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Academic-Practice Collaborations in Automation and Control: Keys for Success

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Abstract: This study identifies the keys for successful collaboration between the communities of academia and practice in the field of automation and control. The findings are based on the analysis of 85 different collaborations reported in a survey of the international control community conducted by the Industry and Education Committees at IFAC. Addressing a joint problem, understanding and respecting each other, frequent communication, and adequate funding are among the top attributes of successful collaboration. A complete list of the top 10 keys for success is provided in the conclusion section.

Keywords: Academic-practice collaboration, University-industry collaboration, Control education, Success patterns.

1. INTRODUCTION

The gap between academia and practice has been a topic of discussion for many years. The detriment to both sides of the divide is succinctly summarized by Wolfenden, et al. (2019): "The failure to facilitate a creative interface between practitioners and academics results in waste: the waste of academic work that lies untranslated for practice, the waste of practitioner knowledge that lies untheorized." The disconnect extends to education as well, where the technical skills taught to undergraduates are not meeting the needs of the practice community, McMillan, et al. (2020), Rhinehart (2019), Alford (2006, 2017).

On the surface, academia and practice have unreconcilable cultural differences, outlined in Sauermann and Stephan (2013). Academic culture emphasizes the search for fundamental knowledge, research freedom, and open disclosure of research results. Practice, on the other hand, stresses commercial results, limited disclosure, and private appropriation of the financial returns from research. However, the in-depth empirical analysis carried out by Sauermann and Stephan (2013) revealed that the binary and conflicting view overemphasizes the differences, while ignoring the significant heterogeneity within the two sectors.

The IFAC Industry Committee was established in 2017 with the objective to increase industry participation in IFAC activities. A core task of the committee has been to promote interaction between academia and practice by helping each side understand the culture and the motivation of the other, Samad and al. (2020), Mastellone and van Delft (2021).

The purpose of the present study is to conceptualize and articulate the incentives, attitudes, behaviours, and organizational structures that bring together academia and practice for successful collaborations in the field of automation and control. The study was conducted by a joint task force from the Industry and Education Committees at IFAC. The members of the taskforce were:

- 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, USA
- Bran Selic, President and Founder, Malina Software Corp., Canada
- Atanas Serbezov, Professor, Rose-Hulman Institute of Technology, USA
- Jaroslav Sobota, Control System Engineer, Centrum LTD, Czech Republic

A questionnaire was prepared and distributed to individuals who have had direct experiences with academic-practice collaborations. Existing literature suggests that for a successful collaboration all parties must be aligned in their incentives, attitudes, and behaviours, Pertuzé at al. (2010) and Awasthy et al. (2020). Thus, the questionnaire sought first-hand personal observations on these aspects of the collaborations. The answers, which were provided as free text comments, were analysed to extract and formulate the keys for success.

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The paper is organized as follows. Section 2 explains the design of the survey and the methodology for analyzing the responses. Section 3 provides information about the respondents and the collaborations. Section 4 analyzes the free responses in the survey. It summarizes the incentives, attitudes, behaviors, and expectations for the different groups of participants. The paper concludes with a summary of the top 10 keys for success.

2. SURVEY DESIGN AND METHODOLOGY

The survey questionnaire had three sections. The first section used structured responses to collect information about the respondent and the collaboration. The second section sought respondent's perspective on the benefits gained by the participants in the collaboration. The third section prompted the respondent to identify attributes of the participants and of the collaboration that were essential for success. The questions in second and third sections were set as free responses to facilitate unbiased and unconstrained answers.

The estimated time for completion of the survey was 30 minutes. If a respondent wanted to provide information for more than one collaboration, they had to complete the survey multiple times. The survey was implemented via the SurveyMonkey platform. The link to the survey was distributed through IFAC and ISA publications, as well as direct emails to the members of the IFAC Education and Industry Committees. Recipients were encouraged to further distribute to their network of professional contacts.

The "keys for success" were distilled from the analysis of the free responses by utilizing the Grounded Theory (GT) methodology, Chun Tie et al. (2019). The GT methodology is often applied to theorize a concept from analysis of data. The GT methodology is particularly useful when analysing unstructured free response answers. GT uses a process called "coding" to identify ideas, similarities, and conceptual reoccurrences in free response data.

The respondents were asked to comment on different participant groups in the collaboration. In doing so, respondents were speaking not only for their own group, but for other groups as well. It was assumed that the collaboration experience had made each participant sufficiently knowledgeable about the others, and so, all responses pertaining to a particular group were lumped together.

3. RESULTS FROM STRUCTURED RESPONSES

3.1 Respondent Information

There were approximately 260 individuals who opened the survey, but only 125 completed it. The breakdown by continent is shown in Figure 1. Approximately one third of the participants did not report geographical affiliation. In the "Null" category, respondents have provided answers for most of the questions but not this one. Out of those who provided geographical affiliation, most are from Europe or North America. In terms of countries, 24 are represented, with USA and France being the two largest contributors, as seen in Figure 2. The geographical bias in the collected responses is not expected to affect the validity of the conclusions because the fundamental nature of academic-practice collaboration transcends political and geographical boundaries.

Figure 3 reveals that 72 participants have experience in academia and 58 in practice. Of these,33 claim experience in both. In all, not counting the null answers, 55 % of respondents identity with academe and 44 % with practice.

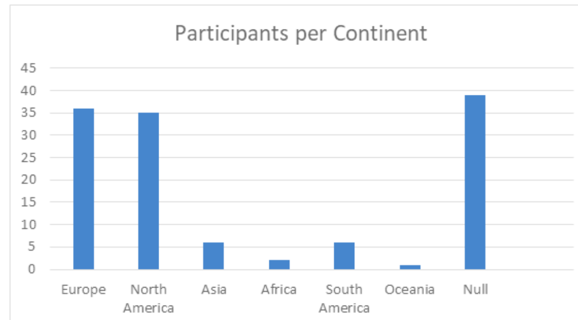

Figure 1. Respondents Breakdown by Continent.

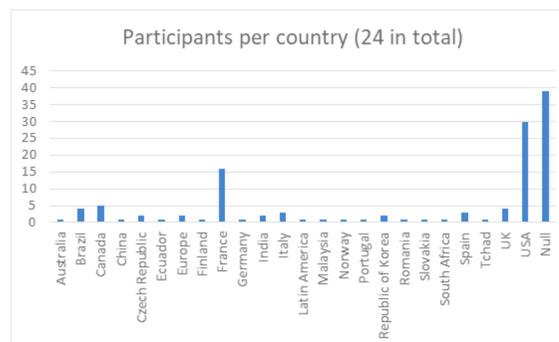

Figure 2. Respondents Breakdown by Country.

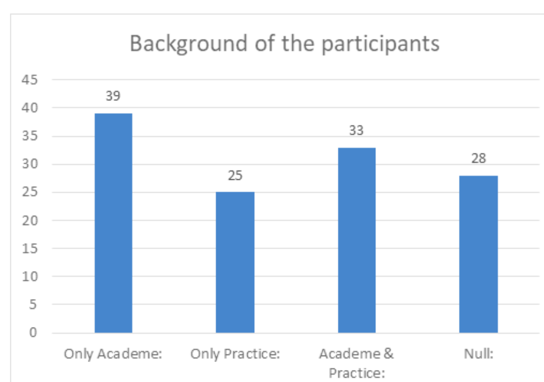

Figure 3. Respondents Breakdown by Background.

3.2 Collaborations Information

A total of 85 different collaborations were described in the survey: 54 active (63.5%) and 31 inactive (36.5 %). Among the 54 active collaborations, 30 (55.5%) involve people either purely from the Practice world or from both worlds, leaving 24 answers (44.5%) of the collaborations with participants from only Academe.

Among the 30 representing the practice, 73.3% (22 out of 30) involve people with experience in both worlds. Only 8 answers (26.7%) were obtained from people having only experience in Industry. For active collaborations, people having a pure academic experience or experience in both Academia and Industry represent 85.2% of the answers. We suggest this indicates that the proclivity to collaborate seems rather to be made by people having an Academic experience.

Among the 31 inactive collaborations, 17 (54.8%) involve people either purely from the Practice world or from both worlds. 14 (45.2% of 31) of the collaborations with participants from only Academe. 9 answers (29%) with people having only experience in Industry. We suggest this has the same meaning – the connection to set up projects seems rather to be made by people having an Academic experience.

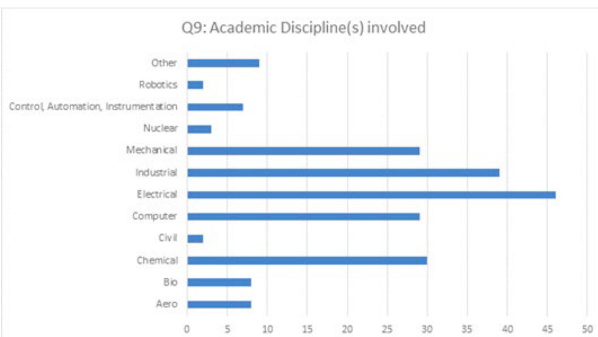

Figure 4. Respondents Breakdown by Discipline.

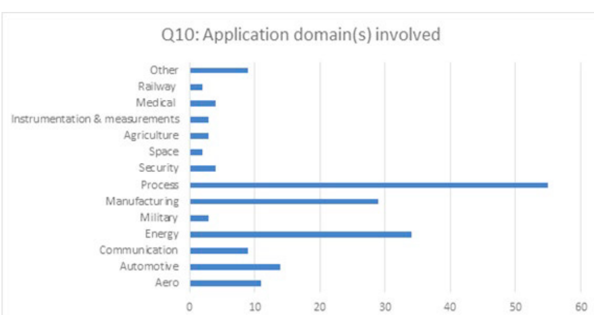

Figure 5. Respondents Breakdown by Application Domain.

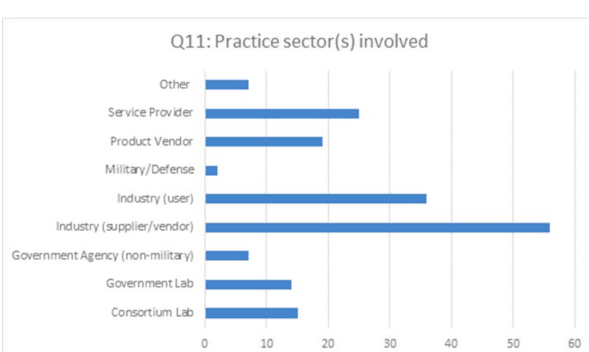

Figure 6. Respondents Breakdown by Practice Sector.

The academic disciplines represented in the survey were dominated by electrical, industrial, chemical, mechanical, and computer engineering, Figure 4. The technology application domains were substantially represented by process, energy, and manufacturing, Figure 5. The practice sectors were substantially represented by industrial suppliers, industrial users, service providers, and vendors, Figure 6. The academic sectors involved were primarily research and graduate programs, Figure 7. Interestingly, most of the research entities listed their focus to be on application rather than pure science.

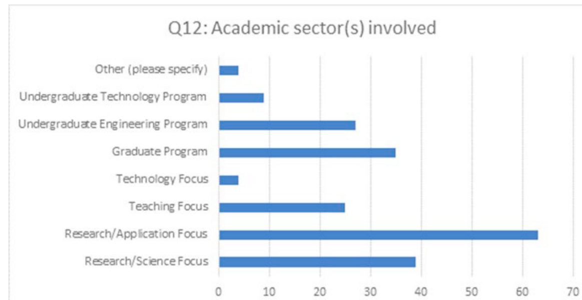

Figure 7. Respondents Breakdown by Academic Sector.

3.3 Funding Sources

Only 43 projects had meaningful information about funding. The breakdown by funding sources is shown in Figure 8. Most projects (24) are funded by Industry: 16 projects of the 24 are only funded by Industry, the others have complementary funding from other sources.

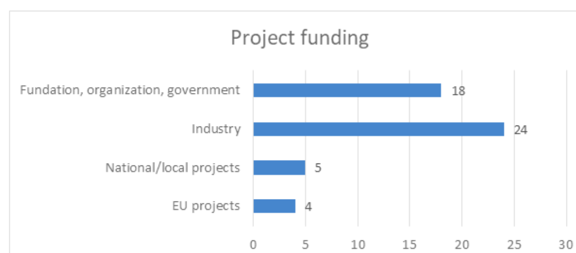

Figure 8. Project Funding Breakdown by Sources.

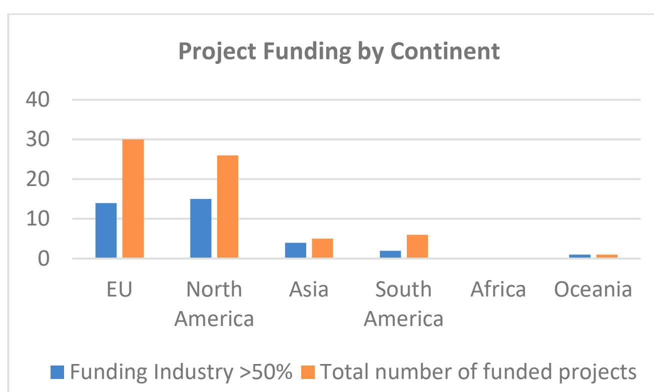

Figure 9. Project Funding Breakdown by Continent.

A breakdown by continent for the projects with more than 50% industry funding is shown in Figure 9. The only meaningful comparison that can be done is between EU and North America. The fraction of projects funded by Industry in North America is higher than that in EU, 58% vs. 46%. Not visible in Figure 9 but present in the data, is that in EU, when a project is not predominantly funded by Industry, it is then funded by

Government. In general, funding sources differ significantly across countries and continents, due to local rules, policies, and business practices.

4. RESULTS FROM FREE RESPONSES

4.1 Incentives and Benefits for Participants

Any successful interaction must generate a win for all participants. Academic-practice collaborations have a diverse group of participants: students (undergraduate or graduate), faculty, academic organization, practitioners, and practice organization. To achieve success, the perspectives of each, what each sees that they are gaining, must be consistent with how the others see a win.

4.1.1 Students

The primary benefit for students is gaining practical knowledge and experience, leading to better career and employment opportunities. Students are excited to work on real world problems, have access to state-of-the art hardware and software, and relate the theory learned in class to specific practical situations. Students want to work with industrial mentors to gain in-depth understanding of the non-technical side of practice, such as soft skills, project management, and market-driven decision making.

For students, academic-practice collaborations can be viewed as a form of project-based learning (PBL). A comprehensive review of PBL is provided by Kokotsaki (2016). PBL is characterised by students' autonomy, constructive investigations, goal setting, collaboration, communication, and reflection within real-world practices.

[A remark based on personal experience of the authors is that students feel the difference between classroom theory and related real-life applications as shown by practitioners, specifically in relation to industrial context and constraints.]

4.1.2 Faculty

Top incentives for faculty are professional development and funding. Professional development includes staying current with the state of the art in the field, selection of relevant research topics, validation of ideas, access to actual data, networking, and career advancement.

It is not surprising to see funding listed as top priority for faculty because most of the academic participants in the survey came from research and graduate program organizations. When success rates for basic research proposals from public sources are decreasing, collaborative projects with practice provide the means to support and sustain an academic group.

Other incentives for faculty mentioned in the free responses are practical relevance of the curriculum and personal satisfaction. Collaboration with practice makes faculty better teachers and mentors to their students due to the first-hand knowledge about technology, practices, expectations, and opportunities. The ability to steer the students in the right direction naturally leads to personal satisfaction.

4.1.3 Academic Institution

Priorities that academic organizations look for are funding, reputation, and societal impact. Programs that are tied to and recognized by the practice community attract high quality students, which in turn brings more interest from prospective partners to collaborate. Student participants are typically offered employment in the partner organization, which elevates the reputation of the academic institution.

4.1.4 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, refresh on theoretical fundamentals, engagement in fundamental research, and peer benchmarking. A small number of respondents listed personal satisfaction as a motivator, specifically, attending conferences, publishing in scientific journals, and an opportunity to influence the education of the next generation.

The increased mobility of young professionals, (Engineers Australia (2017)), has forced businesses to reduce on-the-job training and scrutinize the skillset of new hires. For hiring managers, collaborative projects with academia provide an opportunity to train and evaluate potential employees before extending a job offer.

4.1.5 Practice Entity

For the practice entity, top incentives are new ideas, new product development, recruiting, and brand name recognition. Some respondents viewed collaborations with academia as low-cost research and development. Societal responsibility was also listed as a motivator, in particular, helping and stimulating academia to focus on real world problems and opportunities.

[It may be surprising here to not see the impact on the industrial product in terms of added value for the customers. However, it seems that most respondents were not involved in proprietary development projects.]

4.2 Attitudes and Behaviours

4.2.1 Academic Preferences and Expectations

Academic participants are looking for subject matter experts who are willing to embrace change by stepping out of their comfort zone and daily routines and provide a bridge between academic and contract research. Academics want to work with practitioners who demonstrate genuine interest in the joint work and see themselves as teachers and facilitators. Other expectations include intellectual honesty, curiosity, and willingness to return to academic rigour.

4.2.2 Practice Preferences and Expectations

Practitioners like to collaborate with academics and students who genuinely want to learn about practice and work at the pace of business. Practitioners like to see the experienced academic researchers committed to the project and working side-by-side with the less experienced graduate students. Practitioners are looking for faculty who truly understand and embrace the fact that the main objective of a company is to sell a product and realize profit. Academics are expected to recognize and accept that the results from the collaboration might not be publishable due to confidentiality or intellectual property restrictions. Practitioners want to have a long-term commitment from academia to support the joint work over multiple stages that go beyond the initial fixed timeline of the collaboration.

4.3 Organizational Structure and Implementation

4.3.1 Common Expectations between Academia and Practice

Both sides expect to have a shared vision, well-defined objectives, clear goals, schedule, and milestones. They want support from the leadership on both sides, resulting in adequate and stable funding and staffing. Regular interaction, formal or informal, is seen as important for building trust and personal relationships.

A dedicated program manager, sometimes called program director, is essential in larger scale collaborations. This is a person who understands all groups and can successfully engage people in each organization in order to maintain project schedules, knowledge sharing and delivery of outcomes. The program manager continually interacts with high levels in the funding organization to keep them committed and satisfied and with the collaboration team to ensure they are on track to return benefit to the sponsor.

4.3.2 Academic Preferences and Expectations

Academics expect access to adequate facilities and actual data. They like to see an arrangement that allows them to present or publish some of the work.

Academics want to have specific educational goals recognizing workforce development as a desired outcome of the collaboration. This includes preparation of undergraduate and graduate students, as well as professional development of faculty to make classroom content relevant to practice.

4.3.3 Practice Preferences and Expectations

Practice likes to see goals and outcomes with clearly defined utility to industry (e.g., added value on the final product with respect to customer needs). In the very extreme, practice wants to have full control over the results from the collaboration and keep them confidential.

4.4 Attributes Promoting Successful Collaboration

Addressing a joint problem, ability to bridge the gap by understanding and respecting each other, adequate communication, and adequate funding are top attributes of successful collaboration. The survey analysis shows that cultural aspects, such as mutual respect, common language, openness and willingness to adapt, serve as a fundament for enabling collaboration and bridging the gap between academe and practice. All participants must have clear and realistic expectations, with obligations and rights explicitly stated in formal agreements.

Successful collaborations are typically long-term undertakings, spanning multiple budget years and academic cycles. They start small with frequent communication between participants, fostering openness and respect. Once mutual trust and strong personal connections are established, the scope of the collaboration is naturally expanded.

Adequate staffing on both sides is key to the success of the collaboration. The academic side must not only provide a leader, but also a motivated student team (when the collaboration is supporting student benefit) with proper incentives and qualifications. The practice side must not only provide funding, but make available subject matter experts who are accessible, engaged, and willing to spend time tutoring.

Formal progress reviews between the partners are effective tools to steer the collaboration in the right direction and maintain it long term. They provide a feedback mechanism to ensure that the activities are still relevant and meeting the needs and expectations of all constituents.

4.5 Barriers to Successful Collaboration

Mismatched goals and expectations, lack of trust and respect, personnel turnover, bureaucracy, and intellectual property are common barriers to collaboration. The inbuilt tension between open publication and trade secrets constitutes a particularly important aspect which, if neglected, might take the collaboration to a dead end. Another aspect that deserves particular attention is the differences in time-horizon that academe and practice typically operate within. Other obstacles listed by the respondents are the opposites of the success factors outlined in the previous section: disengagement by the partners, weak mentoring, lack of motivation, and students with inadequate qualifications.

5. CONCLUSIONS

A concise summary of the top ten keys for successful academic-practice collaborations in automation and control is provided in Table 1. The order follows the typical chronological progression of a successful collaborative project, starting from a shared vision for a joint problem and ending with the establishment of lasting personal and professional relationships. The keys can be viewed as links in a chain. Every key is equally important in the relevant phase, and to achieve success all of them must be diligently pursued.

In their very extreme, the preferences of academia and practice can be mutually exclusive, and a compromise is needed to reach common ground. The guiding principle in doing so should be that successful collaborations must generate a win for every participant.

The keys for success identified in this work reflect the collective opinion of the automation and control community. They were formulated based on the personal experiences and observations of 125 individuals covering 85 unique collaborations. In that regard, the presented keys can be viewed as a benchmark. By following these basic guidelines, participants on both sides of the collaboration will steer clear from common pitfalls and frustrations and will significantly enhance the odds for mutually beneficial results.

Table 1. Ten Keys for Successful Collaboration between Academia and Practice.

1. Address a joint problem and share a vision that provides a win for all participants.
2. Define success and deliverables.
3. Define objectives, goals, schedule, and milestones.
4. Gain support of leadership.
5. Secure adequate funding and staffing.
6. Define responsibilities.
7. Appoint a project manager / program director.
8. Build realistic expectations.
9. Stay engaged and connected.
10. Develop mutual trust, respect, and lasting personal relationships.

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REFERENCES

Alford, J. S. and Edgar, T. F. (2017). Preparing Chemical Engineering Students for Industry, *Chemical Engineering Progress*, November 2017, 25-28.

Alford, J. S. (2006). Educating the Engineer. *InTECH*, (11), 48-52.

Awasthy, R., Flint, S., Sankarnarayana, R and Jones, R. L. (2020) A framework to improve university–industry collaboration. *Journal of Industry-University Collaboration.* 2(1), 49-62.

Chun Tie, Y., Birks, M., and Francis, K. (2019). Grounded theory research: A design framework for novice researchers. *SAGE open medicine*, 7, 1-8.

Engineers Australia (2017). The Engineering Profession A Statistical Overview, Thirteenth Edition

Kokotsaki, D., Menzies, V. and Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools*. 19(3):267-277.

Mastellone, S., and van Delft, A. (2021). The impact of control research on industrial innovation: What would it take to make it happen? *Control Engineering Practice*, 111

McMillan, G. K., Jordan, D., Torres, H. H., and Vegas, P. H., (2020). 75th Anniversary Snapshot: Enabling new automation engineers, *InTECH* 67(5), https://www.isa.org/intech-home/2020/september-october/features/75th-anniversary-snapshot-enabling-new-automation

Pertuzé, J., Calder, E., Greitzer E. and Lucas, W. (2010). Best Practices for Industry-University Collaboration, *MIT Sloan Management Review*, 51(4), 83-90

Rhinehart, R. R. (2019). The Elephant, *CONTROL magazine*, Vol. 32, No. 2, 43-44.

Samad T., et al. (2020). Industry engagement with control research: Perspective and messages, *Annual Reviews in Control*, 49, 1-14.

Sauermann, H. and Stephan, P. (2013). Conflicting logics? A multidimensional view of industrial and academic science. *Organization science*, 24(3), 889-909.

Wolfenden, H., et al. (2019). Making practice publishable: what practice academics need to do to get their work published, and what that tells us about the theory-practice gap. *Social Epistemology*, 33 (6), 555–573.