



Building and Evaluating a Multi-tiered Mentor Program to Introduce Research to High School Women (Evaluation)

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Abstract

Worcester Polytechnic Institute (WPI) has developed the Women's Research and Mentoring Program (WRAMP) with the goal of encouraging more women to consider advanced degrees in science, technology, engineering, and mathematics (STEM). A multi-tiered mentor program has evolved to place two local high school students in a graduate student mentor's research lab along with an undergraduate student as a mentor/mentee. Bringing the three populations together provides a unique mentoring scaffold that serves to encourage the high school women and undergraduate women to consider advanced degrees, while also providing the graduate students with valuable teaching and mentoring opportunities. Development of the WRAMP program has followed an iterative process using formative feedback from previous WRAMP sessions and program surveys to adjust the model for improved success. This paper discusses the evolution of the WRAMP program model with three (3) iterations, the successful recruitment of high school participants from underserved populations within the local public schools, and program evaluation from the perspective of the high school mentees. Evaluation of the program was carried out via pre/post surveys and through observations and feedback sessions.

The Program and Iterations

WRAMP 1.0 – *Getting Started*

The Women's Research and Mentoring Program (WRAMP) originated from the desire to have continued engagement with high school (HS) students who participated in our summer pre-college programs and a colleague's comment about wishing to have more professional development opportunities for graduate students. Furthermore, our collective and overarching goal is to provide meaningful, high-touch experiences with students from underrepresented groups in STEM, especially from our local, urban neighborhoods of Worcester, Massachusetts. WRAMP was thus created through funding from an internal grant opportunity by a group of alumna and friends of WPI to support women in STEM [1]. In the very first iteration of the program, the goal was to enable high school women to engage in hands-on STEM research in state of the art research laboratories under the guidance of women graduate student role models for a semester (10-12 weeks).

By having the research projects supervised by graduate students, we did not have to burden faculty members (although they needed to approve their graduate student's participation in the program) and the graduate students had opportunity to develop their skills in scoping a short research project and mentoring younger students. Furthermore, to compensate the graduate students for their time and effort, a stipend (funded by the grant) was provided. The expectation was for the high school student to spend roughly 2-5 hours per week in the lab (based upon a mutually determined time), and the high school student would also receive a small stipend. The stipends were not only an incentive, but an important recognition of people's time and efforts that they should be compensated rather than treating the program as a volunteer or luxury activity that only a few can afford. These program elements are similar to the WISE program at Johns Hopkins University [2].

An application process for both mentors and mentees was communicated through newsletters for graduate students and the WPI Pre-Collegiate Outreach Program [3]. The distribution list for the Pre-Collegiate Outreach Program was limited to the Worcester County. For the high school student, the online application consisted of three short open-ended questions plus questions about their other commitments (i.e., extracurricular activities) or constraints on availability. To reduce barriers in applying, few questions were asked (Table I) and no grades or letters of recommendation were requested.

Table I. WRAMP application questions for high school students.

<i>Tell us about yourself:</i> Why have you applied to the Women's Research and Mentorship Program (WRAMP)? What most excites you about being a part of WRAMP?
<i>Tell us about your aspirations:</i> What are two goals you currently have for yourself that you're hoping WRAMP can help you learn to achieve?
<i>Tell us about a time you struggled:</i> What were the challenges you faced? How did you handle the situation? What was the final outcome?

To prepare the graduate students for the program, a one-time, 2-hour orientation and training session was held with participation of The STEM Education Center at WPI [4]. Program expectations, mentoring experiences and tips, and teaching strategies were shared. As part of WRAMP, the high school students also attended Saturday workshops on college admissions, library resources, and giving presentations that were given by different offices at the university. Six (6) high school students and seven (7) graduate student mentors (with 2 graduate students in the same lab participating as a team) were in the first cohort.

The semester long research projects culminated in a poster session (Fig. 2) and presentation for family members and other guests. By giving a short presentation and participating in a poster session, the mentees were able to be seen as a scientist/engineer and researcher in front of their peers and family, as well as take pride in their work. Theories about identity formation [5] state that one must not only have the interest and see themselves with a particular identity, but also be seen by others. Parents and peers have great influence at the high school ages [6-7], and thus supporting and celebrating the high school students' participation in WRAMP were important components in the design of the program. Each high school student was also able to take home a copy of the team poster.



Figure 2. WRAMP closing ceremony with parents and guests includes a poster session.

Applications for the high school participants were plentiful for the first session, and many students were from the neighboring and more affluent suburban communities. Due to the demand for high-school research experiences, the next iteration of WRAMP doubled the number of HS students to 2 in each research group. With the research and mentor program structure in place, we could then focus on improvements with future WRAMP offerings.

A chance encounter of one of the authors and a graduate student mentor resulted in a program improvement. Their conversation about some of the challenges about communication with the high school student precipitated the idea of having the WRAMP mentors form a Community of Practice (CoP) to share experiences and problem-solve together for the next iteration of WRAMP.

WRAMP 2.0 – Expanding the Leadership and WRAMP Research Teams

For the next WRAMP session and funding cycle, focus was placed on increasing the diversity of the WRAMP participants and supporting women from underrepresented minorities (URMs) in STEM. The intersectionality of underrepresented status of being female and also of certain race/ethnicities [8] was highlighted, and two significant modifications were made in the second cycle.

With the reality that our graduate student (Grad) population is only 2.9% underrepresented minority (URM) in STEM, 32% female, and 1.3% URM female, a significant and needed design iteration to WRAMP was to include an undergraduate student (UG) as part of the research team. Table II shows WPI’s race/ethnicity breakdown for female UGs and grad students [9]. While improvements across the board could be made, there is greater diversity and numbers among our undergraduate student population with 13.4% URM, 40% female, and 5.6% URM female. In addition, adding an UG would narrow the age difference and could provide more shared experiences with the high school students. The UG would also benefit, as research has been shown to be help with college persistence [10]. Additional funding was required to add the UGs and, in part, the total number of research teams was reduced to five. The scheduling of program activities and research times was further complicated, but the efforts were deemed worthwhile.

Table II. Number and percentage of women Graduate and UG students at WPI according to race/ethnicity.

WPI Students Race/Ethnicity	Grad n (%)	UGs n (%)
Nonresident Alien	220 (70%)	124 (7%)
Hispanic/Latino	5 (2%)	180 (10%)
Am Indian/Alaska Native	0	3 (0%)
Asian	5 (2%)	151 (8%)
Black/African American	5 (2%)	48 (3%)
Hawaiian/Pacific Islander	0	0
Two or more races	3 (1%)	47 (3%)
White	77 (24%)	1135 (62%)

Unknown	1 (0%)	144 (8%)
Total	316 (100%)	1832 (100%)

In addition, another meaningful intervention was to add the Director of LSAMP [11] to the leadership team as a co-PI to the grant. In her role, she could help promote and recruit UGs from underrepresented groups, as well as contribute great insight and experience to WRAMP.

With the experience and feedback from the first WRAMP iteration, a multi-tiered mentoring structure (Figure 2) was quickly implemented. The new research teams consisted of 2 high school students, 1 undergraduate as a mentor/mentee, and 1 graduate student mentor. The larger research teams did require more flexibility to accommodate everyone’s schedule, and the Saturday sessions became a clear requirement when applying for the program.

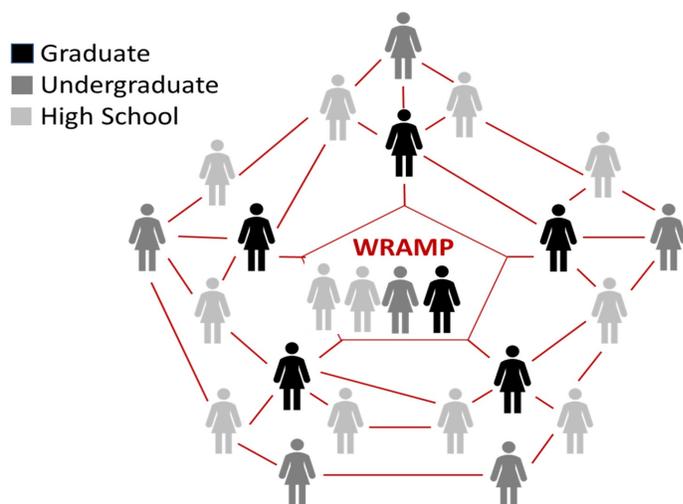


Figure 2. In order to achieve greater outcomes, WRAMP evolved to a multi-tiered structure of 2 high school students, 1 undergraduate, and 1 graduate student for each research team.

For WRAMP 2.0, the professional development training of the grad mentors expanded and was formatted as a CoP with 4 required Saturday sessions that overlapped with the high school Saturday sessions. The undergraduate and graduate mentors participated in discussions and workshops covering topics such as being a role model in the lab; promoting a “growth mindset” [12] and incorporating inclusive pedagogy when mentoring [13]; what “success” means and who decides; examining different identities [14]; and leveraging the mentoring experience when applying for future career jobs. During these sessions, the mentors reported the desire to run the workshops for the high school students themselves and they also helped design the future iteration of WRAMP.

Meanwhile, the feedback from the WRAMP high school participants demonstrated the desire to have more interactions with the mentors and other WRAMP participants. As an example, one student responded on a post-survey question about how they might improve the program: “*I would use the group meetings (the Saturday ones) to create more interactive activities so the participants can get to know each other better.*”

Another goal was to better serve our local school district, which is located in a high-poverty city, as determined by the USDA poverty mapping tool [15]. The Worcester Public School (WPS) district educates more than 25,400 PK-12 students and operates seven high schools [16]. Data from the MA Department of Elementary and Secondary Education for the 2019-2020 academic year [17] classify 57.9% of the families in WPS as economically disadvantaged. Figure 3 shows the diversity of race/ethnicity, and reveals that 18.8% of WPS students are African-American and 41.9% are Hispanic, which is in striking contrast to the demographics of WPI. Many of the WPS students (including the Asian populations) come from immigrant families and may be the first in their families to attend college in the United States.

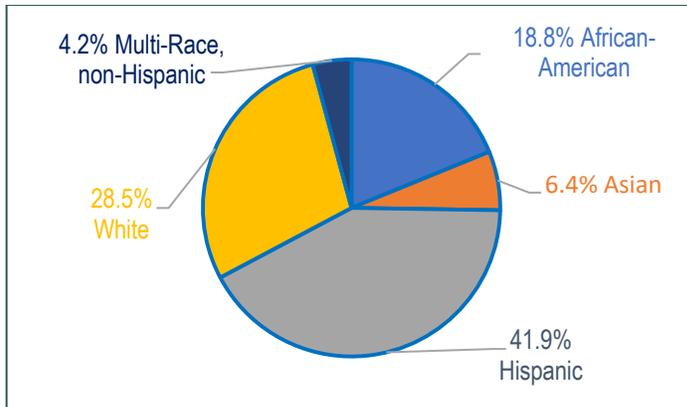


Figure 3. The race/ethnicity breakdown of the PK-12 students in the WPS Public School district with over 25,400 students.

Engagement with the WPS school counselors proved to be extremely helpful, and with each cohort, we are able to serve more of the WPS high school students in our local city. Furthermore, with WRAMP 2.0, we developed a selection rubric based on the WRAMP high school application questions (Table III) and the new leadership team reviewed and scored the applications. We hoped to engage high school women curious about STEM research in a university laboratory and wanting to have a mentor, and also those who hadn't had the opportunity before. Thus, an application that contained many previous research experiences did not fit with the WRAMP goals and objectives, and would not be scored highly.

Up to this point, we were not asking directly about race/ethnicity and hoped that applicants might self-disclose the information if they wanted to. In addition, we could sometimes ascertain the socio-economic status of all applicants based on their responses on applications. We also took HS students attending XPS as a proxy for low-income families since a majority of the students are economically disadvantaged. Because our program goals were to support women of color in STEM, we decided to start including race/ethnicity as part of the WRAMP application and to consider when selecting participants for the next iteration.

Table III. Rubric for scoring the WRAMP high school applicants.

Criteria	Great (5)	Good (3)	Ok (1)
Goals for wanting to be a part of the program are realistic	Clearly communicates that she wants to do research, appears to have applied of her own volition.	Seems to want to do research but is less clear on why.	Very basic and vague explanation; likely being pushed to apply by parents/guardians

Fulfills the prompt of sharing two individual goals/aspirations that align with a research related opportunity.	Shares two goals that strongly align with the skills and experiences acquired in this program.	Shares one or two goals that could align with a research experience but may be not directly.	Shares only one goal or shares two goals that are not related to gaining research experience in STEM.
Clearly communicates a “real” struggle. Response indicates that student has some resiliency and capacity for flexibility.	Struggle is clearly defined, applicant formulated a solution to the problem and demonstrates high level of resiliency and flexibility	Struggle is clearly defined, applicant begins to formulate a solution to the problem and demonstrates some resiliency and flexibility	Struggle is not clearly defined, applicant does not share a solution to the problem or the problem does not demonstrate resiliency or flexibility

WRAMP 3.0 – Strengthening the Pathways with URM

By WRAMP 3.0, we were receiving several HS applications and made a point of stating on the recruitment materials that “Preference is given to young women in WPS Public Schools who identify as women of color.” With the improved communications with WPS counselors and teachers, we began to see an uptick in WPS applications with each session of WRAMP. In 2019-2020 academic year, we were able to offer all the HS mentee slots to WPS women!

To date and over 5 WRAMP sessions and 3 program iterations, forty-nine (49) high school women have been served, with 30 (or 61%) from underrepresented groups. As Figure 4 shows, we have been able to increase the overall number of women participating in WRAMP and increase the diversity as we continuously improve the program. Figure 5 demonstrates the need to increase the number of URM graduate students, and also reflects the importance of including our URM undergraduate students in the program.

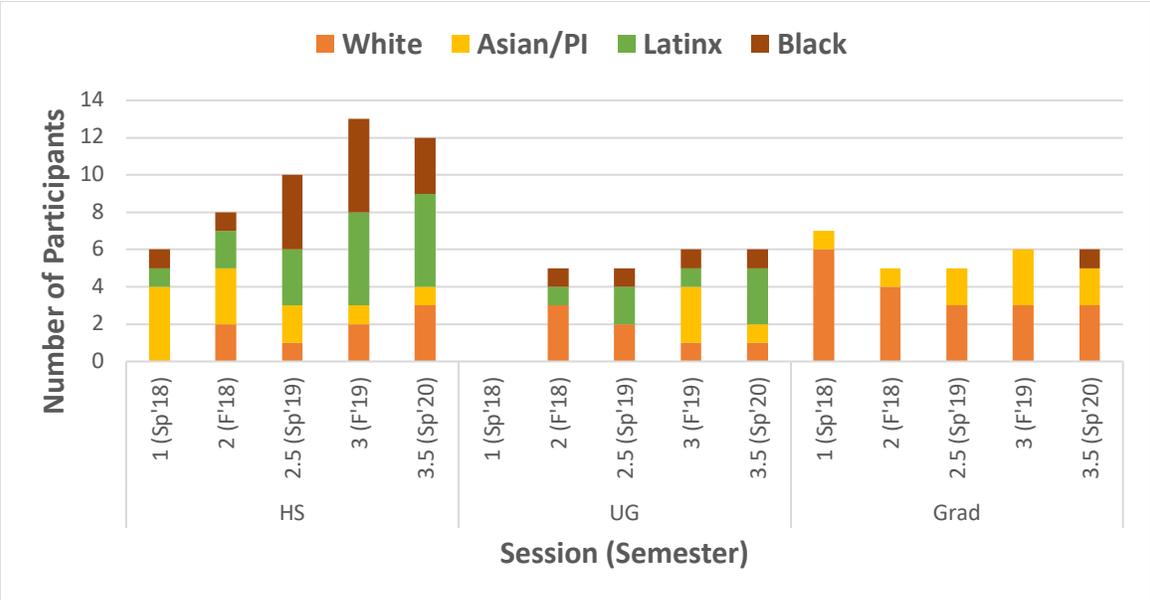


Figure 4. Increase in WRAMP participants and increase in diversity with the addition of the undergraduate students starting in Session 2.

This program fits into the overall strategy of the Pre-Collegiate Programs Office to keep WPS students engaged with WPI. For the HS students who complete WRAMP, they will also get \$500 towards any summer program at the university and may become a WPS Summer Scholar that can attend a summer program for free each year. In regards to WRAMP being a recruitment strategy for WPI, 8 out of the 13 WRAMP high school women that are old enough to apply to college did so (which is a 60% yield and surpasses national averages). Two of them were admitted, but did not enroll. One stated it was due to financial reasons. We are investigating how we might provide more support for WRAMP and WPS high school students to be accepted to WPI. Many of the WRAMP participants have yet to graduate from high school and we plan to track them if they apply to WPI and where they end up attending (through the National Student Clearinghouse [18]).

Three women have continued their engagement with WPI by attending summer programs sponsored by the Pre-Collegiate Programs Office. Approximately 50% of WRAMP participants have stayed engaged with other WPI outreach programs. While it is too early to report the influence of WRAMP on college choices, it appears that many of the participants have strengthened their interest in STEM through their continued engagement.

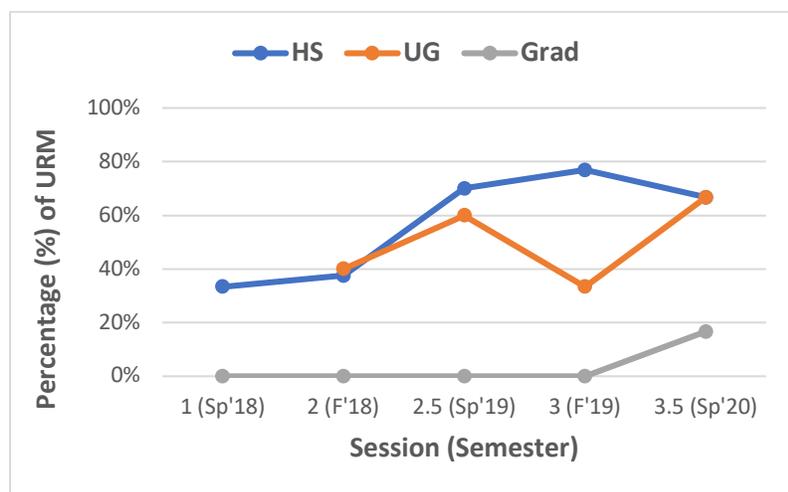


Figure 5. The percentage of WRAMP participants that are from underrepresented groups in each tier (high school, undergraduate, and graduate student).

The Saturday sessions for WRAMP 3.0 evolved to two required weekend sessions with the entire WRAMP group (i.e., Opening and Closing Ceremony). The mentor trainings (for the WPI undergrads and graduate students) were moved to late afternoons during the week to accommodate the students wishes to minimize weekend commitments. The opening session added an ice-breaker and women empowerment activity about self-promotion [19]. Imposter syndrome [20], recognizing one’s strengths, and supporting one another are topics that resonate with all the WRAMP mentors and mentees.

The mentors also took on the non-lab mentoring and socializing aspects with their HS students, and helped coach them on the college selection and application process. Mentors also received a small amount of funding for these fun events outside of the lab. Anecdotal feedback was that these non-lab sessions really allowed the WRAMP teams to bond (Figure 6 [21]). These

activities help contribute to the development of Yosso’s conception of “social capital” [22] and sense of belonging to keep the HS students motivated in pursuing STEM in college [23]. While shifting some of the non-lab mentoring activities to the responsibility of the mentors rather than during the Saturday sessions, a high school student responded as a program improvement: *“I wouldn’t change it much, but guess maybe having more Saturday meetings as an entire group, because I really loved them and would’ve loved to have more!”* In a dynamic system of interdependent factors, what might seem as a program improvement might produce unintended outcomes. For this particular issue, more of the mentors and lab teams are arranging their out-of-lab experiences together. And several of the graduate students take their research teams to visit other labs.



Figure 6. Instagram selfie picture of a WRAMP research team which captured the sense of belonging and closeness of the women.

Evaluation Surveys

The WRAMP participants also completed pre and post surveys. The high school mentee survey questions included several from AWE (Assessing Women and Men in Engineering) [24]. However, we discovered that the questions didn’t necessarily align directly with the WRAMP goals. Initial analysis of the AWE responses on our small numbers each session did not result in anything statistically significant. Fortunately, we incorporated our own additional questions on the post surveys. Quantitative assessment targeted feedback on the WRAMP program (Table IV) and the high school student’s experience (Table V) using a 4-point Likert scale (Strongly Disagree = 1; Disagree = 2; Agree = 3; Strongly Agree = 4).

Table IV. Post-survey statements using Likert scale about the WRAMP program for the HS students.

If I needed help during the program, it was readily available.
I found it easy to get to know the other participants in this program.
I enjoyed being a part of this program.
I liked my graduate student mentor.
I liked my undergraduate student mentor.
The amount of time I met with my mentor in the lab was enough to complete my project.
I learned new things from my mentor.

Table V. Post-survey reflective statements using Likert scale for WRAMP HS students.

<i>My participation in this program:</i>
Helped me understand science better
Led me to a better understanding of my own career goals
Increased my interest in studying science in college

Made me think more about what I will do after graduating from high school
Made me decide to work harder in school
Made me decide to take different classes in school (including college) than I had planned to
Made me more confident in my ability to succeed in science
Increased my confidence in my ability to participate in science projects or activities

As we reviewed the survey results, we looked for any responses that were in the “1-2” range as things to address and to improve our program. The responses were consistently in the “3-4” (Agree to Strongly Agree) range, indicating that WRAMP was enjoyable and educational for the high school students. While these survey questions capture the mentee’s self-reported attitudes, much of the program improvements came from direct feedback from all participants through informal conversations and from the program coordinators’ analysis of the many different components of WRAMP.

We also performed qualitative assessment with open ended questions. For instance, we asked the HS mentees what they liked most about the program and we got responses such as:

I liked that we got to work with grad students and had the opportunity to work hands-on in the lab, and do our own research/project in the process.

I liked my group members and how we all learned from each other.

My favorite part about the program really was having a 1 on 1 experience with my mentor, and really jumping into different topics like Python, ROS, etc. ... I really like learning more about colleges, meeting professors, and thinking more about what I want to do in college.

From these responses, feedback from the mentors, and our own observations, we are confident that the high school women are getting unique experiences that are helping them gain confidence in exploring STEM in college. With the increased number in applications from high school, undergraduate, and graduate students each session, there is a demand to continue WRAMP.

Summary

WRAMP started out with six (6) teams of a graduate student and high school student doing research for 2-4 hours per week for one semester, and then with each cycle, improvements were made from a programmatic standpoint and from a recruitment/participation aspect. After three cycles of the program (or five sessions/semesters), we now have WRAMP teams consisting of two high school students from local public schools, one undergraduate, and one graduate student working together in a research lab for a semester. The multi-tiered program highlights empowering women to be supportive of one another and seeing themselves as scientists/engineers, and each cohort for each session has its own personality (Figure 7). The high school women enjoy working with older women at WPI and being exposed to research in many different fields at the university level. We also have increased the diversity of our participants with strategic adjustment, such as partnering with the Director of LSAMP at WPI and networking better with the Worcester Public School district. Intentional recruiting through our improved application and selection processes has yielded desired outcomes. To date we have served 49 high school women, with the majority from the Worcester Public Schools. Based on

multiple assessment methods, the WRAMP participants enjoy their research and mentoring experiences.



Figure 7. The WRAMP cohort for Spring 2020 with high school, undergraduate, and graduate students, as well as program coordinators.

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