OPERATIONS

Best Practices for Collaboration Between Industry and Academe

By R. Russell Rhinehart, ISA & AIChE Fellow

Better collaboration between academic institutions and industry practitioners can improve outcomes for industrial businesses and the schools, professors, and students they depend on.

Academic research about education is what substantially shapes higher education, which often leaves manufacturing and industrial businesses complaining about how new engineering graduates lack industry readiness. But if teachers had a better grasp of the applications and perspectives needed by industrial businesses, they could do a better job of creating an educational environment that generates fit-for-employment graduates. Additionally, with better collaboration, the creativity and expertise of academics could be a problem-solving resource for industry.

There is a need for industry to more effectively engage academic experts, and for more useful knowledge exchange. Although automation professionals and faculty are effectively working together in some places, there is a gap between what industry practitioners need and what academic experts provide. More frequent and influential collaborations can lessen that gap.

First, understand why a gap is there. Here are several reasons, categorized by contrasting terms:

Practicable-possible

Although industry requires what is practicable, faculty research is guided by what might be possible (and its mathematical demonstration). That means the knowledge being published in academic journals (like *ISA Transactions*) rarely affects the practice. Even if relevant, the journal articles require substantial cultural translation to become implementable. If academe is to support the practice, the practice needs to find a way to shape academic research.

Urgency-analytical
Academics work in a precommercial environment and have the investigative time to seek a clear and comprehensive system view of the fundamentals associated with a technical discipline. They want to discover nature and fundamentally defensible procedures. In contrast, practitioners tend to focus on immediate solutions for specific application cases, often using intuitive actions, workarounds, or a shotgun approach. Although true knowledge would be useful to them, situation urgency means practitioners often miss fundamentals that could become helpful.

Sufficiency-perfection
Industrial applications of technology are performed within a complex context, constrained by safety, regulations, human aspirations, and more; they are also applied on nonlinear processes. Such aspects are usually imprecisely quantifiable. Application success requires simple solutions, both mathematically and procedurally. By contrast, to achieve career goals, academics often seek complexity of mathematical analysis and proofs of certainty. These necessarily require an idealized context. One side is seeking perfection in an idealized context, while the other is seeking sufficiency in an ambiguous context.

Fruition-fundamentals
Industry wants to make things happen, to create and sustain a productive process or a marketable product. Academe seeks to discover the fundamental principles about nature. One focuses on how to do it, or the synthesis. The other focuses on defense of claims, or the analysis.

When people on one side read the publications of the other, they find little to nothing to address their needs. It is not that one side is doing it all wrong. Each side is doing what is right within its dissimilar environment. The gap between them—the differing goals, motivations, and measures of success—is what makes collaboration difficult.

About the survey

Collaboration, while difficult, is not impossible. In fact, the examples shown elsewhere in this article involving Miami University of Ohio, University of Michigan, and Purdue University are the results of successful collaborations. To bridge the gap in more places and for more institutions and industry practitioners, the International Federation of Automatic Control (IFAC) conducted a survey of best practices. (Read this article online [https://isa.org/intech] to see key survey result statistics, a glossary of terms, and additional articles related to this topic.)

ISA is one of nine professional societies in the American Automatic Control Council (AACC), which represents the U.S. to the IFAC Industry Committee (figure 1). An IFAC Industry Committee task force created the survey and analyzed the results, which are presented here.

The survey had 19 questions, about half of which solicited open text responses. The link to the survey was distributed within commercial publications, as well as via direct emails to the members of the IFAC Education and Industry Committees and ISA Divisions. Recipients were encouraged to further distribute the survey to their network of professional contacts. Approximately 260 individuals opened the survey, and 125 completed it.

Of those who provided geographical information, most are from Europe and North America. A total of 24 nations from six continents are represented, with the U.S. and France being the two largest contributors.

Most survey participants have experience in academia. In all, about 60 percent identify with academe and 40 percent with the practice; some claim significant experience in both. It is worth noting that many control practitioners are part of nonprofit, government, military, and even academic organizations, not just industry. So, we use the term "practice" to include all professionals who practice automation and control, regardless of their place of work. That is why we replaced the commonly used expression "university-industry collaboration" with the more inclusive "academic-practice collaboration" throughout the survey and this report.

The 12 academic disciplines represented in the survey were dominated by electrical, industrial, chemical, mechanical, and computer engineering. The 14 technology application domains were primarily represented by process, energy, and manufacturing. The nine practice sectors were substantially represented by industrial suppliers, industrial users, service providers, and vendors. The eight academic sectors involved were primarily research and graduate programs. Interestingly, most of the research entities listed their focus as application rather than pure science.

Understanding collaboration

Collaboration can take many forms, all of which can be mutually beneficial. Collaboration is an activity whereby individuals work together for a common purpose to achieve a common target benefit. Essential skills include trust, tolerance, self-awareness, empathy, transparency, active listening, and conflict resolution. Collaboration is not people working independently and following their own paths. Collaboration means accepting the experience of the others in the joint effort.

Examples of collaboration include industry practitioners helping in classrooms by providing guest lectures on topics and application perspectives often omitted in education. They could provide case studies for teaching examples or student projects. Industry could help in laboratory experiences by providing equipment and technical support.

With such collaboration comes many benefits: The teaching faculty comes to better understand the needs of the practice. Respectful relations are formed for possible future problem-solving benefit. Contact with students gives industry folks a recruiting advantage. Students benefit from the exposure and enjoy the real-world insight.

As a reciprocal, industry could host academic associates at invited seminars or short courses for employee continuing education and skills development. The experience shapes the academic focus, improving both teaching and research.

Another example is industry-sponsored research projects for undergraduate or graduate students. Preferentially, these are precommercial investigations designed to help practitioners answer their questions or explore a possibility that might seem promising. The sponsorship could be one on one or within a consortium, and the students and faculty would be allowed to publish the results.

There is a need for industry to more effectively engage academic experts, and for more useful knowledge exchange.

Industry also could hire faculty on an individual basis to solve a problem or to help develop a product, or it could engage equipment, faculty, and students to provide support through a university contract. Here, intellectual property (IP) concerns related to rights to inventions and patents would restrict academic publication. Myopic lawyers within both the industry sponsor and the academic institution seem to place IP possession above the benefit of collaboration and argue that their side should have exclusive rights. The IP impasse is often a barrier to collaboration, but when agreement can be reached, product and process development is enhanced.

The five players and their motivations

The survey reveals that five separate groups are involved in any academic practice collaboration. Each group must have an incentive to participate and to invest its resources to make a collaboration successful. The collaboration needs to be structured so each of the players experiences a benefit that justifies its investment. Each group also has its own culture and way of interacting. A collaboration must permit those diverse ways to synergize. The five groups are students, faculty, academic institutions, practitioners, and practice entities. Here is what motivates each to collaborate.

Students

Students are seeking practical knowledge and experience about the industrial context, which will lead to career and employment opportunities. Students are excited to work on real-world problems, to have access to state-of-the art hardware and software, and to relate the theory learned in class to specific practical situations. Students want to work with industrial mentors to gain in-depth understanding of the nontechnical side of practice, such as soft skills, project management, and market-driven decision making.

Faculty

Top incentives for faculty are professional development and funding. Professional development includes staying current with the state of the art in the field, selecting relevant research topics, validating ideas, having access to actual data, networking, and maintaining visibility through academic publications. Research funding is required to build a research group, support equipment and travel, and provide summer income. Industry-funded projects provide the means to support and sustain an academic group. Sponsored projects identify ideas faculty can use for their more science-oriented research.

Other incentives for faculty are practical relevance of the curriculum and personal satisfaction. Collaboration with practice makes faculty more comprehensive teachers and mentors to their students, due to exposure to first-hand knowledge about technology, practices, expectations, and opportunities. Industrial collaboration can provide a unique and advantageous perspective on the state of the art. The ability to steer the students in the right direction naturally leads to personal satisfaction.

Academic institutions

Academic organizations seek funding, reputation, and societal impact. Sustainable programs tied to the practice community attract high-quality students, which in turn brings more interest from prospective partners to collaborate. Student participants typically are offered employment in the partner organization, which elevates the reputation of the academic institution. Universities like displaying collaborative programs and societal impact in their messages to alumni and when reporting to legislatures. Secondary benefits are acquisition of facilities, networking, and education quality.

Practitioners

Top priorities for practitioners are professional development, career promotion, and better ability to hire qualified personnel. Professional development includes access to new ideas, technological surveillance, refreshers on theoretical fundamentals, engagement in fundamental research, and peer benchmarking. Incentives also include personal satisfaction as a mentor, attending conferences, publishing in scientific journals, and an opportunity to influence the education of the next generation.

Collaborative projects with academia also provide an opportunity to train and evaluate potential employees before extending a job offer. In addition, student allegiance to the corporate collaborator is a recruiting advantage for students who are familiar with the technologies and practices of the corporation.

Practice entity

Top incentives for industrial companies and other practice entities are new ideas, new product/process development, access to new knowledge, recruiting, and brand-name recognition. Even if the involved students accept employment elsewhere, they might have a preference to use a collaborator's product there, and their in-school affirmation of the experience will aid the sponsor's recruitment of other students.

Companies may view collaborations with academia as low-cost research and development initiatives, or as investments in workforce development. The benefit-to-cost ratio is often enhanced when government funding also supports the initiative. Demonstrating societal responsibility is another motivator, achieved by helping and stimulating academia to focus on real-world problems and opportunities.

Ensuring collaboration success

Collaboration is not a one-sided game. An erroneous industry view is that a company hires the academic to develop a solution, the same way it might hire a consultant. An erroneous academic view is to take the position and the money and run (in pursuit of scientific publication). Notably, people may claim their academic-practice partnership is a collaboration, but in a collaboration the individuals share, are flexible, and accept each other's perspectives.

Mutually beneficial collaboration requires all players to understand how the others perceive the initiative, and to help provide what the others will interpret as a win. It may require each player to give up on getting its primary "win" and to settle for a secondary benefit, so that other players also can experience a win. For example, faculty may primarily want to use industrial funding to support mathematical analysis and journal publications. This provides little value to an industrial sponsor. It is acceptable to pursue and publish mathematical analysis, but also seek to return the sponsor's interpretation of benefit.

Successful Collaboration: Miami University of Ohio

The Pulp and Paper program at Miami University of Ohio has a process control minor to prepare engineering graduates to supply industrial needs. To recruit students into this relatively unknown career, collaboration with industry partners offers both a three-week intersession course in the practice of process control and summer internship opportunities for students.

The course segments are offered by application-oriented faculty and practitioners, and the course topics are aligned with both industrial needs and engineering education criteria. The course and internships are attractive for students, and industry is happy that an academic program is supplying their workforce development needs. Visit https://www.miamioh.edu/cec/sasi.

Successful Collaboration: University of Michigan

The Reconfigurable Manufacturing Systems (RMS) program at the University of Michigan was established in 1996 with partial support from the National Science Foundation as an Engineering Research Center (ERC) to improve manufacturing productivity. It was funded by more than 30 company collaborators.

Benefitting industry, from 1997 to 2012, ERC-RMS produced more than 350 graduate students, most of whom are working in U.S. industry, and improved productivity in more than 69 production lines in 15 factories in the U.S. and Canada. Benefitting academe, application projects have been essential to the career development of many students and faculty and for bragging rights of the university. Although initial funding has waned, the legacy of collaboration, labs and courses, and relevant teaching continues. Visit https://erc.engin.umich.edu.

Successful Collaboration: Purdue University

The Center for Innovation in Control, Optimization, and Networks (ICON) at Purdue University explores innovative control solutions to challenges associated with manufacturing, transportation, supply chains, health care, power, communication, and social networks. These systems are rapidly growing in scale and complexity, driven by advances in autonomy and connectivity. ICON seeks to develop knowledge and techniques for control and optimizing, to customize curricula to meet emerging educational needs, to collaborate with industry to tackle priorities, and to provide employment-ready graduates. It was established in 2020, has about 70 faculty researchers from a dozen departments, has funding from both industry and government, and enjoys strong collaboration with Saab, Rolls-Royce, Northrop Grumman, and John Deere. Students provide biweekly reports to industrial partners who provide feedback direction, advice, and serve on dissertation committees. Visit https://engineering.purdue.edu/ICON.

As another example, industry may primarily want, in return for a bit of funding support for a student, to be able to claim all rights to the lifetime of knowledge that the faculty advisor has acquired. Alternately, industry should accept the workforce development benefit of their contribution. Success requires each entity to find a way to shape the process and outcomes to satisfy their values, while making it satisfactory to the other entity. To create a win-win (actually win-to-the-5th-power) means that the process and outcomes that generate success for all may be suboptimal for any one entity. Industry practitioners are familiar with this condition of suboptimally operating one process unit to maximize manufacturing.

Collaboration also means mutual respect for the viewpoints and experience that the other has acquired. Having acquired career success, key individuals on either side of the gap are strongly immersed in their way of doing things. They have their own terminology, symbology, values, and conventions and often do not understand the other's situation, ways, and needs.

Several survey respondents reported that players on either side belittled the "inferior" experience and context of the other, which alienates the other and effectively undermines collaboration. It is important for experts in one domain to respect and understand the viewpoint of those in the other domain, and to help the other acquire a comprehensive view. It is also important for experts in one domain to accept what the others would like them to understand.

As the survey results indicate, two aspects of collaboration are central to the success or failure of practice-academe initiatives: Give the other collaborator adequate wins and respect the other's experience. A summary of the top 10 ways to improve collaboration is listed in figure 2; full survey results are available online.

Read this article online (https://isa.org/intech) to see key survey result statistics, a glossary of terms, and additional articles related to this topic. ■

1. Address a common purpose, a shared vision.
2. Define success and deliverables (objectives, goals, schedule, milestones).
3. Build realistic expectations (compatible with skills and resources).
4. Define responsibilities.
5. Appoint a project manager/program director who can bridge the gap.
6. Ensure a commitment to share adequate resources (funding, data, time, staffing).
7. Gain support of leadership and participants (ensure all see their "win").
8. Stay engaged and connected.
9. Build mutual trust, respect, and personal relationships.
10. Partner with organizations where there are other beneficial interactions (workforce development, employee training, technical access). Synergize.

Figure 2. Top 10 ways to improve collaboration

ACKNOWLEDGEMENTS

The author enjoyed collaboration with task force members and others on the IFAC Industry Committee. We are especially grateful to the 125 survey respondents who provided valuable input and to *Control* magazine, ISA divisions, and IFAC for soliciting participants.

ABOUT THE AUTHOR

R. Russell Rhinehart (www.linkedin.com/in/r-russell-rhinehart-71bb0239) is an ISA Fellow and an AIChE Fellow. Rhinehart is a retired professor and former head of the Oklahoma State University School of Chemical Engineering, as well as the author of several books on engineering optimization, model-based control, and related topics (www.amazon.com/author/rrussellrhinehart). He is currently an engineering coach based in Stillwater, Okla.

The International Federation of Automatic Control (IFAC) is primarily an academic organization seeking to share automation possibility, theory, and analysis worldwide. The American Automatic Control Council, a consortium of nine U.S. professional societies (of which ISA is a member) represents the U.S. to IFAC. The IFAC Industry Committee, established in 2017, has had a core task of promoting interaction between academia and automation and control practitioners in industrial, nonprofit, military, government, and other institutions by helping each side understand the culture and the motivation of the other.

The author greatly appreciates the members of the IFAC Industry Committee task force who created the 2021 survey of best practices and analyzed the data. They include:

David A. Anisi, associate professor, NMBU/UiA, Norway	**Philippe Goupil**, aircraft control system expert, Airbus, France	**Chris Manzie**, professor, The University of Melbourne, Australia	**R. Russell Rhinehart**, professor emeritus, Oklahoma State University, U.S.	**Tariq Samad**, director, management of technology, University of Minnesota, U.S.	**Bran Selic**, president and founder, Malina Software Corp., Canada	**Atanas Serbezov**, professor, Rose-Hulman Institute of Technology, U.S.	**Jaroslav Sobota**, control system engineer, Centrum LTD, Czech Republic

Figure 1. About the IFAC Industry Committee