

CUR Focus

Novel Transdisciplinary Undergraduate Research Provides A Developmental Pathway

The Mayo Innovation Scholars Program (MISP) is a six-month research program that provides unique and challenging opportunities for multidisciplinary teams of undergraduates majoring in economics, business, or STEM (science, technology, engineering, mathematics) fields to evaluate a product or innovation in biomedical technology for potential transfer to market. MISP was created in 2005 by John Meslow, a retired executive from a medical device company. He envisioned a program that would afford outstanding undergraduates the opportunity to work in teams led by graduate students to analyze real innovations in biomedicine developed by professionals at the Mayo Clinic, and thereby provide valuable analyses to Mayo Clinic innovators. With grants from the Medtronic Foundation and administrative support from the Minnesota Private College Council, each year Meslow and his staff work with project managers at Mayo Clinic Ventures, the Center for Innovation, and other clinical departments at Mayo Clinic to select suitable projects. Now in its seventh year, more than 300 students from 11 Minnesota private colleges have discovered the potential of invention and entrepreneurship through this investigation of translational medicine.

MISP has evolved into a flagship program that regularly receives positive feedback from participants, advisors, and the Mayo Clinic. At the beginning of each fall semester, project descriptions from the Mayo Clinic are distributed to colleges. Because these projects are innovations under development, protection of this intellectual property is an essential component of MISP, and each participating individual and institution signs a nondisclosure agreement. Faculty advisors on each campus select projects offered by Mayo Clinic. These may be medical devices, procedures, novel applications of existing drugs or technologies, service programs, or other innovations. Each campus has autonomy in the criteria and application process used to select students. All work completed by the teams remains sole property of the Mayo Clinic and protected by confidentiality agreements in perpetuity.

Typically, teams consist of two students majoring in STEM fields and two majoring in business, economics, or marketing. Undergraduate participants receive a \$1,000 stipend for their work, and at the discretion of each institution, may also receive academic credit. Participating institutions also provide one or more faculty mentors who receive a total

faculty stipend of \$1,000. Importantly, faculty mentors serve as resources and guides for teams, but do not *lead* teams. Instead, the team leaders are graduate students in business management or organizational leadership at one of the participating private universities. Thus, MISP also serves as an experiential learning opportunity for graduate students who are responsible for communicating with Mayo Clinic project managers and leading the undergraduate teams in meeting the deliverables set by the Mayo Clinic innovators. Typical deliverables include analyzing the competitive market landscape, determining market potential (SWOT), and recommending a developmental and financial strategy, if appropriate, for the proposed innovation. Additional deliverables specific to each innovation may also be requested.

MISP director John Meslow and academic program director Elizabeth Jansen work together with administrative support to oversee the program and its annual budget of \$100,000.

Program Outcomes, Format

Since its inception, MISP has met its three principal outcomes. First, the program seeks to assist the Mayo Clinic in the assessment of new innovations or products developed by Mayo Clinic researchers. Delivering consistently high-quality research from the teams is imperative to achieving this outcome and to the continuation of the program. Secondly, MISP provides applied research opportunities for science and business students in a format that is novel for undergraduates. In addition to increasing competency in their respective disciplines, students work collaboratively to share their knowledge and research methodologies *across* disciplines, recognizing they are working on innovations in a dynamic business environment. Finally, MISP aims to provide leadership-development opportunities for graduate students. In meeting these three objectives, MISP creates transformative, "transdisciplinary" experiences for students and delivers useful analyses to the Mayo Clinic for innovations under development.

MISP kicks off each October with an orientation at the Mayo Clinic geared especially for participating undergraduates and the graduate students leading the teams. This one-day event occurs shortly after teams have conducted preliminary background research. During the orientation, students learn about the history of the program and the Mayo Clinic, are

introduced to Mayo Clinic intellectual-property experts and project managers, receive general information on patents and intellectual property, tour the Mayo Clinic, and meet with the inventors of their project.

A key learning component and challenge for teams is the initial ambiguity inherent in the projects. Teams are provided with a brief synopsis of the innovation and a general description of the desired deliverables. The orientation meetings are crucial, providing the teams with the opportunity to ask thoughtful questions of the project managers and inventors. Teams return to their home institutions ready to fully dive into the research, exploring the relevant intellectual property, patents, peer-reviewed publications, competing technologies in the marketplace, and ethical considerations. They explore the potential scope of applications for the proposed innovation, evaluate the market space, identify potential licensees if appropriate, and assess options and recommendations for next steps.

Each team decides how to structure the timing of its workload. Some colleges with a January term conduct the bulk of the research during that month, while other campuses spread the work over several months. Depending on the nature of the innovation under study, some teams may primarily conduct online research, while others administer surveys or interview patients, caregivers, or healthcare or industry professionals. Teams may also consult with ethicists to explore potential ethical considerations. The projects culminate in March when each team submits a comprehensive written report that includes the discovered strengths and weaknesses of the innovation, opportunities and threats for the innovation in the market space, and the team's recommendation for next steps. Importantly, teams are aware that a recommendation *not* to proceed with development is an optional conclusion; each year typically brings in a "no go" recommendation. Teams also deliver an oral presentation at the Mayo Clinic outlining their project, approach, research, and recommendations to an audience of their peers, mentors, physician-scientists, and Mayo Clinic inventors and intellectual property experts. The question-and-answer sessions following presentations are often a highlight for teams and Mayo Clinic professionals.

While the MISP staff has been successful in securing program funding, each year brings new challenges to acquiring financial support. The Mayo Clinic covers the costs of presentation days and some travel, and participating colleges cover other costs associated with travel, but stipends and the vast majority of the research expenses have been supported by a grant from the Medtronic Foundation. Another challenge is working with 11 different academic calendars, as well as the schedules of graduate students and Mayo Clinic professionals. This makes scheduling the fall orienta-

tion and spring presentation days particularly challenging; however, 100 percent of student participants have taken part in these events each year. Because campuses are located throughout the state, another challenge is that the graduate student team leaders may live a considerable distance (up to 250 miles) from their undergraduate teams. Dedication and creativity are therefore required to build team dynamics and maintain strong communication. This particular "real world" challenge is usually addressed via a combination of voice and video conference calls, emails, and face-to-face meetings. Finally, because of the nature of the intellectual property and the length of time required for an innovation to make its way to market, feedback on outcomes and future directions of projects is slow to make its way back to teams. All of these features mirror the real-world technology-transfer environment.

Outcomes

Despite the challenges associated with managing MISP, it has been an overall success, with improvements implemented each year. Regarding the first MISP objective—to assist the Mayo Clinic in assessing new innovations—the response has been positive. Mayo Clinic inventors and project managers have provided feedback on the program, including the following anecdotal examples of MISP's impact:

- The inventors of one product continue to utilize the 75-page report from their MISP team in meetings with investors. They are now preparing to bring their product to the marketplace, and they credit this report with helping them communicate the potential of their product to investors. The investors have been impressed!
- One inventor identified a new direction for a project based on the MISP team's report and described how the team had suggested additional applications and approaches to the innovation. The MISP team opened the investigator's eyes to new applications for the technology, which are being added to the development plan.
- A project manager described the benefits of the teams' reports this way: Students have the luxury of being able to dive deeply into a field and paint a nuanced picture of the landscape in which the project resides. With hundreds of projects in development at any one time at the Mayo Clinic, this is the kind of in-depth look that professional project managers often do not have time to conduct. The project manager also appreciates that he can refer to teams' reports for background materials when working on related projects or innovations.



John Meslow, MISP director, gets a presentation from project participants at Concordia College.

To assess the second and third outcomes related to, the educational impacts on undergraduates and leadership-development opportunities for graduate students, each year the undergraduates, the graduate students who are team leaders, and campus faculty mentors are surveyed in order to gauge successful aspects of the program and to identify areas for improvement. The electronic surveys are administered by the Minnesota Private College Council and include bipolar interval questions on a 5-point Likert scale, as well as open-ended questions.

Undergraduates are asked to rate their experience overall; the role and value of the graduate student team leader, faculty mentor, and Mayo Clinic project manager; the value of MISIP to their academic experience; and the value of the activities at the Mayo Clinic during orientation and presentation days. Graduate students are asked similar questions along with their rating of the undergraduates' work and the impact of the program on their own leadership development. Faculty mentors are queried for ways to improve the program and asked to rate the quality of the educational experience for their students, the value of the team leader and project manager to the outcomes of the project and to interactions among members of the team, and the value of the orientation experiences for faculty and students.

All 40 undergraduate participants completed the 2011-12 survey. On a scale from 1 to 5 with 1 = poor and 5 = excellent, the mean rating inclusive of all categories related to the program was 4.42 (SD = 0.36). Thirty-eight of the 40 students elaborated on their rating of the value of the program to their academic experience. Several students acknowledged the challenging nature of the work, but all the comments received were positive. The following are representative remarks from undergraduates:

- "As a student studying Nursing and Management, this program perfectly bridged both disciplines. It also helped me to realize the multifaceted methods of inno-

vation at Mayo Clinic. I plan to integrate these ideas into my career plans and intend to do similar work in the future."

- "The MISIP provided a unique opportunity to learn about the health care industry and in particular the medical device industry from a different perspective. Above all, however, the lessons I learned from working in a team for an extended period of time on such a large project had the greatest impact on me. It was often challenging, but we worked together to accomplish the goals set forth. It was a good experience all around."
- "This program taught me skills and knowledge that I would not have been able to learn in any class. It was immeasurably helpful to have a real-world problem to work with—this was no mere simulation!"
- "In my opinion, this was an incredible academic experience. We got valuable experience in both writing a manuscript and giving a professional presentation."
- "It exposed me to what it would take in the real world to produce a final product."
- "Because all of my previous research involved scientific projects, they ignored all forms of business that would go into developing an actual product. I believe that the business knowledge that I gained from this experience is invaluable and will play an important role in my future as I pursue a career in health."

Seven of the 10 graduate students who were team leaders in 2011-2012 rated the ability of the undergraduates to work independently, meet deadlines, communicate effectively, and work together toward stated goals as "very high" or "high" (mean 4.20, SD=1.08). Moreover, the 20 faculty mentors who responded to the survey gave the highest ratings of the value of MISIP to their students' personal development and academic program, the orientation session, the role of Mayo Clinic project managers, and the graduate student team leaders' interactions with the undergraduates (overall mean 4.64, SD=0.26). In open-ended comments, some faculty mentors summarized the benefits of MISIP as follows:

- "The Mayo Innovation Scholars Program has earned the reputation on campus as being a premier program that provides invaluable experience like no other internship or research program is able to do. For our science students, many of whom are looking toward medical school, this experience is the only opportunity that they have in learning business skills and understanding the economics of biotechnology. Likewise, our economics students have limited exposure to the sciences and generally do not see the connection between

science and business until they have participated in the Mayo Innovation Scholars Program. Nearly every student that interviews for a position after participating in MISIP will comment on how they were able to highlight the skills and knowledge gained, during their job application and interview process. MISIP opens doors for the students as they enter the job market and graduate programs."

- "An open-ended research question, like the one given to the Mayo Innovation Scholars, truly stretches our students. They are, at first, uncomfortable. However, it is amazing to see their confidence and abilities grow as they gain expertise about the medical need and design of the device they are evaluating. Furthermore, being forced to work together as a team, while it holds many awkward moments, is invaluable for top students all used to leading the way on any group project. It was exciting to see their trust and camaraderie grow."

Alumni Ratings

After the program's sixth year, a survey was conducted of 220 alumni who participated in the program as undergraduates. The electronic survey consisted of dichotomous, open-ended, and bipolar integral questions on a 5-point Likert scale and achieved a 58-percent response rate (129 respondents). Alumni were asked to rate MISIP for its value in shaping their decisions in choosing a career path or contributing to their success in pursuing graduate or medical school; seeking employment; performing a job; and feeling a sense of accomplishment. Despite the challenges of tracking alumni during the first few years after graduation, respondents included MISIP alumni from all participating institutions, with a response rate of between 46 percent and 75 percent for each institution. The academic majors represented were evenly distributed among the STEM disciplines, business, economics, and marketing.

When asked the question, "In general, how do you rate the impact of your participation in the Mayo Innovation Scholars Program on your undergraduate experience?" 78 percent reported that the program had a "very high impact" or "high impact" on their undergraduate experience. The follow-up question on the survey asked *how* MISIP impacted their undergraduate experience. The majority of respondents rated several components of the experience as having "very high" or "high" impact, including teamwork (95 percent of respondents), confidence in abilities outside the classroom (79 percent), contribution to an interest in healthcare (76 percent), strengthening of leadership skills (76 percent), and influence on academic choices in terms of course or major selection (33 percent).

Based on these data, the chief impact of MISIP seems to be in skills development. As most of the program participants are high-achieving juniors or seniors, it is not surprising that they may be less likely to change academic focus at this stage of their training. Sixty-six respondents offered comments about the value of the program, all of which were positive and demonstrated that they found the experience with MISIP to be rewarding, educational, and enjoyable. Many alumni described how the program provided a unique chance to apply their learning in a real-world setting, combine disciplines in a way they previously had not been challenged to do, and work together as members of a team. The following are representative comments from undergraduate alumni one to six years after participating:

- "MISIP gave me the confidence to work in a group and be comfortable sharing my ideas. I feel like I gained leadership skills as well as learned to work really well with other students. Although I was already interested in health care, this highlighted an entirely new field that I was not aware of. ... This experience also made me consider going to graduate school, which I am presently attending."
- "The program opened my mind up to the connections between science and business. It also helped me to learn how to think outside of the box and develop relationships between two seemingly different ideas."
- "The fact that MISIP allowed me to delve into the process that an idea needs to go through to become something marketable has actually opened up the doorway to a new career option for me—the biotech industry. Prior to the MISIP experience, I was pretty much only thinking about the academic path; but due to its influence, I believe I should consider the industry path too after my Ph.D."
- "It's a great thing to have on my résumé, and one of the first things employers zoom into. I had an overall great experience and would recommend the internship to others."

Conclusion

MISIP is a unique partnership between private Minnesota colleges and universities and a nonprofit medical care, research, and educational institution. However, we believe that it can serve as an adaptable multidisciplinary model to prepare other students for tomorrow's opportunities. Within participating colleges and universities, faculty mentors and campus administrators repeatedly report drawing on their experiences with MISIP as they develop other campus programs and initiatives. Whether emphasizing multidisciplinary team

approaches to problem solving, creating programs that provide benefit for all participating entities, or initiating novel intra- and inter-campus collaborative programming, MISP serves as a useful model for innovative program development.

One recent example of adapting the MISP model comes from Concordia College. An MISP alumnus is co-founder of a nonprofit organization in west-central Africa. Through that organization, the college will pilot a program in 2013 modeled after MISP in which a team of undergraduate students in business and the STEM disciplines will evaluate a new healthcare technology developed by an innovator at an African university. If successful, the founders of the organization aim to have undergraduate students analyze and evaluate other innovations proposed by African innovators. This will also allow students to engage in an international experience as part of their investigative process. Concordia faculty and the MISP alumnus initiating this program directly credit his experience in MISP with demonstrating the value of interdisciplinary collaboration in taking innovations to market.

Thus, MISP serves as a useful model that can be adjusted to other institutions and corporations or to non-profits, inside or outside of biomedicine, to engage undergraduates from multiple disciplines in the real-world process of taking an idea from inception through analysis and development

toward entry into the marketplace. From the experiences of MISP over seven years, this model is a successful mechanism for real-world, transdisciplinary, experiential learning for our science and business leaders of tomorrow.

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Krystle Strand is an associate professor in the Department of Biology and works with the Neuroscience Program at Concordia College in Moorhead, Minnesota. She has been a faculty advisor for the Mayo Innovations Scholars Program (MISP) for seven years. Her other research interests include developing interdisciplinary curricula for STEM (science, technology, engineering, and mathematics) programs and studying gene regulation mechanisms of autoimmune diseases such as lupus and multiple sclerosis, as well as environmental enrichment paradigms influencing gene expression and molecular pathways in models for these diseases.

Elizabeth Jansen is an adjunct professor in the biology department at Macalester College and academic program director of the Mayo Innovation Scholars Program. In addition to teaching courses in neuroscience, reproductive biology, and global health, she works with the college's Science and Research Office to develop programs that link students with diverse research opportunities in science and health, including the Mayo Innovation Scholars Program.

CUR RELEASES NEW HOW TO Guide

How to Get Started in STEM Research with Undergraduates

Edited by Merle Schuh

Faculty members face unique challenges and issues in doing successful research with undergraduates in STEM fields. *How to Get Started in STEM Research with Undergraduates* provides a general discussion of these special issues and discusses ways to deal with them. Examples of such issues include: setting up and managing a research laboratory, designing student research projects, working with administrators, seeking research grants, writing successful grant proposals, integrating research into the classroom, dealing with information management, and making optimal use of the primary literature. Although the monograph is directed toward helping faculty who are in their early years of teaching, it should also be valuable in showing administrators the needs they must address in providing an environment in which new faculty researchers can be successful and what expectations they can have of faculty. The appendix lists some research agencies that fund undergraduate research.

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