



## **MapCores: Improving the Representation of Women in STEM**

### **Program developed to encourage and recruit women in computer science, mathematics and physics**

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The gender gap in participation in mathematics, physics, computer science and engineering is a well-known problem of higher education.<sup>1-3</sup> Researchers have identified numerous social and environmental factors that contribute to gender differences in entry and persistence in these disciplines, including:

- Differential experience with spatial tasks and complex problem solving.
- Societal expectations from parents, teachers and peers.
- Gender stereotypes and discrimination.
- Inaccurate information about the variety of career options available in these disciplines.
- Lack of access to role models.
- Beliefs about the role of effort and ability in achievement.<sup>4</sup>

Typical coeducational approaches to science, technology, engineering and mathematics (STEM) undergraduate education are generally unable to address these social and environmental factors. One reason is that the classrooms replicate the “real world” in that they unintentionally perpetuate the gender expectations and stereotypes that make it difficult for women to enter or persist in these disciplines. Additionally, the competitive and individualistic environment often found in mathematics and natural science classes may cause women to feel discouraged and seek out other educational environments in which they can foster relationships with their professors.<sup>5,6</sup>



Women-only education from the junior-high level on has had some success in steering women toward the STEM disciplines.<sup>7</sup> At the same time, girls' high schools and women's colleges have become rarer and less desirable as women in general have had greater access and success in higher education. Even if more women chose women's colleges as an option, the approach has limits. While it can reduce stereotypes, provide numerous role models and build confidence, it can't replicate the "real world" women will encounter after college or the kinds of challenges a learning and working coed environment present.

Our project exploits the unique educational environment of the College of Saint Benedict (CSB) as a means of providing controlled inoculation against, and exposure to, the societal and environmental pressures that discourage women in mathematics, physics and computer science. It is a model that can be replicated in typical coeducational college environments.

CSB is a private liberal-arts college that enrolls 2,000 traditional college-aged women. It shares a single, joint curriculum and faculty with Saint John's University (SJU), a primarily undergraduate institution that enrolls 1,850 men. The two schools share academic departments in every discipline, and have identical academic calendars and degree requirements. All students take classes together on both campuses but live on separate residential campuses. The unique structure of CSB and SJU allows the institutions to focus explicitly on gender development for women and men. Students intentionally reflect on gender, gender stereotyping, fairness and equity.

Even in an environment that keeps gender issues front and center, the educational and professional choices of the students mimic national trends. To improve the representation of women in STEM fields, in fall 2009, CSB started the Math, Physics, Computer Science Research Scholars (MapCores) program. The MapCores program uses scholarship support, special curricular offerings and research opportunities to increase the success of women. CSB enrolled three cohorts into MapCores starting in fall 2009, and the National Science Foundation is supporting the cohorts that started in 2010 and 2011.



## **Curricular Opportunities**

The MapCores program has curricular portions throughout the student's career at CSB designed to prepare students to thrive in STEM careers. The curricular portion of the program not only helps students learn skills that will help them in their careers, but also fosters a supportive cohort. MapCores students make connections across mathematics, computer science and physics major boundaries that they might not otherwise have made. This is crucial because the support of peers is a key factor in the persistence of women in STEM fields.<sup>8,9</sup>

In their first year of MapCores, students take a special version of First Year Seminar (FYS), which is CSB and SJU's replacement for the traditional introductory courses in English and Speech that are taught at many institutions. It is a year-long course in which the students remain with the same group of students and faculty members throughout the year and are taught skills in four main areas: writing, presentation, discussion and critical reading. Each FYS has a particular topic for the material to be used in the class. Typical FYS sections have an equal split of male and female students.

The students' topic is science in the broad sense, including readings in mathematics, physics, computer science, the philosophy of science and women in science. It also includes exercises in thinking scientifically. For example, much of the first class period is spent doing Fermi estimates for problems, such as determining how many blades of grass are in a typical lawn or what fraction of the United States is covered in hard, artificial surfaces, such as roofs and pavement. The authors of this article also serve as advisors and aid the students in determining their schedules and their career options.

As sophomores and juniors, along with their usual course loads, MapCores students take special one-credit classes. These courses are intended to build the students' skills, confidence and interest in science by working on exciting interdisciplinary topics. Note that the sophomore and junior seminars require some knowledge of all of our fields, so students should take courses in all three fields, in addition to their major. Furthermore, the courses build on the supportive cohort that was established in the first year. Particular emphasis in these seminars is placed on more advanced analytical thinking and presentation skills. Students periodically report



their results to class, and at the end of the year each student presents a poster about one of her projects at the campus-wide Celebrating Scholarship and Creativity day.

The one-credit class for the sophomore year is called Problem Solving Seminar. In this course, students are given two to three weeks to solve various problems in groups of three. The problems for this course have included the following: programming robots to follow paths, soldering electronics projects, simulating simple biological ecosystems and analyzing the probability of occurrence for several types of mass extinction events.

In the junior year, the one-credit course is called Research Seminar. In this course, students work all semester on one project. One of the goals of this class is to prepare students for their yearlong senior thesis project. Projects for this course have included modeling of complex ecological systems, the human perception of color constancy, geolocation by GPS and sextant, and building and testing a touchscreen painting program.

As seniors, the students complete theses and present their results to the faculty and to general public on Scholarship and Creativity Day. Senior theses require a year-long program of research, and we expect many students to go on to present at various professional conferences.

Students are strongly recommended to complete at least one summer research program at CSB or elsewhere. This experience is beneficial for their future careers and can lead them to a good topic for their senior research projects.

### **Scholarships and recruitment**

Choosing the students for MapCores is a key to the success of the students and to the program. The goal is to recruit a diverse mix of students our program can help prepare for careers in mathematics, computer science or physics. Ideally, there would be an equal mix of mathematics, computer science and physics majors, but many more applicants are interested in mathematics, so a majority of incoming students intend to major in that area. CBS tries to balance its cohorts in other ways, including race and ethnicity, financial need and whether they come from a city, suburb or rural hometown.

*ASQ Higher Education Brief* June 2012 (Vol. 5, No. 3)

[www.asq.org](http://www.asq.org)



The selection process involves close coordination with the admissions department. It starts by mailing and emailing information about the MapCores program to all applicants to CSB who express an interest. Then, their admission applications are examined to determine potential candidates to proceed to the interview. Next, each interested applicant is interviewed on campus. In a handful of cases, phone or video chat interviews are used. Finally, a meeting is held to decide whom to invite into the program.

Deciding who to invite into MapCores is a complicated process. As described above, diversity is valued, as are students who think the program can help them succeed. Student readiness is determined based on student transcripts, test scores and interviews of the students, which are used to gauge how serious the students are about careers in our fields, as well as how well they have taken advantage of their opportunities to prepare themselves for technical careers.

After students have agreed to be in MapCores, the requirements for remaining in the program are simple. They must maintain adequate progress toward a mathematics, computer science or physics major, and they must take the MapCores-specific course work mentioned earlier.

## **Results**

MapCores has worked well thus far, and the first cohort of MapCores students is scheduled to graduate in 2013. The program has three main objectives:

1. Increase women's participation and persistence in the fields of mathematics, physics and computer science.
2. Include women as junior members of the scientific community.
3. Strengthen women's academic confidence and interest in the targeted disciplines.



The cohort approach has succeeded in building connections among students across mathematics, computer science and physics majors starting in their first year, and continuing through their college careers.

Despite this success, it is inevitable that some program attrition occurs. Students have left the program for a variety of reasons, and some of these variables cannot always be controlled. For example, some students leave CSB for financial reasons or because they want to get started on an engineering career sooner than they originally planned. Others have decided to go into other majors such as chemistry and accounting. While MapCores strives to attain a 100% retention rate, this goal is not realistic. However, our research has shown that MapCores women are less likely to withdraw from any of the emphasized disciplines compared with those not enrolled in the program.

The cohort that began in fall 2009 started with 12 students and dropped to nine students by the end of their first year. Of the nine seniors, five elected to pursue graduate school, and the remaining students will have a computer science career or actuarial science career. These numbers are significantly higher than what is typical for any of the other female majors in a given graduating class.

All of these students currently have summer internships or are participating in Research Experiences for Undergraduates (REU), and have their senior theses lined up for the fall. Of this group, the primary major is mathematics for five of the students, computer science for three of the students and physics for one of the students, though the majority of the students have a secondary major or minor in one of the other MapCores disciplines.

The cohorts starting in fall 2010 and fall 2011 each started with 18 students. The fall 2010 cohort dropped to 15 students by the end of their first year and to 13 by the end of the second year. The fall 2011 cohort was down to 12 students at the end of the first year. Of those in the fall 2011 cohort, three have internships or an REU. It is not typical for students to participate in summer research after their sophomore year.



Past research suggests that providing women in STEM disciplines with strong mentoring can increase women's persistence in these fields.<sup>10, 11</sup> The MapCores students reported higher levels of mentoring than non-MapCores students, which suggests the program is providing students with strong mentoring. Having the three faculty members attend every FYS class has led to the MapCores students perceiving they have multiple mentors and advocates on campus, although that hasn't been formally tested this assertion.

Past research has also suggested that women who feel isolated and who lack support are more likely to leave STEM disciplines than women who feel strong social support and a sense of community in their chosen discipline. Additionally, having high self-esteem has been associated with positive academic outcomes.<sup>12</sup> The MapCores women reported moderately higher levels of perceived social support than non-MapCores students and much lower levels of loneliness than non-MapCores students. These feelings of support and lack of feelings of isolation suggest the cohort model may help students persist in the STEM disciplines.

The MapCores students also had higher self-esteem levels than non-MapCores students. Our intention was to have cross-cohort mentoring in addition to faculty mentoring to assist with retention, as well as self-efficacy. But the difficulty in making this occur as frequently as hoped, especially given that MapCores women are ambitious, is actually a positive attribute. Program leaders are currently devising methods of interaction that will respect the students' time and also improve the communication across graduation classes.

There are some additional benefits to the MapCores program that were unforeseen. Several non-MapCores women who have remained in mathematics, in particular, have elected to participate in summer research programs or continue to pursue pre-engineering as a result of bonding with the MapCores women. The program's participants have created a positive, strong and directed group that is inclusive of all women who have similar academic goals. Therefore, CSB expect more women to elect to persist in mathematics, physics and computer science in the future.



## Acknowledgements

*This material is based on work supported by the National Science Foundation under Grant No. 0965705. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.*

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