The Success Factors Powering Industry-Academia Collaboration

Claes Wohlin, Blekinge Institute of Technology

Aybüke Aurum, University of New South Wales

Lefteris Angelis, Aristotle University of Thessaloniki

Laura Phillips, Macquarie Group

Yvonne Dittrich, IT University of Copenhagen

Tony Gorschek, Håkan Grahn, and Kennet Henningsson, Blekinge Institute of Technology

Simon Kågström, Net Insight AB

Graham Low, University of New South Wales

Per Rovegård, Factor10

Piotr Tomaszewski, ST-Ericsson

Christine van Toorn, University of New South Wales

Jeff Winter, Blekinge Institute of Technology

// Collaboration between industry and academia supports improvement and innovation in industry and helps to ensure industrial relevance in academic research. This article presents an exploratory study of the factors for successful collaboration between industry and academia in software research. //

SOFTWARE DEVELOPMENT ORGANIZATIONS are always seeking new technologies and processes to ensure global competiveness—Ericsson, for example, devotes 80 percent of its R&D budget to software.[1] To address challenges related to competitiveness, organizations often look beyond industry partners to academic collaborators for innovation.[2] However, successful collaboration doesn't just happen; it must be carefully planned and nurtured. It's therefore important to fully understand what makes such collaboration a success.

Previous research has focused on technology transfer projects—for example, Ana Bernardos Barbolla and José Casar Corredare interviewed 30 researchers from different areas, analyzing the actual projects and experiences to determine what made them successful or not.[3] The researchers uncovered a set of important factors for collaboration covering areas such as project, people, industrial organization, coordination, and trust. Tina Barnes and her colleagues identified factors that would increase the probability of successful collaboration between industry and academia.[2] The result was a good practice model for effective management of collaborative R&D projects that covered areas such

0740-7459/12/$31.00 © 2012 IEEE

as partner evaluation, project management, trust management processes, and mutual benefit. The factors we present in this article align well with the areas Barnes and her colleagues identified.

In particular, the studies we present here extend the research on success factors for industry-academia collaboration into software development for software-intensive systems. Furthermore, they make the relative importance of each success factor explicit by allowing participants to prioritize factors by importance. Our studies include participants from both industry and academia, and our findings are based on two exploratory studies: one conducted in Sweden and the other in Australia.

> Our objective was to leverage and collect experiences and lessons learned from successful collaboration between industry and academia.

Context

The companies represented in this article specialize in several different application domains: professional and personal services; pharmaceuticals; telecommunications; automation; banking, finance, and insurance; health and aged care; and manufacturing. The company sizes range from a couple hundred employees to large multinational entities. From industry, stakeholders include product managers, project managers, developers, and testers, and from academia, professors and students at different levels.

Sweden

We conducted the Swedish study via a six-year collaborative project between industry and academia (www.bth.se/besqproject); industry provided matching funds primarily in terms of in-kind funding. Five companies participated for the project's duration. PhD students, each of whom had one main industrial partner, conducted the majority of the collaborative work. Many of the students had electronic access cards, a work space, and computer logins with their main industrial collaborator. This study took place under a stable and ongoing collaboration between Blekinge Institute of Technology and its industrial partners after four years of collaborative work, which implies that a certain level of trust was in place and all parties were familiar with procedures for collaboration.[4] The senior researchers, primarily involved as the PhD students' advisors, and industrial respondents contributed both with their experience from this project and from other collaborations. The latter included other smaller research projects, student projects, and master's theses.

Australia

The Australian study had a more general context and was primarily related to information systems research.[5] It included respondents from more than one university and didn't focus on a single long-term collaborative effort. Thus, the respondents in the Australian study had a more diverse experience base. The senior researchers generally had experiences similar to the Swedish senior researchers, but industry participants had varying experiences with different forms of collaboration due to different types of student research projects, joint research projects, industrial training for students, consultancy, and development projects. The students participating in the study came from various levels, including both master's and PhD levels, and had different experiences, including various thesis projects, typically associated with data collection in industry.

Methods

The studies presented here investigate three research questions using a survey approach. The survey allows participants to rank a set of potential success factors for industry-academia collaboration. In particular, it allows participants to assign relative values to success factors.

Research Questions

Our objective was to leverage and collect experiences and lessons learned from successful collaboration between industry and academia in two different settings. Based on ongoing research collaborations between Blekinge Institute of Technology in Sweden and the University of New South Wales in Australia, we decided to replicate the original Swedish study in Australia. Although we made some changes to the research method before conducting the new study, we were happy that the actual context for the two studies differed because it enables a greater possibility to generalize the findings. We investigated the following research questions:

1. Which success factors are considered most important in collaborations between industry and academia?
2. What are the differences between industrial and academic perceptions of these factors?
3. What are the differences between the Swedish and Australian studies concerning these factors?

We investigated questions 1 and 2 in both studies and formulated question 3 later on for additional research.

Survey

We surveyed participants with an Excel file of success factors believed to be important for successful collaboration between industry and academia. The factors in the Swedish study were based on literature[2] and a brainstorming session with three university researchers. We asked two industrial representatives experienced in industry-academia collaboration to review the list to ensure reasonable completeness. Both confirmed the usefulness of the following 14 factors:

1. collaboration champion on site;
2. champion's network within the company;
3. buy-in and support from company management;
4. buy-in and support from industry collaborators;
5. short-term results and impact on industry;
6. organizational stability (industry partner);
7. researcher's visible presence in industry;
8. regular meetings;
9. researcher's relevant expertise;
10. researcher's attitude and social skills;
11. researcher's commitment to contribute to industry needs;
12. research project's organization;
13. research environment at the university; and
14. prior experience of industry-academia collaboration.

We then asked the participants to prioritize the importance of these success factors, giving them 1,000 points to distribute among the 14 factors based on how important they believe a success factor is. (This method is often called *cumulative voting*.[6]) The result is a prioritized list with quantifiable gaps representing the difference in and level of importance between success factors.

We sent the survey to students, senior researchers, and practitioners. Initially, our intention was to cover different roles within industry and academia. However, we found no statistical differences among responses from the different roles within each group, so we focused on the overall categories of industry and academia.

The Swedish study included nine doctoral students, six senior researchers, and 24 practitioners; the latter represented four companies, one of which was overrepresented with 15 respondents. Respondents in the Australian study included 15 students, 18 senior researchers, and 17 practitioners. We checked all responses to ensure that no single company's responses dominated the industrial data.

We added two additional success factors to the Australian study:

15. trust and
16. short-term result/impact on the university.

In the individual analysis, we used all the factors identified from this study; in the comparative study, we analyzed only the 14 common factors.

Statistical Analysis

The bounded nature of success factors (that is, the application of a 1,000-point distribution) violates the normality assumption for parametric methods (such as ANOVA and t-test). To be able to apply parametric methods for the comparison of roles, we transformed the data using Blom's transformation,[7] which utilizes the ranks of values and the inverse of the cumulative normal distribution function. The resulting data was normally distributed and standardized (mean of 0 and standard deviation of 1) so we could apply ANOVA or t-tests. Results with a p value lower than or equal to 0.05 are considered statistically significant. We applied the nonparametric Kruskal-Wallis and Mann-Whitney tests to the original values of the factors to confirm the results.

Results

Given that the survey ran in both Sweden and Australia, we can investigate the findings from each country separately and compare the findings between the countries. The results illustrate both a number of similarities and some differences (which might be due to different contexts).

Swedish Study

Note that the Swedish survey presented all 14 success factors because, according to the representatives we asked, they were all important. Thus, although the respondents didn't regard the success factors at the bottom to be as critical as they did the higher-ranked factors, we still shouldn't neglect the lower-ranked factors. This is one of the major points differentiating our study from others in this area.

> Initially, our intention was to cover different roles within industry and academia.

Rankings of success factors (research question 1). Using the survey, we merged individual responses from the Swedish study and identified the top three success factors:

1. buy-in and support from company management,
2. collaboration champion on site, and

3. researcher's attitude and social skills.

The bottom three factors were

12. research project's organization,
13. research environment at the university, and
14. prior experience of industry-academia collaboration.

From this analysis, it's clear that the company-side factors will enable collaborative success. However, given that it's typically the researcher who will physically go to industry, another important factor is the researcher's ability to fit into the company's organizational context. The lowest-ranked factors primarily focused on the situation at the university, providing further motivation to focus on organizing the company side well.

Industry versus academia (research question 2). The next step was to identify any major differences between the views of the industrial and academic participants. To study the differences, we looked at the success factors with a difference in rank of 4 or higher—for example, industry might rank one factor first, but academia ranks it sixth, so the difference in rank is 5. The difference doesn't imply that one view is more correct than the other, it simply illustrates that the two groups have differing opinions about a factor's importance.

Industry in Sweden ranked the following factors more important than academia did:

- researcher's commitment to contribute to industry needs (difference in rank = 6),
- buy-in and support from company management (difference in rank = 4), and
- researcher's visible presence in industry (difference in rank = 4).

Academia in Sweden ranked the following factors more important than industry did:

- champion's network within the company (difference in rank = 6) and
- buy-in and support from industry collaborators (difference in rank = 4).

The differences show that industry was more concerned with a company's management and the researcher's commitment to contribute and help them, whereas academia was more concerned with the actual collaborators, including the main champion at the company.

We undertook a t-test for all factors (applied to normalized values) with respect to the two-level variable (industry/academia). The independent samples t-test showed significant difference for the researcher's commitment to contribute to industry needs ($p = 0.035$); industry perceived it as more important than academia did. We also obtained significant p values for the research environment at the university ($p = 0.007$) and prior experience of industry-academia collaboration ($p = 0.007$). The Mann-Whitney test produced similar results ($p = 0.050$, $p = 0.015$, and $p = 0.016$, respectively). For the latter two variables, academia perceived them as more important than industry did. The Mann-Whitney test indicated a significant difference for one more factor—champion's network within the company ($p = 0.050$). Academia perceived this factor as more important than industry did.

Australian Study

We chose to add two factors for the Australian study to complement the 14 factors from the Swedish study.

Rankings of success factors (research question 1). As with the Swedish study, we merged individual responses in the Australian study and identified the top three factors (with two factors being tied for second place in ranking):

1. buy-in and support from company management,

2a. collaboration champion on site, and

2b. short-term results and impact on industry,

and the bottom three were

14. researcher's visible presence in industry,
15. research environment at the university, and
16. short-term results and impact on university.

Once again, the top two success factors relate to the company's management and champion. Researcher presence was different across the two contexts. The Swedish study was part of a continuous collaboration involving the same people, whereas the Australian collaboration was mostly based on shorter visits obtaining data from industry.

These findings indicate that industry's commitment to collaboration is paramount and ultimately will lead to its success. Additionally, short-term results and impact on university is the lowest-rated factor, adding strength to the view that it's more important that industry (rather than academia) obtains value and results from the collaboration. The value on the academic side often comes to the individual researcher or student involved in the collaboration, whereas industry expects value for the organization as a whole rather than for individual employees. Note that one of the two new success factors included in the Australian study (short-term results and impact on university) ended up in the last position, but the other factor (trust) ended up in the middle.

Industry versus academia (research question 2). As with the Swedish study, we studied differences in ranks between industry and academia in the Australian study to capture differences in viewpoints.

TABLE 1

Comparison of success factor rankings.

Success factor	Sweden			Australia		
	Overall	Industry	Academia	Overall	Industry	Academia
Buy-in and support from company management	1	1		1	1	2
Collaboration champion on site	2	2	1	2	2	1
Researcher's attitude and social skills	3		2			
Short-term results and impact on industry				3	3	
Researcher's commitment to contribute to industry needs		3				3
Champion's network within the company			3 (tie)			
Buy-in and support from industry collaborators			3 (tie)			

Industry in Australia ranked the following more important than academia did:

- champion's network within the company (difference in rank = 4)—and if we consider only students' responses, the difference is even greater (difference in rank = 8),
- short-term results and impact on industry (difference in rank = 5),
- regular meetings (difference in rank = 6), and
- trust (difference in rank = 8).

Academia in Australia ranked the following more important than industry did:

- buy-in and support from industry collaborators (difference in rank = 4),
- researcher's relevant expertise (difference in rank = 9), and
- researcher's commitment to contribute to industry needs (difference in rank = 9).

In Australia, academia focuses more on the actual researcher and collaborators than industry, although industry prioritizes the collaborator's network. Furthermore, industry focuses more on results, meetings, and trust. Some of these findings are actually reversed from the Swedish study (for example, champion's network within the company), indicating the need to perform statistical analysis to identify the significant differences.

We applied the same analysis to both the Australian and Swedish studies with all factors (normalized and standardized) and with role taking on two different values (academia and industry). The independent samples t-test showed significant differences for buy-in and support from company management ($p = 0.009$), which industry views as more important than academia. In addition, we found significant differences for the researcher's relevant expertise ($p = 0.016$) and his or her commitment to contribute to industry needs ($p = 0.004$). Academia perceives the two latter factors as more important than industry does. The Mann-Whitney test found comparable results ($p = 0.016$, $p = 0.022$, and $p = 0.005$, respectively). The Mann-Whitney test gave an indicated a significant difference for one more factor: research environment at the university ($p = 0.048$). Once again, academia perceives this factor as more important than industry does.

Comparison between Swedish and Australian Studies (Research Question 3)

As stated earlier, we observed no statistically significant differences between students and senior researchers across either the Swedish or Australian study; hence, we considered only two variables in our comparison: origin (Sweden or Australia) and role (industry or academia). Table 1 shows the top three factors in both countries overall, for industry, and for academia.

Table 1 shows a relatively high percentage of agreement. The key success factors identified were buy-in and support from company management and collaboration champion on site. In Sweden, researcher attitude and social skills ended up ranking third. This is most likely due to the long-term collaboration, where it's particularly important that researchers (in the

Swedish study, the PhD students) are able to work with industry; hence, attitude and social skills become particularly important. When we look at the third-ranked success factor, more differences appear. However, the factors that ended up ranking third were all related to the company side of the collaboration. To further study the differences, we conducted a statistical analysis.

We based the statistical comparison between the two countries on a two-way ANOVA and applied it to the normalized and standardized values of the 14 common factors. We first rescaled the variables in the Australian study to sum up to 1,000 (because the Australian study originally had 16 factors). We considered each success factor a dependent variable with the origin and the role as the independent variables. We found significance for variables' effects on several success factors:

- *Buy-in and support from company management*. Only role effects were significant (p = 0.011); they were more important for industry.
- *Research environment at the university*. Both origin and role effects were significant (p = 0.01 and p = 0.001, respectively); they were more important for academia in both Sweden and Australia.
- *Researcher's visible presence in industry*. Only origin effects were significant (p < 0.001); they were more important in the Swedish study.
- *Researcher's attitude and social skills*. Only origin effects were significant (p < 0.023); they were more important in the Swedish study.
- *Researcher's commitment to contribute to industry needs*. Only role and origin interaction's effects were significant (p = 0.001); they were most important for Swedish industry and Australian academia.

According to our findings, industry stresses the need for buy-in and support from company management more than academia does. Given the importance of the industrial side in the collaboration, academia must understand the need to have management support when launching collaborative projects. Simply put, industry doesn't view the actual research environment as important as academia does.

Other effects are likely due to the differences in context between Sweden and Australia—for instance, participants in the Swedish, long-term collaboration realized that presence, attitude, and social skills are important elements in making a long-term collaboration work. A final observation is more difficult to interpret, and hence our explanation comes mostly by way of speculation. Swedish industry and the academic respondents from Australia agreed that the researcher must be committed to contribute to industry needs. A potential explanation is that Swedish academia perceives this as part of the package with a long-term joint project. At the same time, Australian industry might view a more short-term collaboration as a basis for recruitment rather than focusing on the actual contribution and impact, whereas the academic respondents in Australia would like to see a contribution to industry needs.

The most important lessons we learned from the studies are

- buy-in and support from company management is crucial;
- there must be a champion at the company, and not only a person assigned the responsibility;
- there are different understandings between different categories of people (for example, industrial people, senior researchers, and students); and
- social skills are particularly important in a long-term collaboration.

Because our studies spanned two different countries with different contexts, we're confident that our results will withstand scrutiny against construct, internal, external, and reliability threats owing to our previous collaborations, the study's exploratory nature, and the multiple contexts. We believe that other researchers could replicate our results if they conducted the studies with the same partners. Although we don't have sufficient data to claim generalizability, it's promising that the results are similar despite the different study settings.

Acknowledgments

We express our sincere thanks to all participants in the survey in Sweden and Australia as well as those who helped us collect data. The research is partially funded by the Knowledge Foundation in Sweden under research grant 20100311 for the project BESQ+. Finally, we thank our editor and reviewers for valuable feedback.

References

1. *Swedish Industry Has a Software Soul*, Swedsoft, 2010 (in Swedish); www.swedsoft.se/Mjukvaran_%C3%A4r_sj%C3%A4len_i_svensk_industri.pdf.
2. T. Barnes, I. Pashby, and A. Gibbons, "Effective University–Industry Interaction: A Multi-Case Evaluation of Collaborative R&D Projects," *European Management J.*, vol. 20, no. 3, 2002, pp. 272–285.
3. A.M. Bernardos Barbolla and J.R. Casar Correda, "Critical Factors for Success in University—Industry Research Projects," *Technology Analysis & Strategic Management*, vol. 21, no. 5, 2009, pp. 599–616.
4. T. Gorschek et al., "A Model for Technology Transfer in Practice," *IEEE Software*, vol. 23, no. 6, 2006, pp. 88–95.
5. L. Phillips, *Success Factors Powering University–Industry Collaboration in Australia*, University Industry Collaboration, 2009; www.wohlin.eu/Phillips_Report.pdf.
6. D. Leffingwell and D. Widrig, *Managing Software Requirements—A Unified Approach*, Addison-Wesley, 2000.
7. G. Blom, *Statistical Estimates and Transformed Beta Variables*, John Wiley & Sons, 1958.

ABOUT THE AUTHORS

CLAES WOHLIN is a professor of software engineering at Blekinge Institute of Technology. His research interests include empirical methods in software engineering, software processes, and software quality. Wohlin received a PhD in communication systems from Lund University. He is a senior member of IEEE and the Swedish Royal Academy of Engineering Sciences. Contact him at claes.wohlin@bth.se.

AYBÜKE AURUM is an associate professor at the University of New South Wales. Her research interests include decision support in software development, requirements engineering, value-based requirements engineering, and software product and project management. Aurum received a PhD in computer science from the University of New South Wales. She is a member of IEEE. Contact her at aybuke@unsw.edu.au.

LEFTERIS ANGELIS is an associate professor of statistics and information systems at Aristotle University of Thessaloniki. His research interests include statistical methods and models applied to software engineering, knowledge discovery from Web data and databases, statistical modeling and analysis of simulation results, and optimization algorithms. Angelis has a PhD in experimental designs from Aristotle University. Contact him at lef@csd.auth.gr.

LAURA PHILLIPS works in IT operations at Macquarie Group. Her research interests include nonfunctional requirements and how they are managed in organizations. Phillips has first-class honours in information systems and management from the University of New South Wales. Contact her at phillips.laurabeth@gmail.com.

YVONNE DITTRICH is an associate professor at the IT University of Copenhagen. Her research interests include use-oriented design and development of software and software development as cooperative work. Dittrich has a PhD in computer science from Hamburg University. Contact her at ydi@itu.dk.

TONY GORSCHEK is an associate professor of software engineering at Blekinge Institute of Technology. His research interests include empirical software engineering, process assessment and improvement, requirements engineering, and software product management. Gorschek has a PhD in software engineering from Blekinge Institute of Technology. He is a member of the International Software Product Management Association, IEEE, and ACM. Contact him at tony.gorschek@bth.se or www.gorschek.com.

HÅKAN GRAHN is a professor of computer engineering and research dean at Blekinge Institute of Technology's School of Computing. His research interests include computer architecture, multicore systems, parallel computing, and performance evaluation. Grahn has a PhD in computer engineering from Lund University. He is a member of IEEE and ACM. Contact him at hakan.grahn@bth.se.

KENNET HENNINGSSON is program manager and lecturer of software engineering at Blekinge Institute of Technology. His research interests include practically applicable process improvement and quality issues. Henningsson has a licentiate degree in software engineering from Blekinge Institute of Technology. Contact him at kennet.henningsson@bth.se.

SIMON KÅGSTRÖM is a software developer at Net Insight AB. His research interests include multiprocessor operating systems, binary translation, and program portability. Kågström has a PhD in computer systems engineering from Blekinge Institute of Technology. He is a member of IEEE. Contact him at simon.kagstrom@netinsight.net.

GRAHAM LOW is an emeritus professor in the School of Information Systems, Technology and Management at the University of New South Wales. His research interests include implementation and adoption of new technologies by the IS/IT industry. Low has a PhD in chemical engineering from the University of Queensland. Contact him at g.low@unsw.edu.au.

PER ROVEGÅRD works as a software consultant at Factor1. His research interests include organizational processes for handling software change. Rovegård has a PhD in software engineering from Blekinge Institute of Technology. Contact him at per.rovegard@factor10.com.

PIOTR TOMASZEWSKI is a software architect at ST-Ericsson. His research interests include software development, productivity improvement, software metrics, and prediction methods. Tomaszewski has a PhD in computer systems engineering from Blekinge Institute of Technology. Contact him at piotr.tomaszewski@stericsson.com.

CHRISTINE VAN TOORN is a lecturer and director of the BIT and ISM Co-op Scholarship Programs at the University of New South Wales. Her research interests include knowledge management, e-learning, and collaborative learning. Van Toorn has an MS in information systems from the University of New South Wales. Contact her at c.vantoorn@unsw.edu.au.

JEFF WINTER is a PhD student of software engineering at Blekinge Institute of Technology. His research interests include participatory design and action research. Winter has a licentiate degree in software engineering from Blekinge Institute of Technology. Contact him at jeff.winter@bth.se.