

CHAPTER 11

Enriching a Culture of Research: Expanding Opportunities to a Broader Community

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Pursuing Targeted Initiatives

The theme that “scientific learning is best achieved by doing science” permeates the curriculum in the Division of Natural and Applied Sciences at Hope College.² For approximately 85 percent of our science, technology, engineering, and mathematics (STEM) majors, working side-by-side with a faculty member on an original research question is a key part of a challenging and personalized learning experience.

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² Hope College is a four-year liberal arts college with an enrollment of about 3,200 full-time undergraduate students.

In recent years, Hope College's faculty and administrators have become concerned about enrollments in several areas. Few of the high school students enrolling in our STEM programs are from underrepresented groups, and we have not attracted many transfer students into our STEM programs. Despite a nationally recognized teacher-education program, the numbers of students preparing to be science and math teachers are surprisingly low.

In order to broaden the participation of students in the STEM disciplines, as well as build on our historic strength of collaborative and productive student-faculty research experiences, Hope College has created a suite of programs designed to attract, retain, and graduate a more diverse group of students with STEM majors. The four programs listed in Table 1 are a direct outgrowth of the Division of Natural and Applied Sciences Vision 20/20 strategic initiative.³ They constitute Hope College's comprehensive and connected approach to broadening participation by providing students in high school, two-year colleges, four-year colleges, and pre-service teacher programs with meaningful research experiences in STEM disciplines. All four of these

Table 1. Programs Designed to Broaden Participation in Research

Program	Program creation	Targeted Participants	Number of student participants
HHMI Science Education Scholars Program ^{a)}	Fall 2004	Hope College undergraduate students interested in science or math K-12 teaching careers	2005—5 scholars 2006—6 scholars 2007—8 scholars 2008—5 scholars
Project REACH ^{b)}	Fall 2005	Holland-area high school students	2006—11 students 2007—12 students 2008—13 students
STEM-ENGINES Undergraduate Research Collaborative ^{c)}	Spring 2006	Two-year college students interested in STEM fields and possibly transferring to a four-year college	2006—3 students (pilot program) 2007—5 students 2008—4 students
S-STEM Scholars ^{d)}	Fall 2007	Two-year college students who will transfer to Hope College	2008—7 scholars

a) Kathy Winnett-Murray (biology) serves as the SciEd Scholars Coordinator.

b) Karen Nordell Pearson (chemistry) serves as the REACH Director.

c) Kenneth Brown (chemistry) serves as the URC Coordinator.

d) Herb Dershem (computer science) serves as the S-STEM Scholars Coordinator.

³ For more on the Vision 20/20 strategic initiative, see www.hope.edu/academic/natsci/missionvision.htm. Accessed March, 2008.

programs benefit from the widespread support by students, faculty, and administrators at Hope College and also by many partnering individuals and institutions.

Serving Pre-service Teachers

In the fall of 2004, we launched the Howard Hughes Medical Institute (HHMI) Science Education (SciEd) Scholars program. We believe that it is critical for K-12 science teachers, who have the potential to positively impact large and diverse numbers of K-12 students, to have first-hand knowledge of the investigative process.

Our approach is to engage future K-12 teachers in a combination of research activities and science-curriculum development. The goals are for SciEd Scholars to develop a better understanding of how scientific knowledge is constructed and of the parallels between teaching science and doing science (e.g., inquiry, elements of investigation, learning cycle, evaluation of evidence, etc.).

Recruiting and Selecting Participants

Program information is circulated to both students and faculty members throughout the science and education departments. Personal invitations extended by faculty members teaching General Education in Mathematics and Science courses, which are typically populated by younger students with undeclared majors, are very effective in recruiting applicants from a pool of students who typically do not perceive such opportunities as being relevant or available to them.

SciEd Scholars are selected by the HHMI steering committee,⁴ based upon career goals and interests, their written perspective on how participating in the program will prepare them for a teaching career, a description of the types of curriculum-development and research projects the applicant plans to engage in during the summer, GPA, and letters of recommendation.

Connecting Research and Teaching

Supported by stipends for 10 weeks during the summer, SciEd Scholars are involved in the research activities occurring in their mentors' groups and departments. Scholars regularly interact with other summer research students and make short presentations to departmental research groups.

Starting in 2006, some of the SciEd Scholars have been involved in teaching Hope College's Summer Science Camps for K-8 children. These students develop specific questions about children's science learning and collect data to help answer those questions during the course of the science camps. Other SciEd Scholars assist with

⁴ The HHMI steering committee is composed of the HHMI Program directors and faculty representatives from the departments in the Natural and Applied Sciences Division and the Psychology and Education Departments.

local school programs and/or science activities hosted by Hope College faculty members for K–12 students and teachers. Often these activities have been co-developed by the Hope College faculty mentor, the K–12 teachers, and the SciEd Scholars.

Although it is not required, many of the SciEd Scholars combine their research projects with curriculum-development components. For example, one student studied the competition for pollination in autumn olive shrubs and developed curricular activities on plant life cycles. Another student studied the toxicity of copper in the sediment of local suburban ponds and developed related activities on pond pollution. A few SciEd Scholars worked on the development of interdisciplinary case studies to be implemented at the high school and college levels. The projects of the SciEd Scholars who have worked with the science camps have included studying the perceptions of children and parents concerning science learning and the assessment of children's learning styles. By participating in and thinking critically about both doing and teaching science and math, SciEd Scholars are becoming better equipped to understand and articulate the connections among the STEM fields.

Engaging with the Teaching Community

Perhaps the most important aspect of our SciEd Scholars program is that it encourages pre-service teachers to become professionally involved with other science-education professionals during very early stages of their careers in science education. The program was developed and implemented with significant input from area K–12 teachers. They have enhanced and extended the program by being involved in ways ranging from co-directing the entire summer program to leading mentoring meetings and conducting workshops. The in-service teachers receive honoraria for their participation.

SciEd Scholars and at least one of the K–12 teacher-mentors meet weekly for discussions or workshops on topics related to teaching. Typically, these meetings involve an informal lunch followed by a discussion with, or workshop presentation by, the guest teacher on topics including writing in science, interviewing, and understanding the Michigan State Science Standards. These workshops have involved nine guest K–8 teachers from nine different schools or organizations in western Michigan. Students never run out of questions to ask of these “real life models” about their own prospective careers. Based on the scholars' evaluations, being part of a community with current teaching professionals plays an important role in their summer experiences and their decisions about careers.

Funding SciEd Scholars

The SciEd Scholars program has been fully funded through the HHMI award to Hope College in 2004. The four-year grant covers stipends, supplies, and travel for the scholars, stipends for the coordinator, and honoraria for the in-service teachers

who come to present workshops. With the demonstrated early success of the SciEd Scholars program, we anticipate supporting an expanded program for four more years as part of our 2008 HHMI award, which has an even stronger focus on science education.

Demonstrating Outcomes

Of the 10 scholars who have graduated, seven are in teaching positions. Post-program evaluations reveal that students gained confidence in their teaching and research skills far beyond their experiences in previous science-methods courses. Nearly every participant described how valuable the combination of research and curriculum-development experiences was to their future teaching careers. Three student publications are in preparation, and 16 of the 19 scholars have presented to other educators at professional meetings.

A significant, but unanticipated, benefit of the SciEd Scholar program has been the increased awareness among faculty members and students in the Division of Natural and Applied Sciences of the value of putting pre-service teachers “into the research spotlight.” Not only has this enhanced the self-confidence of the SciEd Scholars, but it has visibly included them in one of the most distinctive aspects of Hope College’s STEM program. This sends an important message to the entire Hope College community that preparing leaders in science education is “on a par” with preparing pre-medical students, pre-graduate students, etc.

Reaching Out to High School Students

Informed and inspired by our participation in the HHMI-initiated Symposia on Diversity in the Sciences⁵ in the fall of 2005, we launched a program called Project REACH (Research Experience Across Cultures at Hope). The goal is to provide meaningful research experiences for high school students who plan to study one of the STEM disciplines in college. Project REACH is loosely modeled after the HHMI-supported Meyerhoff Scholarship Program at the University of Maryland, Baltimore County.⁶ It invites students from Holland-area high schools to come to Hope College for a paid five-week summer research experience.

Recruiting and Selecting Participants

Area high school students, usually rising juniors and seniors, apply to Project REACH by submitting answers to a short questionnaire, a one-page essay, a letter of recommendation from a teacher or counselor, and their current transcript. Brief project descriptions from faculty mentors are posted on the REACH Web site, and students indicate their interest in up to three research projects.

⁵ Symposia on Diversity in the Sciences was held at Harvard University, Cambridge, Massachusetts, November 18 and 19, 2005.

⁶ For more information, visit www.umbc.edu/meyerhoff.

Since one of the goals of Project REACH is to provide research opportunities for underrepresented students, at least fifty percent of the positions are allocated accordingly. Despite being a majority Caucasian community, Holland-area schools have many African-American, Latino/Latina, and Asian-American students. For the purposes of this program, any student who is non-Caucasian is considered underrepresented.

We are most interested in students who express an interest in STEM research and who are recommended by their teachers as hardworking, well-prepared, and eager for this opportunity. While there is no minimum GPA requirement, most applicants have GPAs above 3.00. Although we are interested in high-achieving students, we have found that this experience can be inspiring and transformative for students with a variety of educational experiences and expectations. This makes selection challenging, but we balance what the students write in their essays with their GPAs and the recommendations of their teachers, in order to select students who are well-suited for the opportunities and challenges of each research project.

Students are selected by an advisory committee composed of the program director, the dean of the Division of Natural and Applied Sciences, a member of the admissions staff, a member of the staff of the Multicultural Education Office, and the faculty members who have agreed to be research mentors. Many of Hope College's most active and productive faculty researchers choose to mentor these students even though they do not receive any additional compensation. Mentors are recruited by the REACH Program Director.

Taking a Holistic Approach

Project REACH students become members of their faculty-mentor's summer research group, with their own or shared projects to focus on during the five-week summer session. Project REACH also provides participants with career-development opportunities, including working alongside current undergraduates, field trips to local businesses, workshops on scientific communication and ethics, and sessions on applying to college and securing financial aid.

In addition to inviting the students to participate, we engage their parents or guardians by inviting them to an opening luncheon, where they meet the faculty mentors and tour our STEM facilities. Parents or guardians also are invited to a Celebration Luncheon at the end of the five weeks. At this event, students present short seminars on their research projects. Teachers, principals, other high school administrators, and civic and business leaders are also invited to the luncheon.

Funding Project REACH

The commitment to this program has been shared across campus. To date, Project REACH has been supported by a combination of sources, obtaining funds from the

provost's and dean's offices, external awards or supplements to individual investigators or departments, and departmental research and discretionary budgets. For the next four years Project REACH will be supported through Hope College's 2008 HHMI award.

Demonstrating Outcomes

Project REACH is fostering students' pursuit of higher education, as well as contributions to the literature. All 18 students who participated in 2006 and 2007 currently are or are planning to attend college. Six students have contributed to five manuscripts.

Of the 18 students, 10 are from underrepresented groups. In their post-program evaluations, seven of the 10 said that their research experience had significantly impacted their interest in pursuing a career in science. Five of these 10 participants said that their research experience had significantly impacted their decision to attend college.

All five of the Project REACH participants from underrepresented groups who have since graduated from high school are enrolled in college and at least four of them are majoring in science. We are delighted that four of these five students are enrolled at Hope College.

The word about Project REACH is getting out. In 2008, we received a record 59 applications. Nearly half of the applicants are female, 21 of the applicants are from underrepresented groups, and five of the applicants participated in the program in 2007. We selected 13 students to participate in Project REACH during the summer of 2008.

Collaborating with Two-Year Colleges

In early 2006, Hope College joined with a group of more than 10 two-year and four-year colleges to create a National Science Foundation-funded Undergraduate Research Collaborative (URC). The Science, Technology, Engineering, and Mathematics-Engaging the Next Generation IN Exploring Science (STEM-ENGINES) URC aims to increase the number of students obtaining baccalaureate degrees or advanced graduate degrees in STEM disciplines (see Insight B). This program specifically targets students from two-year colleges to participate in research during their first or second years as both motivation and preparation for matriculating to a four-year college. Thomas Higgins at Harold Washington College, a two-year college in Chicago, serves as principal investigator.

Piloting the Concept

In early 2006, six months before the proposal was submitted to NSF, faculty members from Hope, Harold Washington, and Harper Colleges discussed student research

opportunities. Three two-year college students applied for and were accepted to participate in Hope College's 2006 summer Research Experiences for Undergraduates (REU) program. That same summer, a Hope College REU student participated in research at Harold Washington College. We were delighted by the success of these URC pilot projects and moved forward with the collaborations. The research projects are still active at all three colleges, and two manuscripts from these collaborations are in preparation.

Recruiting and Selecting Participants

The summer of 2007 marked the official beginning of Hope College's STEM-ENGINES URC involvement, with five summer students. A second set of summer students was scheduled to participate in 2008. The director of Hope College's URC program works closely with faculty members at the two-year colleges to review applications and select students who show potential for success in research.

One important feature of our STEM-ENGINES URC activities is a visitation weekend each spring funded by Hope College. The selected students tour the campus and the research facilities and meet with their research mentors. During this weekend, the research mentors work one-on-one with students to provide background information and literature about their research projects. Our hope is that through the visits, the participants will be better prepared and more comfortable when they arrive early in the summer.

During the 10-week research experience, URC students work alongside other undergraduate and high school students doing research. The URC participants take an online ethics course, participate in safety training, participate in a scientific-ethics workshop, and give a short presentation about their research to faculty members and students in their department.

Funding Two-Year College Students

A supplement to the chemistry department's NSF-REU grant provided much of the funding for the pilot summer in 2006, while Hope College funded the student and faculty visits to campus and covered the housing costs for three summer research students. The NSF award began covering most of the costs for the summer program in 2007. The exception is the weekend visit in the spring, for which students cover their own travel costs and Hope College provides the meals.

Demonstrating Outcomes

On their evaluations, STEM-ENGINES URC students commented that the research experiences solidified their desire to pursue a four-year degree and, in some cases, to pursue an advanced degree in a STEM discipline. Of the three students who did research at Hope College during the pilot program in 2006, one has transitioned into medical school, another is working in the chemical industry, and the third transferred

to Hope College in January 2007, where she is one of the top chemistry majors. Three out of the five 2007 URC participants applied for admission to Hope College, and two of these students are now enrolled as science majors. The other two 2007 participants have been accepted into other baccalaureate programs. Additionally, one of the STEM-ENGINES URC students who conducted research at another institution transferred to Hope College in the fall of 2007.

All five of the 2007 participants have continued their involvement with undergraduate research. Two manuscripts have been published with three student co-authors, and more than 10 presentations have been made at conferences.

As we had hoped, the relationships that have developed among faculty members at Hope, Harold Washington, and Harper Colleges have enhanced the STEM-ENGINES URC by maintaining research connections between the colleges throughout the academic year and by helping recruit participants for the summer research programs. Currently, three faculty members at Hope College and one faculty member each at Harold Washington and Harper Colleges maintain ongoing research collaborations.

In 2008, 15 students from two-year colleges applied to Hope College's URC summer research program, and four participants were selected. Of these four, three are non-traditional students, including a married couple.

Supporting Transfer Students

In 2007, Hope College received funding from the NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Scholars program. The goal is to further diversify the national STEM workforce by providing scholarships, mentoring, and research opportunities for students transferring from two-year colleges to Hope College to complete their baccalaureate degrees in a STEM discipline. Having spent much of 2007 and early 2008 developing relationships with faculty members and students at six regional two-year colleges, we are hoping to attract as many as eight transfer students per year for the next three years.

Recruiting and Selecting Participants

Like the URC program, the S-STEM Scholars are students from two-year colleges, many of whom are non-traditional students. However, the students selected as S-STEM Scholars have been accepted to Hope College and awarded two-year scholarships of up to \$10,000 per year. While scholarship recipients must be adequately prepared to transfer into a Hope College science program, the determination of the scholarship recipients is not solely based on academic merit. Rather, the criteria for selection include the difference the scholarship will make in the ability of the student to pursue a degree and a career in a STEM field and the potential the student has

to increase the diversity of the STEM workforce, either directly as a member of an underrepresented group or indirectly as a STEM educator who will reach underrepresented populations.

Focusing on Research

An important feature of the S-STEM Scholars project is that each participant is offered a paid summer research position in the student's chosen STEM discipline for the summer prior to enrolling at Hope College. Most of them will live on campus, they will get to know many students and several professors through their research experiences, and they will have the opportunity to form a cohort group with the other S-STEM Scholars. By being part of our summer research program, the S-STEM Scholars will become part of the community of more than 200 students and faculty members on Hope College's campus each summer who are conducting research in a STEM field. We hope that this will help the transfer students make a successful transition to our academic and student-life environments.

Providing Ongoing Mentoring

After S-STEM Scholars begin their studies at Hope College, they will be given extensive mentoring from faculty members and peers. This mentoring will assist students in dealing with challenges such as adjusting to a residential-college environment, being unfamiliar with the campus culture, or being a non-traditional student. The cohort of S-STEM Scholars will meet regularly to talk about their experiences and support each other. Current students who transferred to Hope College from two-year colleges have already volunteered to be part of these mentoring groups.

Funding S-STEM Scholars

The NSF S-STEM award provides the scholarships and a portion of the summer research support for each S-STEM Scholar, as well as a stipend for the coordinator. Through the dean's and provost's offices, Hope College is committed to providing the remaining funding for the summer research stipends, summer housing, and additional academic advising and mentoring support during the academic year.

Demonstrating Outcomes

In the program's first year, we have already enhanced the diversity of our student body in STEM disciplines. Of the seven 2008 S-STEM Scholars, six are females and four are non-traditional students who did not pursue full-time college education directly after high school. We have also built bridges between programs, with one participant in the 2007 URC program becoming a 2008 S-STEM Scholar. This program is also fostering relationships with faculty members and students at regional two-year colleges.

Connecting and Strengthening Programs

Dedicated faculty members, administrative commitment, and support from various agencies have led to this suite of programs. They are the beginning of a long-term

and evolving plan to strategically attract, recruit, retain, and graduate a more diverse pool of STEM students. Our next steps are to share strategies, leverage resources, and develop a culture to sustain our efforts.

Coordinating Activities

We hope that sometime during the 2008-2009 academic year, we can hire a STEM Director for Diversity Programs who will help connect and strengthen all four of these programs. This person will strengthen faculty- and peer-mentoring, professional development, and other transitional support aspects of these programs so that all the participants are ready for success beyond these research experiences.

Increasing the Effectiveness of Mentoring

All four of these programs involve faculty-mentored research opportunities for participants. While all of our faculty members have experience in mentoring undergraduate students, participants in this suite of programs have varying backgrounds and perspectives. Faculty members receive training on cultural sensitivity through best-practices workshops sponsored by the Office of Multicultural Life. Since many of the students, especially those still in high school or from two-year colleges have not had a rich background in science and math, research projects need to be tailored to their level of preparation, and faculty members may need to commit additional time to providing background context and training in the conduct of experiments. Since a single faculty mentor is often not familiar with both research and curriculum development, we need to find mentors for the SciEd Scholars in both the STEM and the education programs.

Extending the Network of Funding Sources

Generous funding from external agencies and foundations, along with significant financial contributions from Hope College, supports each of these four programs. To date we have been able to find the resources to support student research stipends, small budgets for supplies for the research projects, and the "extra" program costs such as visits, meals, and workshops associated with these programs. Efforts are under way to provide support for faculty mentors, as well as for the continuation of these programs after the grant periods are completed.

Fostering the Integration of Research Programs

We are using a multi-pronged approach to address concerns about low enrollments in key areas. Due to the relative newness of these programs, they are not yet fully integrated into the structure and culture of our collective undergraduate research activities. Most faculty members still consider working with participants in these programs as something extra or on top of their work with other students in their research groups. By securing the funding to continue these programs, however, we anticipate that they will be woven more tightly and seamlessly into the fabric of our scientific community.

Related Contributions

	Chapters	Insights
Type of institutions		
Primarily undergraduate institutions	5, 10, 11, 12, 14, 20	F, J, K, N, O
Two-year college programs	6, 7, 8, 11	B, C, G, L, M
Targeted recruitment		
Underrepresented ethnic and racial groups	5, 10, 11, 16, 17, 18, 19, 20, 21	E, F, I, N, P
First- and second-year students	6, 7, 8, 9, 11, 13, 15, 16, 17	A, B, C, D, E, G, J, L, M, O, P, Q
Transfer students	6, 7, 8, 11, 15, 16	B, M, P
High school students	11, 12, 14, 17, 20	
Pre- and in-service teachers	11, 12, 14	
Other design principles		
Continuous evaluation	5, 9, 11, 14, 15, 16, 18, 19, 21	A, J, O, Q

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⁷ Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.