraduate Survey participants will be called “WISE” students, and the random sample of female ‘science and engineering interest’ students will be called “non-WISE” students.

Each student in the “treatment” group has utilized the Women in Science and Engineering program for some reason, whether it was for tutoring, mentoring programs, or study classes. These students are considered to be WISE students for the purposes of programming and also for research purposes. The control group excludes any students who are in the treatment group, and is a sample of female students who indicated interest in science or engineering on either an admission application or a SAT/ACT form.

In the fall of 2005, Center for Workforce Development staff ascertained the enrollment status of the 175 participants in the Female Undergraduate Survey (FUS), and the status of a random sample of 200 students from the Science and Engineering Interest population. The random sample of 200 students was selected from the population of students in the Science and Engineering Interest group, which is described earlier (n=1032). Any students in the WISE database were excluded from the Science and Engineering Interest population before the sample was taken. One student in the random sample is currently a graduate student, and was subsequently excluded, resulting in a final sample size of 199.

This is not a cohort study, since the students in the pool are tracked individually. The only requirement for those included in the beginning is that they indicated an interest in science or engineering before arriving at the institution. Because the University of Washington’s College of Engineering has a two-tiered admissions system in which students are not admitted to a major until the end of their second year, this makes measuring retention at UW more difficult than at an institution where students are admitted directly to a major in their first year. To circumvent the two-tiered system, we use the proxy of “students indicating an interest in science or engineering” to create an initial sample to track over time. This proxy, while not ideal, helps us include students in their first and second years who would not otherwise be trackable, and who are most apt to leave a science or engineering major. Thus, retention is defined as: The percentage of students indicating an interest in science or engineering, either prior to their entry to the university, or because of their interest in WISE, who in Fall of 2005, are either currently enrolled or have graduated from a STEM major.

Students were placed into one of five enrollment status categories. The categories are: student had left the university, student currently enrolled in a non-STEM major, student graduated in a non-STEM major, student currently enrolled in a STEM major, or student graduated in a STEM major. These five categories were collapsed into three categories for some analyses. The collapsed categories are intuitive: leaver of UW, leaver of STEM and stayer in STEM.

Multiple analyses were performed. First, retention rates were calculated using updated status data from fall quarter 2005. Female students interested in science and engineering are considered to be ‘retained’ if they were currently enrolled in STEM or had graduated in STEM by the Fall quarter of 2005. A STEM major is defined as one of the following majors: Aeronautical and Astronautical Engineering, Bioengineering, Chemical Engineering, Civil and Environmental Engineering, Computer Science and Engineering, Electrical Engineering, Industrial Engineering, Materials Science and Engineering, Mechanical Engineering, Technical Communication, Applied Mathematics, Astronomy, Atmospheric Sciences, Biology, Chemistry, Earth and Space Sciences, Mathematics, or Physics.

Data on entry differences (high school grades, SAT scores), achievement in science and engineering gateway courses (Math), and current achievement (cumulative GPA as of the most recent quarter, GPA for the most recent quarter only) were taken from the registrar's student database for both WISE and non-WISE students. Independent sample t-tests were used to determine differences in entry preparation, gateway course achievement, and current academic achievement between the WISE sample and the non-WISE sample. Independent sample t-tests were also used to determine differences between students who left STEM and those who persisted in STEM. The WISE sample and the non-WISE sample were combined to perform this second analysis.

Additionally, using a one-way analysis of variance (ANOVA) on WISE students only, the differences between three groups (leavers of UW, leavers of STEM, and stayers in STEM) are examined. The variables used for this analysis come from the survey that only the Female Undergraduate Survey (FUS) participants completed, and thus the analysis is not replicable for the random sample of non-WISE students. A one-way ANOVA assesses differences in means between more than two nominal level groups. The ANOVA used in this project identifies when the variability between the group sample means is larger than the variability within each sample group. The "between groups" estimate only tells us that the means are different, but does not indicate direction or magnitude of difference. Based on the results of the ANOVA, an independent sample t-test then examines differences between the leavers and stayers of STEM.

Results

This section reports the results of the analyses discussed above in the methodology section. For the sake of space and parsimony, tables and discussion have been simplified. More detailed tables and analysis is available upon request. Additionally, future papers on this topic will include additional analyses, such as a multivariate regression. In Table 1 are descriptive statistics for both the WISE and non-WISE sample.

Table 1. Descriptive Statistics of WISE and Non-WISE samples

Ethnicity	WISE		Non-WISE	
	N	%	N	%
African American	4	2.3	6	3.0
Asian American	56	32.0	70	35.2
Hispanic	12	6.9	7	3.5
Native American	2	1.1	4	2.0
Caucasian	75	42.9	81	40.7
International	13	7.4	7	3.5
Other/ Unknown	13	7.4	24	12.1

There are few large differences in the distribution of participants by ethnicity. It does look like there is a large difference in the proportion of Hispanic and international students in the samples, with the WISE sample having double the percentage of the non-WISE sample; all other differences seem minimal. The WISE sample was admitted to the university in a range of years, from 1999 to 2004; while the non-WISE sample was admitted in 2002. However, some students

in the non-WISE sample had enrolled, dropped out and then re-enrolled in 2002, or had taken a summer program at the university in a year prior to 2002. The years of initial introduction to the university for the non-WISE sample ranges from 1996 to 2002, even though all of the students were technically admitted (or re-admitted) in 2002. Thus, in both samples, students did not all enter as freshmen. Overall, 70% of all research subjects entered the University of Washington in 2002 or 2003.

The retention rates of the WISE and non-WISE sample are summarized below in Table 2. *Retention refers to the percentage of students indicating an interest in science or engineering, either prior to their entry to the university, or because of their interest in WISE, who in Fall of 2005, are either currently enrolled or have graduated from a STEM major.* The differences in retention are substantial. Fully 80.6% of the Female Undergraduate Survey participants remained in STEM, while only 46.2% of the non-WISE sample of female students interested in science or engineering stayed in STEM. A crosstabulation of the retention data indicates that retention status designations and membership in the WISE or non-WISE sample group are associated. Chi-square equals 54.22 and has a probability value of .000, indicating that we can reject the null hypothesis of independence, i.e., there is a statistically significant association between membership in WISE/non-WISE and a person's retention status.

In order to determine which status designations were most different between the two samples, the adjusted residuals were examined. Adjusted residuals indicate the significant differences on different status designations. The asterisks appended to the status designations indicate significant differences, and the adjusted residual values are in parentheses. Only the status designation of graduated in STEM is not significantly different between the WISE and non-WISE sample.

Table 2. Retention Rates as of Fall 2005

Status	WISE		Non-WISE	
	N	%	N	%
Left UW* (2.6)	14	8.0	34	17.1
Enrolled but Non-STEM* (4.4)	16	9.1	53	26.6
Graduated Non-STEM* (3.1)	4	2.3	20	10.1
Enrolled STEM* (7.0)	123	70.3	68	34.2
Graduated STEM (.5)	18	10.3	24	12.1
Total	175	100	199	100
Retention Rate	80.6%		46.2%	

Often, it is interesting to examine where students go after they leave a STEM field. All of the fourteen WISE students who left the UW had no majors reported in the student database. Of the twenty WISE students who left STEM, eight went to the social sciences, four to business, four to the humanities, two to architecture, one to general studies, and one to information science.

The 106 non-WISE students who left UW or a STEM major went to the following majors: eight students did not declare a major, ten were pre-majors, fifteen went to a STEM field (all these had

left the university), forty-two to social science, thirteen to business, ten to humanities, two to architecture/design, one to the arts, four to a health-related field, and one to general studies.

T-test analysis

The results of the independent sample t-tests are below in Tables 3 and 4. The first table shows the results of the t-test of mean differences between the WISE and non-WISE sample. The second table analyzes the differences between all leavers of STEM and all stayers in STEM, regardless of WISE affiliation. The students who left the university were excluded from this second analysis. The variable “Stayed in STEM” is a dichotomous variable, and excludes students who left the university.

Table 3. Independent Sample t-test of WISE and non-WISE samples

	WISE			Non-WISE		
	N	Mean	S.D.	N	Mean	S.D.
High School GPA* (p=.04)	149	3.77	0.22	166	3.72	0.26
SAT - Verbal *(p=.024)	149	574.03	107.69	178	548.65	94.65
SAT - Math	149	618.46	83.80	176	603.69	90.09
Cumulative GPA* (p=.032)	171	3.28	0.41	190	3.17	0.52
Most Recent Quarter GPA	152	3.33	0.57	168	3.23	0.66
Grade in Math 124	90	3.22	0.74	72	3.17	0.68
Stayed in STEM*** (p=.000)	161	0.88	0.33	165	0.56	0.50

Table 4. Independent Sample t-test of Leavers and Stayers in STEM

	Stayers			Leavers		
	N	Mean	S.D.	N	Mean	S.D.
High School GPA	201	3.77	0.23	80	3.72	0.24
SAT - Verbal *(p=.03)	205	574.29	103.66	84	548.69	84.12
SAT - Math*** (p=.000)	204	628.14	83.01	83	585.78	80.87
Cumulative GPA	230	3.29	0.41	90	3.25	0.41
Most Recent Quarter GPA	216	3.31	0.60	81	3.34	0.52
Grade in Math 124	117	3.27	0.67	29	3.02	0.75

There are significant differences in means between the WISE and non-WISE sample for high school GPA, Verbal SAT score, and cumulative GPA (Table 3). In all cases, the WISE sample had higher mean values than the non-WISE sample. This suggests that the WISE sample is coming into college with better preparation and that they are performing better once they are in college. This better preparation may help account for the differences in retention seen in Table 2. Future research will explore this issue in more depth, and will utilize multiple regression analyses to sort out the effect of student characteristics on retention.

In an analysis of the significant differences between leavers of STEM and stayers in STEM (Table 4), verbal and math SAT scores were higher for the stayers than for the leavers. It is interesting that there was no difference in performance while at the university, as indicated by

the cumulative and most recent quarter GPA, and the class grade for calculus. This concurs with some qualitative research, which indicates that many women who leave STEM are not leaving because of poor performance, but because of other reasons (Seymour and Hewitt, 1997). “Pull” factors attract women to other disciplines, and “push” factors, such as climate issues, deter women from remaining in STEM.

ANOVA and T-test of WISE participants’ retention status

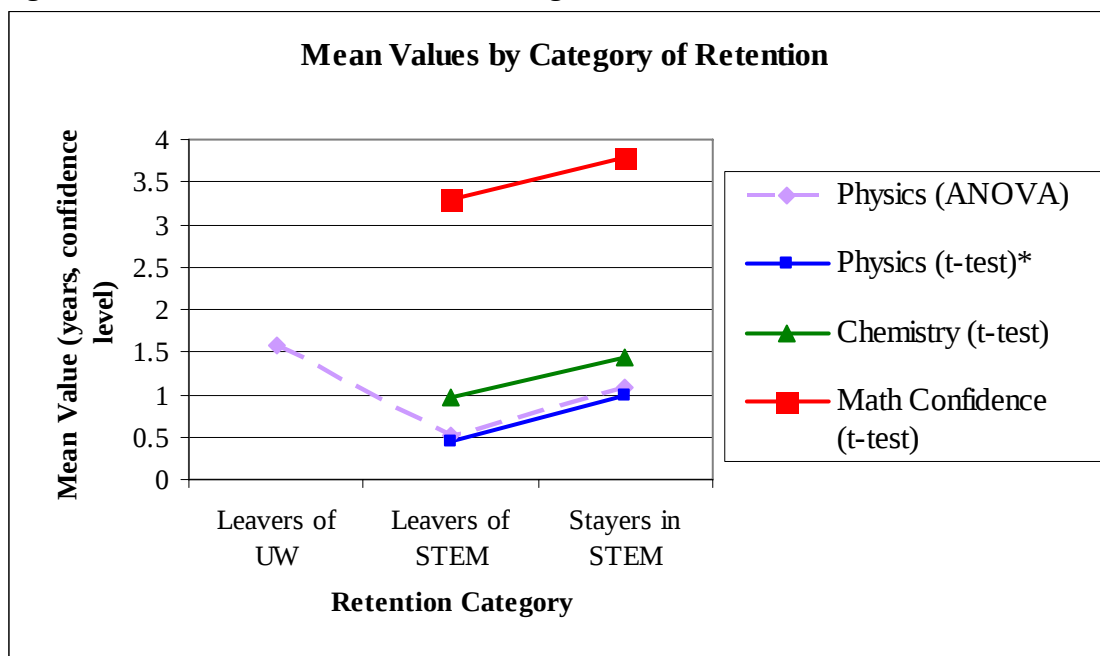
This section reports the results of two analyses conducted only on the WISE sample. The first analysis is an ANOVA using the three retention groups (UW leavers, STEM leavers, and STEM stayers). The second is a t-test of the differences between STEM leavers and STEM stayers. As a subset of the combined sample of WISE and non-WISE, the better prepared WISE students offer distinct advantages for analysis since questions from the Female Undergraduate Survey (FUS) can be used for the analysis.

These two analyses used students’ self-reported answers to the following questions: years of algebra in high school, years of physics in high school, years of chemistry in high school, years of calculus in high school, years of computer related coursework (all ‘years’ questions had possible values from 0-4 years). Also included were questions on confidence as a math student, confidence as a science student (both confidence questions range from 1-5, with ‘1’ indicating the lowest level of confidence, and ‘5’ the highest level of confidence), high school GPA, math and verbal SAT scores, and number of barriers to academic progress.

As indicated in Figure 1, only one question (years of high school physics ($p=.007$, $n=168$)) reached significance in the ANOVA of the three retention categories. In Figure 1, the dotted line indicates the ANOVA results. Although it is not possible to tell if it is statistically significant just by looking at the image, it seems that UW leavers may be more similar to STEM stayers than STEM leavers. To obtain accurate information about the differences, a Bonferroni test was applied to the analysis of the three retention groups. It indicates that the real differences in years of physics preparation lie between leavers of UW and leavers of STEM, and also between stayers in STEM and leavers in STEM. Leavers of UW and stayers in STEM are not significantly different on years of high school physics, as suggested above. This suggests that retention efforts targeted toward university leavers will not suffice for STEM leavers.

Because students who leave the university seem to be different from the other two groups, and presumably leave for different reasons than students leaving a STEM discipline (Attinasi, 1989; Rice & Alford, 1989), an independent samples t-test analysis was conducted to determine differences only between the WISE leavers of STEM and the WISE stayers in STEM; UW leavers were excluded. The Levene test was used if variances were not assumed to be equal. The results in Figure 1 are very similar to the finding for all three groups, only there are more differences between the two groups. Leavers of STEM and stayers in STEM differ significantly on years of physics in high school ($p=.014$, $n=156$), years of chemistry in high school ($p=.001$, $n=158$), and math confidence ($p=.045$, $n=160$). It is to be expected that stayers in STEM have greater preparation, and thus are more ready to succeed in a STEM field.

Figure 1. ANOVA of WISE retention categories



*Note: The values for the physics t-test have been slightly decreased to allow the ANOVA line to show in the figure. The true values of the t-test would completely obscure the ANOVA line.

Discussion and Future Research

This study finds a large difference in retention rates between WISE and non-WISE female students. WISE students stay in STEM at slightly less than twice the rate of non-WISE students. This study also found that WISE students seem better prepared than non-WISE students to succeed in a STEM field, as evidenced by their higher means on high school GPA, verbal SAT score, and their current cumulative college GPA. As expected, students who stayed in STEM had higher mean SAT scores in both verbal and math, than students who left STEM. This last finding contradicts Hartman & Hartman (2006), who found that leavers had higher mean verbal SAT scores.

In the analysis of the subset of only WISE students, leavers and stayers also have different levels of preparation for STEM degrees. Specifically, stayers had more years of physics and chemistry in high school, and higher levels of math confidence than leavers had. Additionally, UW leavers were significantly different from STEM leavers in their years of physics in high school. The findings regarding preparation for a STEM discipline echo the findings of Astin & Sax (1996), that better preparation is consistent with higher rates of retention. Also, the finding of a large difference in retention is a critical piece of evidence to support the efficacy of WISE programs, especially the UW WISE program.

However, multiple factors could be affecting the retention finding, most of which are unmeasured in this data. Students who choose to participate in WISE services may be fundamentally different from students who do not participate in WISE services. That is, students self-select into WISE, which may mean that they are more serious about graduating in STEM, which could affect a retention rate. Future analysis is planned to attempt to tease out the effects

of unmeasured characteristics on retention rates. This future analysis will also utilize a multivariate regression technique to control for additional characteristics which are measurable. Other limitations of the data include the operationalization of WISE and non-WISE membership; the admissions office's process of identifying females interested in STEM may be flawed, resulting in the inclusion of students who are not truly interested in a STEM major.

Future research should address one of the findings of Goodman and Cunningham (2002). They found no statistical differences in the overall persistence rates of females at WISE and non-WISE schools, suggesting that student access to support programs (WISE or non-WISE) may be a key factor in student persistence. The WISE program at the University of Washington offers a variety of services to WISE members including mentoring, tutoring, networking, and professional development. To avoid the duplication of efforts, similar services may not be available elsewhere on campus. Thus, it is possible that the non-WISE sample either used very few student services or did not access the same quality of service provided by WISE.

The authors will offer suggestions to other WISE programs on how to collect similar data at their institutions at the conference presentation.

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