Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #45625

Advancing Medical Innovation: The Innovation Fellows Program for Training Early-Career Engineers and Scientists Advancing Novel Technologies

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Abstract:
The Center for Medical Innovation - Innovation Fellows Program is designed to support early-career engineers and scientists with supplemental training to advance translational research and novel medical and life science technologies to address real-world needs. This year-long, non-clinical program offers sequential education on key market readiness topics to increase the fellow's understanding of their translational research or technology's commercialization potential. These topics include intellectual property, customer segmentation, market analysis, market adoption, regulatory pathways, reimbursement strategies, commercialization funding mechanisms, and manufacturability. A critical element of the Innovation Fellows (IF) Program is pairing fellows with three mentors: an experienced SME, an innovation-focused academic liaison, and an industry-embedded mentor, resulting in a tri-directional mentoring pathway. Mentors provide technology- and industry-specific guidance to accelerate technology and business development, building the fellow's entrepreneurial acumen. Through structured training, customer discovery requirements, flipped classroom presentations, and industry mentorship, participants gain the necessary skills to navigate the complex commercialization landscape. Several goals of the programs include the Innovation Fellows' ability to improve their networking and customer discovery interviewing skills, including developing market-focused hypotheses and formulating interview questions; assessing and improving their capability to collaborate across research areas and professions; and assessing their level of interest in technology commercialization and entrepreneurship. Initial outcomes from the program show increased market readiness of participant technologies and expanded network with industry stakeholders.

Key words: translational science, 3-layer mentor, different directionality of mentoring relationship

Background

For several decades, many higher education institutions have developed strategic plans to set priorities and develop strategies to deal with a changing and competitive environment. Decreasing federal funding, inflation, changing demographic patterns, and competition for a shrinking number of traditional college students intensified the institutions' uncertainties [1]. Penn State University is a complex enterprise of colleges and campuses, geographically dispersed, but sharing a common, university-level strategic plan. Although the Innovation Fellows (IF) Program is fairly new, originating under a Strategic Plan (2016–24) that will soon reach the end of its lifecycle, it directly supports the priorities of the upcoming Strategic Plan (2025–30) [2]. Both Plans emphasize mentoring as a strategy to maximize existing investments and improve educational and research outcomes.

In alignment with these strategic goals, the Innovation Fellows Program has begun to demonstrate meaningful impact. Preliminary pre- and post-fellowship data is presented,

capturing two cohorts of fellows' perceptions of their competencies in the areas of technology propositions and industry networking, where a nearly two-fold improvement was observed. Qualitative responses are used to inform continuous improvement efforts. This paper outlines the structure of the program, key educational components, and its impact on both fellows and the technologies they advance, highlighting its role in bridging the gap between academic research and industry and facilitating collaboration and interdisciplinary work, engaging various external individuals, organizations, and companies. As a harbinger for future college-industry relational pathways, the IF Program model integrates several important engineering innovation themes: industry mentors; entrepreneurial and commercialization case studies; and engineering professional development.

Strategic Plan / initiative

The Innovation Fellows Program supports several University Presidential Level Priorities and Goals. However, only two Priorities and Goals are discussed here for illustration. Each Goal has supporting Objectives (what we want to achieve) and Metrics (to measure success). Figure 1 below shows this Strategic Plan structure and mapping of the Strategic Plan elements.

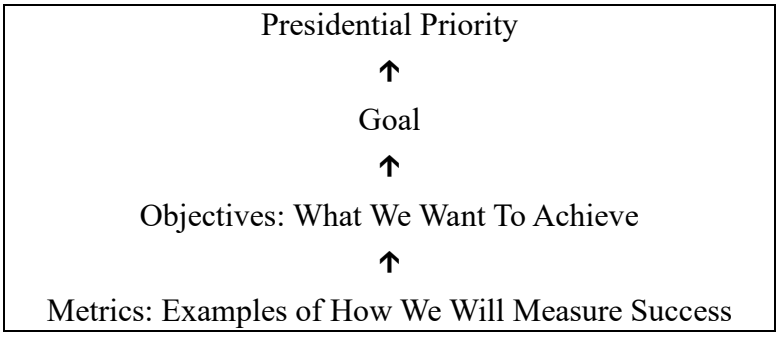

Figure 1: Mapping of Strategic Priorities, Goals, Objectives, and Metrics

Presidential Priority - Grow (Inter)disciplinary Research Excellence. To fuel our pursuit of groundbreaking discoveries, we will concentrate our efforts and resources to drive impactful change. Table 1 below illustrates this Presidential Priority.

TABLE 1: Grow (Inter)disciplinary Research Excellence

Presidential Priority	Grow (Inter)disciplinary Research Excellence
Goal	Penn State will leverage the breadth and depth of its scholarship and expertise to tackle the most pressing challenges facing the Commonwealth, nation, and world.
Objective 1	Grow research that positively impacts lives in the Commonwealth, the nation, and the world.
Metrics 1	Top-cited papers and books Measures of interdisciplinarity such as co-authors and graduate student committees from various disciplines/colleges

	Creative practice and scholarship Licensing revenue and other tech transfer outcomes Number of licenses executed Industry partnerships, industry-sponsored research expenditures, and consulting activities Number and value of grants External recognition, utilization, and dissemination of faculty research and expertise
Objective 2	Become a top 15 research university.
Metrics 2	Research expenditures Citation number and impact / Eigenfactor / h-index High-value, multiple principal investigator grants, including those with investigators from multiple disciplines/colleges Number of research graduate degrees awarded Scholarly impact measures such as engaged scholarship, professional service, contributions to the arts and humanities

Presidential Priority - Increase Land-Grant Impact. To elevate our stature as a land-grant university, we will concentrate our efforts and resources to drive impactful change. This Presidential Priority is shown in Table 2.

TABLE 2: Increase Land Grant Impact

Presidential Priority	Increasing Land-Grant Impact
Goal	Penn State will be a key contributor to the economic development, innovation environment, workforce growth, and overall vitality of the Commonwealth.
Objective 1	Leverage our assets and strategic partnerships to build resilient, sustainable communities for the betterment of the Commonwealth.
Metrics 1	Research and collaborative projects with business, industry, and non-profit groups Businesses started, assisted, retention rates, and economic impact Jobs created or retained Penn State led community-centered resilience and sustainability-oriented efforts/initiatives In-state students graduating and then working in Pennsylvania Licenses executed with external partners Number of research findings translated into actionable solutions for Commonwealth challenges Research and creative activities delivered related to health, education, and arts that engage Pennsylvania communities Tangible impacts of partnership projects, such as infrastructure improvements, public health advancements, or economic gains

Objective 2	Amplify our academic enterprise through partnerships with business and industry, non-profit groups, communities, and residents.
Metrics 2	Business, industry, community, and non-profit partnerships Experiential learning opportunities for students through business, industry, community, government, and non-profit partnerships Number of sustainability upgrades to Penn State energy grid Sustainable operations data for Penn State locations Sponsorships for University training, professional development, events, and conferences Licenses executed, start-ups formed, and community-engaged research projects initiated
Objective 3	Galvanize an engaged and effective network of advocates and investors in Penn State
Metrics 3	Registered Penn State advocates and active engagement Funding appropriation and per-student-funding parity, linked to Pennsylvania legislative performance-based measures Demonstrated economic and community impact to Pennsylvania legislators and the public Overall fundraising numbers from donors University campaign goal progress Funding from businesses, industry, and corporate philanthropy

Innovation Fellows Model

Penn State University needs to provide innovation training and resources in order to accelerate the timeline to exit for translational technologies. Additionally, there is a need to encourage innovative thinking and work towards a more advanced research culture across the university. The Innovation Fellows Program helps address these needs by providing senior trainees – post-doctoral fellows, medical students, and senior graduate students – with the tools and knowledge to support innovative research projects. The model, developed by the Massachusetts Institute of Technology (MIT) and refined by Case Western Reserve University [3]-[5], was developed with a venture approach to creating translational scientists and engineers, whose work could be scaled with cross-disciplinary applications. Emphasizing the iterative nature of training, the Innovation Fellows program provides protected time to learn and practice innovation work which advances the technology readiness while advancing the experience and expertise of the fellow. The key to success is a diverse mentoring team. Mentorship and team mentoring have been shown to be an effective tool for workforce development and career development in academic research [6]. This teaching methodology also creates a transmission pipeline of knowledge back to the lab and the greater research community [7]. This training model focuses on the needs of innovative biomedical and healthcare researchers. It provides training in regulatory requirements, intellectual property demands, and other aspects of entrepreneurship unique to healthcare technologies. Mentorship is provided by medical technology and clinical experts. Speakers are chosen for their experience with biomedical and clinical innovations.

Goals: The Innovation Fellows Program aims to support early career researchers with supplemental training to accelerate innovative and novel medical and life science translational research towards university exit. The program will increase fellows' understanding of the commercialization potential of their technology while simultaneously providing fellows with necessary skills to navigate the complex commercialization landscape. Fellows will improve their networking skills, learn customer discovery interviewing skills, develop market-focused hypotheses, improve their presentation skills, and assess their career interests in technology commercialization and entrepreneurship. The institution accelerates the time to exit for the technologies and can also benefit from increased commercialization success [8]. The fellows benefit from an advanced understanding of innovation and entrepreneurship processes which not only affects their work in the lab but also influences their career success.

Structure: The program is made up of monthly themes that include

- Customer Discovery
- Competitive Analysis
- Pitch Development
- Finance and Capital
- Regulatory Requirements
- Intellectual Property

Each month, fellows meet as a cohort with the CMI team and learn about the themes from expert guest speakers, workshopping, and conversations. During the rest of the month, fellows meet individually with their team of mentors. They collaborate with their subject matter expert (SME) - the principal investigator in the lab - to develop experiments and tackle the translational research roadmap. They meet with their Penn State University CMI innovation mentor to discuss the topics and assigned tasks. There are asynchronous learning objectives with videos, readings, practice tasks, and individual research assignments to complete. Finally, fellows individually meet with their industry mentors to discuss their translational research, their career development goals, and their progress on learning the monthly themes. All of these approaches combine to form a coordinated, cohesive, and complementary program focused on the success of the fellow and their technology.

Mentoring

There are numerous opportunities for industry partners to mentor students and be part of the co-curricular academic program [9]. Typical pathways including serving as project sponsors, serving on advisory boards, hosting site visits, and providing internship opportunities. Less common ways industries are involved include research, serving as adjunct professors, and mentoring the students. Industry mentors serve a critical link between the classroom and the application of knowledge beyond academia. These industry and university partnerships help to reduce the lack of understanding and knowledge between the two [10].

Mentorship is a valuable tool for the Innovation Fellows Program. The program enlists multiple mentors in a layered approach to provide a comprehensive support system. Using multiple

mentors from diverse backgrounds allows for a wide range of perspectives and experiences and allows the program to maintain an assortment of specialties, networks, and backgrounds. The model provides accountability between mentee and mentor, but also among mentors. A subject matter expert, an innovation mentor, and an industry mentor together provide a solid foundation of support for innovation, commercialization, and career development.

Research Mentor
The fellow comes to the Innovation Fellows Program at the recommendation of their research mentor, the subject matter expert (SME). All fellows must include a letter of support from the research mentor in their application to the program. The SME is the first line of mentoring, creating the innovation pathway from basic science research discovery to translational research validation and product optimization. In the lab, the fellow works with the SME to design experiments and validate discovery data in various models. Prototypes are built and tested, software is iterated, diagnostics are tested and refined. The day-to-day execution of these tests usually falls to the fellow and teammates within the lab, while the mentor guides and advises.

Innovation Mentor
The innovation mentor is a member of the university affiliated with the Center for Medical Innovation (CMI). These mentors are employees of the university and come with a range of experience in innovation. Most have some industry experience, a background in biomedical technologies, some lab expertise, and are now working as part of academia to support translational research in some capacity. Their job is to support the fellow in education – understanding the themes, practicing their work, guiding their networking, and answering questions. These mentors provide expertise in intellectual property, contracts, and university policies. In addition, they lead the programming for the IF Program and help connect the fellows to their industry mentor, potential sources of customer discovery, and regional experts in innovation and entrepreneurship. The innovation mentor serves as teacher, counselor, advisor, and ally, meet with the fellow at least monthly, but often several times a month as the first line of communication and guidance.

Industry Mentor
Industry mentors are the final foundational support for the IF Program. Industry mentors are volunteers, usually sourced from a pool of interested alumni who volunteer to serve on university advisory boards. The alumni volunteers are chosen from biotech, pharma, government, law, etc. and often have experience in several disciplines. For example, one of the industry mentors is a university alumnus with an MD, PhD, and MBA. He spent several decades supporting investment in academic research through regional accelerators and serves as director of life sciences research for an asset management company. Another mentor and alumnus has spent her career between academia and industry serving as research faculty, dean, provost, and president in higher education, plus as chief scientific officer of a small biotech firm that underwent successful acquisition.

As alumni, mentors are interested in giving back to the university community and enjoy interacting with students and trainees. They want to tell their stories, give guidance, and support

the growth of both the person and the technology. They meet monthly with their assigned fellow and provide contacts for networking, advice about how innovations are successfully commercialized, and career counseling from a unique perspective. Many industry mentors come back year after year, citing the success and growth of their mentee as the reason. As the needs of the program grow and change, we can take advantage of our mentors' connections and networks of peers to expand the pool of industry mentors.

Results

Following before- and after- programmatic reflections, Innovation Fellows Program alumni reported a more than two-fold increase in their confidence along eight dimensions of innovation and design. Fellows were asked the degree to which they were confident with the following aspects of the innovation and design pathway:

1. Identify potential customers of the technology
2. Determine an optimal regulatory pathway for the technology
3. Determine a value proposition for the technology
4. Ability to present the technology/project to a broad audience
5. Ability to secure NIH funding for the project
6. Ability to secure private investment for the project
7. Navigate intellectual property and legal issues
8. Ability to network with other scientists and industry mentors

Participants reported positively that industry mentoring and networking were key draws to the program, and all would recommend the program to a peer (Figure 2).

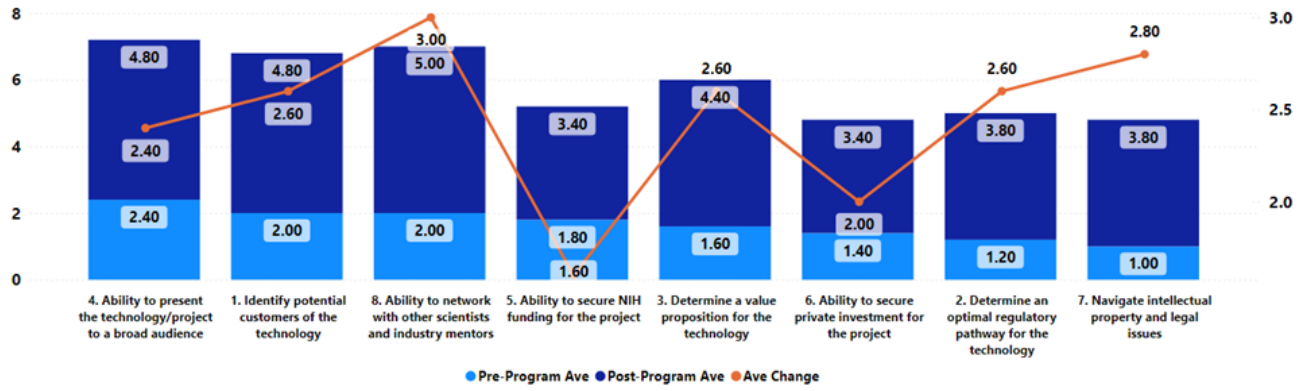

Figure 2: Innovation Fellow Self-Assessment from Pre- and Post-Program Perceptions

Discussion

The early outcomes of the Innovation Fellows Program show promises for future growth and continued success, which will depend on a coordinated and consistent effort to stay up to date on best practices. Team mentoring, provided as a foundational support system spanning education,

career development, technology development, commercialization, and innovation culture will be the lynchpin of the program.

Our team mentoring approach provides a means to create a stronger workforce. The biotechnology and healthcare industries need employees who understand how academic research can be translated into marketable products. Layered mentoring from a wide range of backgrounds engages the fellows on a personal level and allows them to look beyond academia to apply the teachings in their careers. We provide an environment for mentors to develop active relationships through storytelling and setting goals and encouraging growth and learning. It is the goal of the IF Program to create long-term connections between the fellows and their mentors, lasting well beyond the termination of the 12-month program. That requires effective guidance and building trust between mentor and fellow.

Conclusions

Moving forward, CMI looks to maximize the impact and value of the multi-layered mentoring relationship. Industry experts will be embedded in monthly themed medical technology discussions where mentors and potential mentors can offer insights in an informal panel setting. Additionally, CMI plans to document lessons learned and best practices to develop a roadmap for replication at other institutions. Providing a step-by-step implementation guide, including necessary resources, funding models, and institutional partnerships, that would make it easier for universities and research centers to adopt this approach.

Quantitatively capturing mentor impacts is also a key growth area for CMI. Business and management disciplines have created ‘coachability’ measures that CMI looks to implement in mentor recruitment and post-program assessment protocols [11]. Key to CMI’s novel approach is staff leadership, wherein embedded CMI staff guide and coach mentors through initial mentee project meetings providing supplemental project planning and management. Staff leadership also ensures that program expectations are met for both mentors and mentees. The current outcomes show immediate improvements in fellows’ confidence and commercialization skills. Tracking alumni career trajectories, startup creation, funding success, and sustained industry engagement over multiple years would validate the program’s long-term impact and provide insights for continuous improvement.

Multiple perspective mentoring also offers a more adaptive structure for CMI to tune mentoring schedule and post-meeting feedback results to mentees’ project needs. Within this mentoring framework, CMI looks to track milestone capture, engagement frequency, and final impacts—ultimately creating a dataset allowing for success modeling. For example, enhanced mentee intake documentation resulting in meta-data for technology interest, career goals, DISC assessments (Dominance, Influence, Steadiness, Conscientiousness), and other preferences could yield a promising means for mentor-mentee matching. Expanding structured mentor training and evaluation could ensure high-quality engagement and allow for scaling mentorship networks beyond alumni volunteers to broader industry participation.

Finally, as partnerships, project collaborations, and mentoring capacity occupy key spaces in Pennsylvania State University's strategic planning and sustainability efforts, the CMI model holds promise as an innovative approach to driving technology development, faculty development, and experiential learning for students.

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