The Mayo Innovation Scholars Program: Undergraduates Explore the Science and Economics of Medical Innovations

By John J. Pellegrini and Elizabeth Jansen

The Mayo Innovation Scholars Program introduces undergraduates to technology transfer in biomedical sciences by having teams of students from multiple disciplines (e.g., biology, chemistry, economics, and business) analyze inventions in development at the Mayo Clinic. Over 6 months, teams consult with inventors, intellectual property experts, and faculty mentors as they research and explore project viability, potential applications, market forces, ethical dilemmas, and financial considerations. Team members read relevant patent applications as well as journal articles from within the basic sciences, clinical sciences, and business. In some instances, they perform original research, such as surveys of health care providers or potential consumers. The program culminates in formal presentations that include teams' recommendations about what should be done with the invention (e.g., shelve it or pursue a licensing agreement, or pursue some other option) to an audience of intellectual property experts, physicians, faculty, and student peers.

Science educators find it challenging to make their curriculum all they want it to be and all that research indicates it should be: rigorous, engaging, relevant, and interdisciplinary. But at 11 Minnesota private colleges, the Mayo Innovation Scholars Program (MISP) provides an opportunity for students to experience learning with all of these attributes. By participating in a program that explores the intersection of biomedical research and business, students and faculty wrestle with the possibilities and difficulties of turning current discoveries into advances in science and medicine.

Organization and founding principles

The program began in 2005 after John Meslow, a retired executive from the medical device industry, gained insights into the workings of Mayo Clinic's intellectual property development office. The intellectual property development office engages in technology transfer, helping to bring new technologies developed by Mayo clinicians and scientists to the medical marketplace. When Mayo Clinic physicians and scientists make discoveries with possible clinical applications, they bring their ideas to the technology and licensing managers of the intellectual property development office. These experts investigate the potential of the new inventions and pursue various strategies for development, such as filing patent applications, entering into licensing agreements with external companies, or recommending formation of a start-up company. Because there are thousands of researchers at Mayo, the 15 managers in the intellectual property development office manage hundreds of ideas for new inventions each year. Meslow saw the opportunity to create a mutually beneficial collaboration between the intellectual property development office and teams of undergraduate students from Minnesota private colleges. Students would provide the intellectual property development office with fresh perspectives and useful research on the scientific and business possibilities of an invention, and the intellectual property development office would provide students with real-life, interdisciplinary research opportunities at the leading edges of medical technology. Meslow brought together educators from area colleges, technology-transfer professionals from the Mayo Clinic, administrative support from the Minnesota Private College Council (http://www.mnprivatecolleges.org/misp), and a source of funding for the program through the Medtronic Foundation. The Medtronic Foundation supports the program as part of its mission of "educating future generations of scientific innovators" (http://www.medtronic.com/foundation). One year into the program, Meslow, director of the program, recruited Liz Jansen, biology faculty

member from Macalester College and faculty mentor to the Macalester College teams, to serve as academic program director, thereby crafting an administrative structure that mirrors the core mission of the program: bringing together biomedical scientists with business practitioners.

The three main objectives of the program are as follows:

- to assist the Mayo Clinic intellectual property development office in the assessment of new product submissions from Mayo researchers,
- to provide research opportunities for undergraduate science and business students, and
- to provide leadership development and research opportunities for graduate students.

The order of the objectives is intentionally listed this way (mnprivatecolleges.org/MISP) because the program specifically emphasizes the need for the teams' final reports to be of value and use to the intellectual property development office; program directors recognized that the program will not be sustainable if it is "just an academic exercise" for the students. Effective partnerships between colleges and community groups require some reciprocity and mutual benefits, as has been emphasized in the area of service learning (Greene, 1998). This real-world setting and application characterizes the program and motivates the teams to create thorough, professional, and useful final reports.

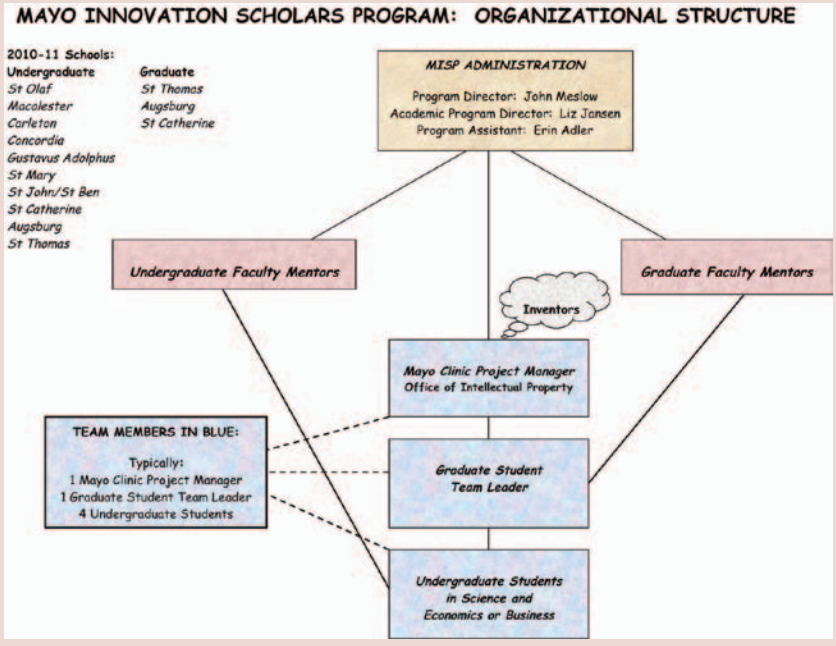
Program participants and their roles

MISP involves cooperation between the program's administrators, college faculty mentors, intellectual property development office staff, and students in science and business or economics. Although that might seem like a lot to manage, the program staff consists of only three part-time members: the program director, the academic program director, and an administrative assistant. The student teams typically consist of four undergraduates (two majoring in scientific disciplines and two majoring in economics or business) plus one graduate student team leader from a masters-level program in business or leadership. Faculty participation varies across campuses, with between one and five faculty members serving as mentors to the teams at each institution. Each team is assigned one technology/licensing manager from the intellectual property development office to serve as a resource during the research phase and to help develop and clarify the deliverables and salient questions. In addition, that manager will arrange visits with the inventors and review the team's final work products (oral presentation and paper; see Figure 1).

MISP directors set the goals of the program, evaluate it, coordinate its major events, and work out logistics. In consultation with the Mayo Clinic intellectual property development office, the directors select inventions that lend themselves to undergraduate student research, that is, those that are novel, relatively clear in their definition, and accessible (not too amorphous or meandering in their application). They then survey participating schools to match school interests with available inventions. After assigning the projects, program directors organize an orientation session for faculty mentors and graduate student team leaders to explain the objectives, expectations, and schedule of the program and to introduce graduate student team leaders to the undergraduate faculty mentors. Specifically, they emphasize the necessity to keep all proprietary information confidential because this is the first experience for many program participants with such conditions. In addition, they describe the nature of the final work products and review the timeline (the bulk of the research is done in January and

FIGURE 1

A schematic representation of the organization of the Mayo Innovation Scholars Program.



the required presentation occurs at the Mayo Clinic in March). They also distribute a student handbook, so that all participants have a detailed reference concerning goals, logistics, and frequently asked questions (see the appendix for the handbook table of contents). Following this orientation, undergraduate and graduate students attend a daylong orientation at Mayo Clinic that includes an introduction to the workings and organization of Mayo, as well as program structure and expectations, and a chance for teams to meet with their project inventors.

Faculty mentors at each college or university are responsible for assembling the teams of students and ensuring that teams make timely progress. Although the student-selection process varies across campuses, schools typically invite applications from students majoring in biology, chemistry, business, or economics. The application consists of a statement of interest that demonstrates an understanding of the program and requirements and the student's qualifications, a copy of the student's academic transcript, and one to two references from faculty members. Team members are usually juniors and seniors who are chosen on the basis of the strength of their application as well as their specific qualifications for that year's assigned project. For example, if the invention pertains to a new antibody, a student who has taken immunology may be selected; if the invention uses computer technologies, a student with experience in that area may be selected. Students who are excellent and self-motivated, able to work well on a team, and willing to wrestle with the ambiguity of open-ended questions are best suited to the program.

After the undergraduates have been selected and instructed in the nature of the confidentiality requirements, faculty entrust day-to-day leadership of the teams to the graduate student team leaders. Graduate students are selected from masters programs in business and leadership. They, too, have faculty mentors from their universities whom they may call on for guidance, but the graduate student team leader is the one responsible for assigning specific tasks and deadlines to the team of undergraduates and providing them with frequent feedback on their work.

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Student presenting findings.

The nature of the research and specific tasks for each team varies with the nature of the invention and its developmental status. Library research, survey administration, and perhaps even laboratory tinkering might be involved. On the science side, students may review general principles but soon enter into the topic more deeply. They read textbook chapters, primary literature, review articles, and any relevant patent applications. They might head to their college's anatomy lab to gain a better sense of the physical structures involved, or they may interview patients or clinical professionals to gain important insights. One team used school lab equipment to provide mild shocks to one other as they tried to simulate the stimulator parameters for a proposed invention. On the business side, students search for related products that are already in existence or in development (prior art). They analyze the potential markets and determine companies that might be potential competitors or partners. They assemble what business scholars refer to as a SWOT analysis, an overview that enumerates and explains the strengths, weaknesses, opportunities, and threats for the proposed invention. In addition, thorough consideration of the ethical dimensions of the projects is emphasized. Ethical dilemmas frequently become apparent through the teams' analyses, such as with a novel diagnostic methodology for a disease with no cure or a costly technology for a very rare condition. Finally, each team is invited to visit the Mayo Clinic toward the end of the fall semester to meet with the licensing/technology manager and, whenever possible, the inventors. In preparation for and during this visit, teams refine and begin to answer their research questions. This meeting with the inventors often serves to "bring the invention to life" for the students as they learn about the medical context or scientific need that spawned the innovation.

The program culminates in a series of presentation sessions that occur in a formal setting at the Mayo Clinic. At these sessions, the students explain their findings to the intellectual property development office, the MISP program directors, and other participating students and faculty; in some cases the inventors are also in attendance. As a condition of participation, teams agree to travel to the Mayo Clinic and attend the entire half-day sessions in which they are both presenters and audience. They are rewarded with excellent, thought-provoking talks, a fine lunch, a tour of the impressive facilities, and a stipend check ($1,000) for participation. The formality of the meeting and the grandeur of the setting encourage students to prepare carefully and communicate lucidly in what is clearly a significant event in their education. For each team, the 30-minute presentation concludes with their recommendation to the intellectual property development office. That recommendation might be, for instance, to license the technology to a specific company or it might be to discontinue pursuing any further development of the proposed invention. After the talk, the licensing manager offers specific feedback on the group's work and its recommendation, and the floor is opened to ques-

tions from the audience. After lunch, participants are given opportunities to take tours and learn about the rich history of the Mayo Clinic and the institution's current developments and facilities. Students are encouraged to imagine what professions they might pursue in science, medicine, and business while touring the Mayo campus.

An interesting aspect of the program is the wide diversity of projects. Some projects involve multiple complex patents and peer-reviewed publications, whereas others are ideas in very early phases or in concept only. Some involve high-tech products or devices and others are elegant in their simplicity. On presentation days, the wide range of project types paints a microcosm of today's biomedical technology transfer landscape. This real-world range of innovations—both in terms of type of technology as well as stage of development—means that no single protocol or simple rubric can characterize how teams should research and analyze their projects. Each team must struggle with initial ambiguity and uncertainty in order to define the best approach for their project. This element provides challenges and sometimes frustrations, but ends up yielding impressive analytical rigor as well as the most transformative experiences. As John Dewey (1930) indicated, uncertainty is part of the search for knowledge, and meaningful inquiry leads to practical action.

Interdisciplinary learning environment and academic credit

Regardless of the complexity of a specific invention, MISP aims to foster interdisciplinary work between students and faculty in the sciences and those in business and economics. Such an environment reflects the interrelated world students enter after graduation (see Carter, 2008, and Hue, Sales, Comeau, Lynn, & Eisen, 2010, for discussions of the importance of interdisciplinary science education). Faculty mentors at each college give periodic feedback to their students' research, including feedback about how to make the research findings accessible to nonexperts (e.g., to the science student who has not previously done market analysis or the business student who has not studied molecular biology). Faculty mentors also encourage students to learn across disciplines. For example, during a progress report meeting, mentors might ask for science students to present the market research and for business students to explain the scientific components. Although the students typically return to their more familiar roles for the final presentation, mentors strive to engage each team member in all facets (scientific, business related, ethical) of the analyses. In this way, the program is a perfect fit for the liberal arts student.

This multidisciplinary nature of the program provides students the opportunity to dive into an innovation in development using the tools of their disciplinary major and also exposes students to disciplines very different from what they have studied in college. Indeed, some of the most gratifying outcomes of the program have occurred when students sought new areas of study in subsequent coursework or considered professions that they had previously been unaware of. Business students gaining confidence in their abilities to master the scientific concepts enough to inform their market analyses is a novel means by which scientific literacy can be advanced (see Hazen & Trefil, 2009, for discussion of the importance of scientific literacy). In addition, there has been more than one science student who, after their experience in MISP, elected to take a business or economics course on the basis of insights gained in the program. These examples go a long way toward true liberal arts training to create an informed citizenry.

Although certain attributes of MISP seem unique, other attributes are shared by initiatives within certain business schools, engineering programs, and high schools (Moore & Sumrall, 2008). Clearly, MISP is fortunate to have the support of a world-class medical research facility and a corporate foundation that invests in training students to be tomorrow's innovators in science. And while not every college will have a nearby technology-transfer office that is willing to collaborate, it is possible that large research universities or biotech corporations might be open to the possibility of participating in such a program. This program provides an example of how approaching novel partners in the community with new ideas about collaborative programming can bring about mutually beneficial partnerships to provide novel opportunities for students.

Across the various participating colleges and universities, the nature of the academic credit that is awarded for participation in MISP varies. Some students are graded by their faculty mentors and will have their participation in the program reflected on their academic transcripts as an internship, independent study, or research course. Other students will have no record of participation on their transcripts, but they will have gained valuable recommendations from faculty mentors and are encouraged to highlight the experience on their resumes. Program directors have respected individual schools' autonomy in deciding best practices on the basis of their own academic criteria and unique institutional milieu.

Program evaluation and refinements

At the conclusion of each program year, MISP staff solicits and analyzes program evaluations from all undergraduate, graduate students, and faculty participants, and they meet with program partners—Mayo Clinic's intellectual property development office, Medtronic Foundation, and Minnesota Private College Council—to assess program efficacy and participant feedback. Evaluations are typically very positive. For example, when asked "How much value does

the Mayo Innovation Scholars Program add to your students' personal and academic development?" all 24 faculty advisors in 2011 responded with the maximum score (5.0 on a 1- to 5-point scale). Undergraduate students gave similarly high marks when they were asked about their "overall satisfaction with participating in the program" (4.8 ± 0.4, mean ± SD, on a scale of 5), and several students responded to the effect that it was the highlight of their college career. From this annual assessment and analysis, program directors continually refine the program each year to enhance the student experience.

In 2011, 154 alumni of the program were surveyed. There were 129 respondents (83% response rate). When asked "In general, how do you rate the impact of your participation in the MISP on your undergraduate experience?" 77.5% of respondents chose "Very high impact" or "High impact." Frequently in the comments section, alumni talked about how their experience was a key point in their job or graduate school interviews. For example, one alumnus stated, "This program was an amazing experience. The amount of research, and ultimately the presentation, was the focal point of my interviews when I was job searching." Another commented, "This was a very 'real-life' experience and showed me that there is a lot more I can do with my biology degree than become a doctor." Similarly, to the question "Was your participation in the MISP one of the highlights of your undergraduate experience?" 92% of respondents stated "Yes." One participant stated, "It continues to be a significant differentiator between me and other candidates when interviewing for new positions." Another alumnus said, "This unique opportunity helped hone my analytical research skills as well as presentation skills."

The MISP has also established a LinkedIn group to provide networking opportunities for individuals who have been associated with the program. More than 280 individuals currently belong to the group, and we expect this social medium to facilitate long-term evaluation of the program in the future.

Conclusion

MISP is an original model for practices in science education that are interdisciplinary, challenging, and applicable to real-world discoveries. This program not only exposes undergraduates to the very latest ideas in biomedicine, but it also fosters scientific literacy and communication skills across disciplines in science and business students alike. Today's students must be able to navigate smoothly across traditional disciplinary boundaries and be able to use their expertise to explain complex ideas to lay audiences or people with different areas of expertise so that they may emerge as tomorrow's leaders in science, medicine, and business. This program provides students with opportunities to develop these skills, opens their eyes to intersections of diverse disciplines, and helps them think about opportunities that exist for them beyond graduation. ■

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Appendix

Excerpts from the 2010–2011 Mayo Innovation Scholars Program Handbook's Table of Contents.