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A Survey of Types of Industry-Academia Collaboration

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A Survey of Types of Industry-Academia Collaboration

Collaborations between industry and academia are, when properly designed and managed, beneficial to both the industry partners and the academic institutions. Such collaborations may take place on both small and large scales, and may involve varying numbers of academic institutions and industry partners. They may also have different purposes, including both research-focused collaborative efforts and programs designed to connect undergraduate students with real-world projects to enhance their education.

In this paper, the authors will provide a survey of different models of industry-academia collaboration in engineering and engineering technology. The paper will include both a survey of existing literature on the topic as well as a survey of publicly available information on existing collaborations. While the primary focus is on collaborations within the United States, some literature on international collaborations will also be included in the survey. It will discuss several different collaboration models, and what factors appear to be significant in those collaborations. Finally, it will conclude with recommendations that can be used to study specific aspects of industry-academia collaborations.

Introduction

Students find it helpful to participate in an internship or co-op experience while in college[1], while faculty find it helpful to collaborate with industry to further their research, increase the student experience, and interact with the community[2]. There are many different types of industry-academic collaborative relationships throughout the United States. Furthering our knowledge by providing a survey of the types of these affiliations will develop our comprehension of how various universities and industries further their research agenda, while providing meaningful experiences for the students.

This work develops a better understanding of the collaborative efforts and further the development of more comprehensive surveys in this area. As we researched this area, it became evident that the scope is large and covers most of the world. Therefore, this survey examines these collaborative relationships only in the United States, while it is important to include foreign literature in the historical development of these relationships.

Background

Industry-academia collaboration is not a new concept as we find the earliest discussion occurring at the end of the 1960's,[3] in Russia. These collaborations sponsored by the governments of countries[4,5] interested in promoting this kind of activity, eventually became individual relationships between companies and universities throughout the rest of the world. Current literature indicates that such relationships became more of the norm in the late 1990's and in the last decade commonplace in various forms. Recently, consideration of minorities, women, and other distinguishing demographic factors are further investigated in these collaborations.[6]

While examining the historical development of these relationships, it is appropriate to examine the perspective to both parties. Industry views these partnerships from the standpoint of how they

are able to influence the bottom line of the company. Often the research or work done by the university results in a new finding to further the wellbeing of the company, and at times a patent or other significant finding is a result of this work.[7] Scholars find these collaborations helpful to the students they engage, as well as the work they and others are embarking on.[4] When reviewing the results of various collaborations, and the material found on websites, one must consider the differences in perspective and expected result of all participants.[8,9]

The greatest benefit for both industry and the research communities is the ability to engage in academic research that benefits both society and the economy.[10] Research focusing on academic engagement normally does not consider the industrial environment or policy making because the researchers receive more attention from commercialization as opposed to policy makers.[10] Mutter and Pruett[11] affirm that the benefit of the industry university collaboration goes beyond these basic benefits. They share that faculty are given the opportunity to stay updated on current trends in industry, students are made ready for the workplace as they encounter authentic experiences, university resources are often updated, and lowering the learning curve as these students move in to the workforce. Collaborations may take many different forms, with some of the commonly cited forms including internships and work-study programs, curriculum advisory boards, and involvement in capstone courses.[12] In fact, much of the published literature from many countries focuses on industry-academia collaborations in terms of the impact on students, through courses and work experiences.[13,14,15] Other forms of collaboration that have been studied focus on research activities,16,17 and in some cases specifically on technology transfer.[18]

Many factors influence the success of such collaborations. In a study covering Sweden and Australia, Wohlin et al. found that one critical factor in success is support from company management, with a champion who truly owns the program, and not simply someone assigned to be in charge of it.[19] In some countries, there are significant bureaucratic obstacles to collaboration, including laws on unfair competition.[20] Evaluating the success of collaborations is also challenging; in order to do so, it is necessary to define what success is, and to determine an appropriate metric. Such metrics will differ according to the goal of the collaboration, and in some cases it may be difficult to determine what the most appropriate metric may be. In the case of research-focused collaborations, for example, co-authorship and funding have been used at times, but they have been found to present an incomplete picture of success in collaboration.[21]

This paper provides an overview of the different styles of industry-university collaborative relationships. Future work will include greater study of these relationships as well as the result of these programs on the student as they enter and navigate industrial careers.

Methods

Information on different forms of industry-academia collaboration was gathered from several sources. These were:

1. Published literature on industry-academia collaborations
2. University websites
3. Websites for multi-university institutes

While the primary focus for this paper was on industry-academia collaboration within the United States, much of the background literature originated outside of the United States. The university websites and websites for multi-university institutes and collaborative efforts were all taken from institutions in the United States.

Once compiled, the information was summarized based on the scale and goal of the collaboration.

Findings

There were a number of different forms of industry-academia collaborative efforts, and some of these major forms are summarized here, with some examples.

Large, multi-university/multi-company collaborations

There are a number of well-established collaborations involving multiple universities and multiple industry partners. Some examples of these are the Automotive Research Center, headquartered out of the University of Michigan; the Commonwealth Center for Advanced Manufacturing, headquartered in Virginia; and Research Triangle Park in North Carolina. A brief description of each is provided.

Automotive Research Center (http://arc.engin.umich.edu/)

The Automotive Research Center, established in 1994 at the University of Michigan, is sponsored by the U. S. Army TARDEC. It includes Wayne State University, Oakland University, the University of Iowa, Clemson University, and Virginia Tech as additional academic partners, and focuses its research on ground vehicle technologies. The ARC also includes 26 industry partners, primarily in the automotive industry, and provides several ways for other industrial partners to participate. These include assigning an employee to be a "Quad member", or industry representative, on an ARC project or providing research funding for new or existing projects, either individually or as part of a consortia or government-industry partnership. In such projects, intellectual property issues are dealt with on a case-by-case basis, with the agreement included in contract agreements.

Each project undertaken by the ARC includes at least one industry representative, a student or research fellow, a faculty member from one of the universities, and a representative from TARDEC. One of the goals of the ARC is technology transfer, which is accomplished both through the projects themselves and through the future employment of students who worked on ARC projects in government and industry employers.

Commonwealth Center for Advanced Manufacturing (www.ccam-va.com)

The Commonwealth Center for Advanced Manufacturing (CCAM), centered in Virginia, allows member companies to pool resources to pursue university research, with five universities, 11 organizing industry members, seven principal industry members, and five affiliate industry members. The universities involved are Old Dominion University, University of Virginia, Virginia Commonwealth University, Virginia State University, and Virginia Tech. The organizing members pay a yearly fee of $400,000, have voting rights in the organization, and sponsor directed research as well as participate in generic research activities of CCAM.

Principal members have an advisory role, and participate in generic research activities, while affiliate members commit equipment and tools, and also serve in an advisory role. Intellectual property developed through generic research activities at CCAM is available to all the members, while intellectual property developed through directed research activities belongs to the company that sponsored and funded the research. CCAM has several technology focus areas: Surface Engineering, Manufacturing Systems, Machining Technologies, Welding/Joining, Additive Manufacturing, and Composite Materials/Processing.

Research Triangle Park (http://www.rtp.org/)

Research Triangle Park in North Carolina was founded in 1959 by the efforts of local industry, universities, and state and local government. The universities involved are Duke University, the University of North Carolina at Chapel Hill, and North Carolina State University. Some of the industries represented are biotechnology, pharmaceuticals, clean energy, and information technology. One of the programs run by Research Triangle Park is The Lab, which provides small companies a cost-effective way to get tools and lab space. One of the unique features of Research Triangle Park is that it is a not-for-profit venture, with profits being invested in the surrounding community. There are currently approximately 200 companies involved in RTP, and 50,000 people overall, and a research budget of $296 million.

Single university collaboration with multiple companies

Some universities have established research labs that collaborate with multiple corporate partners. These may be similar in scope of work to multiple university collaborations, but without the need to coordinate between universities. One such collaboration is described here, although there are undoubtedly other examples in existence.

Wisconsin Electric Machines and Power Electronics Consortium(http://www.wempec.wisc.edu/)

The Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC) is a research group at the University of Wisconsin-Madison, with over 80 corporate sponsors. The research group focuses on all aspects of power electronics, and also features short courses. These courses, typically a few days in length, are intended to expose industry professionals to key topics within the power electronics field. As they are intended for working professionals, rather than earning credit towards a degree participants in the classes earned Continuing Education Units (CEUs) or Professional Development hours (PDHs). This is particularly useful to industrially focused engineers who are licensed, as many states' licensing boards require continuing education in order to maintain a Professional Engineer license. This particular collaboration has also been studied from an engineering education point of view, with Venkataramanan and Muetze studying the learning environment provided by the consortium.[22] They found that this consortium was able draw on the varying backgrounds of the individual researchers to promote a productive learning climate for students.

Single university collaborations with individual companies

Many universities have a large suite of corporate partners, and collaborate with them; often, these collaborations are each run separately and therefore can be considered to be separate collaborative efforts. Such collaborations often focus on providing projects for students, for their capstone design course or a similar class. One example of this is Olin College. Another model is

when a university has a strong experiential learning program that features co-op or internship experiences, such as the co-op program at Kettering University, Drexel University, or the University of Cincinnati. Collaborations may also focus on the professional development of faculty members, as at Rose-Hulman Institute of Technology.

Olin College (www.olin.edu)

As in all engineering programs, Olin College students perform a capstone project. In the Senior Capstone Program in Engineering (SCOPE), seniors work over the full academic year on projects for industry partners. One example of such a project involved improving early detection of lung cancer, while another program had students working with Facebook to improve the Android application experience for users with slow network connections and limited data plans, which is common in some parts of the world.

Kettering University (www.kettering.edu)

At Kettering University, all students are required to complete a minimum number of co-op terms in order to graduate. Originally, when the university was owned and operated by General Motors as General Motors Institute (GMI), all students' co-op terms were spent at GM. Now, Kettering partners with a variety of industry partners, primarily but not exclusively in the automotive industry, and students may co-op with any of several hundred companies. Typically, a student will remain at the same co-op company throughout his or her education, allowing for a depth of knowledge beyond what could be achieved in a single term.

Drexel University (www.drexel.edu)

At Drexel University, students typically experience up to three different companies throughout their co-op experiences, giving them a breadth of experience rather than depth with a single company. There are over 1,600 employers that partner with Drexel, through 33 states and 48 international locations. Drexel University does not require students to co-op; there are programs in which a student can choose to only attend classes in order to graduate. There are also options for students to experience either one or three co-op experiences.

University of Cincinnati (www.uc.edu)

The University of Cincinnati is another co-op oriented university, with co-op integrated into the degree requirements for the College of Engineering and Applied Science as well as many other programs within the university. The co-op options include over 600 institutions of various types, including large and small companies as well as governmental departments.

Rose-Hulman Institute of Technology (http://www.rose-hulman.edu/)

At Rose-Hulman Institute of Technology, faculty are eligible for sabbatical leave after six years of service, and one of the options for leave activities is an industry experience. Such experiences may take place at a variety of companies; as one example, a member of the mechanical engineering faculty spent several summers at Apple and a sabbatical at Google.[23]

Collaborations of individual companies with multiple universities

Individual companies may also develop their own programs with multiple universities, with a variety of different goals. One such type of program would be a fellowship program for educators to spend time in the corporate environment, such as the A. D. Welliver program at Boeing Corporation.[23] In this program, developed in 1994, Fellows were competitively chosen and spent the summer working closely with Boeing personnel. The program was considered to be a success, with the faculty fellows increasing their knowledge of industry's needs and gaining perspectives on how they could better prepare students for industry careers.[24]

Discussion

Collaborations between industry and academia took a number of different forms, and had different purposes. The collaborations examined in this abbreviated study range from very small efforts to extremely large ones, with little infrastructure required to those requiring large organizational structure. Collaborations were found in all levels of education and research with a variety of combinations to suit both the academic and industrial partners.

While industry-academia collaboration is widely accepted to be desirable and beneficial, there are many issues that should be studied in order to improve its implementation and gain the most possible benefit from it. Many of the resources available from both the collaborations and experiences of faculty and professional staff indicate that there are often shortcomings in the project/student fit, student experience and capabilities, as well as expectations from the industrial partners. This provides us with the opportunity to address a few open questions:

- What types of research projects lend themselves to collaboration between industry and academia?
- What are the various approaches to handling intellectual property and technology transfer, and which ones are most beneficial to all involved parties?
- Do universities that have extensive co-op programs leverage their industry contacts to enhance faculty research, and if so, in what ways?
- How does industry-academia collaboration in the United States differ from similar collaborations in other countries, and how does it vary within the United States?
- How do students benefit from collaboration between industry and academia?
- How are projects assessed to fit student capabilities and level of technical knowledge?
- Are the industry expectations on par with student ability to complete assigned issues?

These questions and many more, should be subject to future study. A comprehensive study of any one of these issues would significantly add to what is known about these collaborations, and enhance their effectiveness.

Conclusion

Effective collaborations between industry and academia are widely known to be beneficial, but the factors that make such collaborations effective are not extensively studied, nor are the full range of types of collaborations documented. In this paper, a brief survey of some existing collaborations of various types was presented, along with a list of research questions that arose

during the survey. Future work in this area should build on this survey and address some of these questions.

References

1 Tobias, A. Internships, coop experience provide an edge. *Electronic Engineering Times* **921**, c4-c6 (1996).

2 Posey, L. O., Carlisle, K. E. & Smellie, D. C. An Internship Case Study. *Training & Development Journal* **42**, 59 (1988).

3 Davydchenkov, V. & Latsis, O. *Order for management (zakaz NA upravlenie)*, <http://search.proquest.com/docview/86398117?accountid=13360 > (1967).

4 Abramo, G., D'Angelo, C. A. & Di Costa, F. University-industry research collaboration: a model to assess university capability. *Higher Education* **62**, 163-181, doi:10.1007/s10734-010-9372-0 (2010).

5 Motohashi, K. & Muramatsu, S. Examining the university industry collaboration policy in Japan: Patent analysis. *Technology in Society* **34**, 149-162, doi:http://dx.doi.org/10.1016/j.techsoc.2012.02.006 (2012).

6 Gatson, J. M. *INDUSTRY–UNIVERSITY ENGAGEMENT IN MULTICULTURAL ENGINEERING PROGRAMS: AN EXPLORATORY STUDY*, Kansas State University, (2015).

7 Pertuze, J. A., Calder, E. S., Greitzer, E. M. & Lucas, W. A. Best practices for industry-university collaboration. (2010).

8 Santoro, M. D. & Betts, S. C. Making industry-university partnerships work. *Research-Technology Management* **45**, 42-46 (2002).

9 Edmondson, G., Valigra, L., Kenward, M., Hudson, R. & Belfield, H. Making industry-university partnerships work: Lessons from successful collaborations. *Science Business Innovation Board AISBL* (2012).

10 Perkmann, M. *et al.* Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy* **42**, 423-442, doi:http://dx.doi.org/10.1016/j.respol.2012.09.007 (2013).

11 Mutter, B. V. & Pruett, R. in *Proceedings of the 2011 American Society for Engineering Education conference & exposition. Retrieved from ASEE website: http://www. asee. org.*

12 Roberts, J., and Consumer Experience Design. "The future of academic-industry collaboration." International Association of Societies of Design Research, Hongkong Polytechnic University (2007): 12-15.

13 Sivananda, Salaka, Vinaya Sathyanarayana, and Peeta Basa Pati. "Industry-academia collaboration via internships." In Software Engineering Education and Training, 2009. CSEET'09. 22nd Conference on, pp. 255-262. IEEE, 2009.

14 Demidenko, Serge, Victor Lai, and Zainal Abu Kassim. "Industry-academia collaboration in undergraduate test engineering unit development." In Electronic Design, Test and Applications, 2006. DELTA 2006. Third IEEE International Workshop on, pp. 7-pp. IEEE, 2006.

15 Werth, Laurie Honour. "Industry-academia collaboration to provide CASE tools for software engineering classes." In Software Engineering Education, pp. 245-256. Springer Berlin Heidelberg, 1991.

16 Sandberg, Anna B., Lars Pareto, and Thomas Arts. "Agile collaborative research: Action principles for industry-academia collaboration." Software, IEEE 28, no. 4 (2011): 74-83.

17 Runeson, Per, and Sten Minör. "The 4+ 1 view model of industry--academia collaboration." In Proceedings of the 2014 international workshop on Long-term industrial collaboration on software engineering, pp. 21-24. ACM, 2014.

18 Teng, Heqiang. "University-industry technology transfer: framework and constraints." Journal of Sustainable Development 3, no. 2 (2010): p296.

19 Wohlin C, Aurum A, Rovegård P, Tomaszewski P, van Toorn C, Winter J, Angelis L, Phillips L, Dittrich Y, Gorschek T, Grahn H. The success factors powering industry-academia collaboration. IEEE software. 2011 Jul 22(2):67-73.

20 Kaymaz, Kurtuluş, and Kadir Yasin Eryiğit. "Determining factors hindering university-industry collaboration: an analysis from the perspective of academicians in the context of Entrepreneurial Science Paradigm." International Journal of Social Inquiry 4, no. 1 (2011): 185-213.

21 Lundberg, Jonas, Göran Tomson, Inger Lundkvist, and Mats Brommels. "Collaboration uncovered: Exploring the adequacy of measuring university-industry collaboration through co-authorship and funding." Scientometrics 69, no. 3 (2006): 575-589.

22 Venkataramanan, Giri and Annette Muetze. “Features of a constructivist microclimate situated in a behaviorist learning environment at a university-based engineering research consortium.” in Proceedings of the American Society for Engineering Education Conference, Chicago, IL (2006).
23 Professor Brings Google, Apple Lessons Back to Class. http://www.rose-hulman.edu/news/academics/2012/bringing-google-and-apple-home-to-rose-hulman.aspx (2012).
24 Gorman, Michael E., Vicki S. Johnson, David Ben-Arieh, Shankar Bhattacharyya, Scott Eberhart, Jacob Glower, Klaus Hoffmann et al. "Transforming the engineering curriculum: Lessons learned from a summer at Boeing." *Journal of Engineering Education* 90, no. 1 (2001): 143-149.