Industry-Academia Collaboration: Main Challenges and What Can We Do

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Abstract How can we bridge the gap between industry and academia? How can we make them collaborate more effectively? In this essay, we try to come up with answers to these important questions.

1 Industry and Academe: Never the Twain Shall Meet?

This seems to be an eternal problem. Industry and academe: challenges are as old as science, as old as political tensions in trouble spots. Indeed:

- What can be more applied that calculus? However, Newton waited 20 years for funding to publish his results. He was sponsored by a beer company – probably the only industry that does not use calculus at all.
- Future Nobelist Leonid Kantorovich invented linear programming to solve a practical problem. However, industry folks was unwilling to try it. Only when he beat them in dominoes they realized that he is smart and decided to try; see, e.g., [4].
- During the Second World War, the atomic bomb project was supported only after Einstein's interference.
- A Russian researcher who invented stealth technology (see, e.g., [3]) could not get it implemented in Russia. Only when US picked it up from his open publication, it was implemented in Russia as well.

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Science progresses, but this problem remains. During the 19th and 20th centuries, there was enormous progress everywhere, but in terms of industry-academe collaboration, it was the same old story. Clearly, this shows that this problem is complicated.

How can we solve this problem? It is time to take on this challenge. To deal with this challenge, we need to understand why there is a problem.

2 It Is Not About Whose Fault It Is, It Is About What to Do

Blaming each other does not help. A frequent attitude on both side of the divide is to decide who is guilty. Our experience in dealing with conflicts in academia shows that usually, both sides are not blameless.

We need to act as adults. In general, psychologists teach us that there are two attitudes to problems.

- There is child's attitude: Who broke with window? We find out who is guilty, the guilty person apologizes and promises never to do it again.
- However, someone – an adult – still has to repair the broke window. This is the adult attitude: the most important thing is what to do.

For example, it is easy to blame capitalists for global warming, etc. A much more challenging task is to come up with solutions.

3 So What Are the Reasons for the Challenge?

Communication is one of the main problems. It all starts with communications:

- sometimes, an industry person formulates a problem,
- sometimes, an academic proposes an idea.

The problem is that they do not fully understand each other.

Academic person. A typical academic person:

- does not understand all the complexities of an industrial situation, and/or
- does not know the implicit assumptions that are trivial to an industry person.

Industry person. A typical industry person:

- may not understand the abstract language that the academic is using, and
- may not understand how it is related to his/her reality.

An example of ineffective communication. One of our professors in game theory – Nikolai Vorobiev – taught us how *not* to write papers. He showed us a paper that described an efficient algorithm useful in many applications. However, the paper started with “Let A be a σ-algebra”. How many practitioners were willing to read beyond this phrase?

An example of effective communication. In our Computer Science department, a capstone class is two-semester Software Engineering. In this class, students work with real customers; During their first semester, they do not program, all they do is try to formulate the problem in precise terms. Only in the second semester, they start coding. Why? Because otherwise, their code may be useless.

Ineffective communication within academe: first example. This happens even in academe. Einstein and Goedel were together in Princeton, so Goedel volunteered to help with solving complex math equations. Goedel spent several years and found a new solution. However, this solution had a closed time loop, it violated causality.

Need for causality was so trivially clear to Einstein that he did even bother to formulate it. However, it was not clear at all to Goedel.

Ineffective communication within academe: second example. Another example: one of the top Russian mathematicians wanted to help the Nobelist Lev Landau solve a complex system of equations. He spent several years and . . . proved that this system has a solution.

This might have been a great mathematical result, but to physics, it was useless:

- these equations describe real phenomena;
- these phenomena exist, so clearly these equations must have a solution.

Ineffective communication: third example. One of our professors participated in designing instruments panel for a pilot. They had clear specification, they spent lots of time coming up with a design. However, pilots did not like it as all – since some clear-to-pilot things were never spelled out.

Ineffective communication: other examples. In Russia, we worked on algorithms for reconstructing images from radioastronomy data. Our first idea was computationally great, but astronomers did not like it. Why? The image was mathematically correct, but not physically possible.

To them it was trivial, but no one explained it to us. Now we work with geophysicists — this is Texas after all – and we encounter many similar problems.

4 So What Can We Do: Communicate Better

We need to clearly understand each other’s ideas. This is not easy, it takes time, and it is often very frustrating.

In this, we need to learn from physicists. They know how to sell their ideas. Indeed:

- legislators all over the world approve billions of dollars for particle accelerators and space telescopes,

- while many more useful ideas are not funded.

We in academe cannot be snobbish and expect industry folks to learn what is σ-algebra. On the other hand, industry folks should not dismiss academics as hopeless pie-in-the-sky folks.

If Israel and Egypt managed to sign a peace treaty, there is hope for us.

5 What Else Can We Academics Do?

Three levels of application. There are several levels of application.

- The first level is when a researcher knows a tool and uses it. Sometimes it works, but often it does not. There is a saying about thus, that if all you have is a hammer, then everything looks like a nail.
- The second level is when a researcher knows several tools, and uses the most relevant one.
- However, the third, most successful level is when a researcher invents a *new* tool that perfectly fits the problem. This is what led to most successes.

Was Wigner right? Nobelist Eugene Wigner wrote a famous paper [7] about unexpected effectiveness of mathematics. As examples, he gave:

- quantum physics, where so-called Hilbert spaces turned out to be very useful, and
- general relativity, where curved pseudo-Riemannian spaces are the main tool.

However, Wigner had it backwards (see also [1, 5]):

- Hilbert spaces were invented by John von Neumann when he was trying to describe quantum ideas in precise terms; see, e.g., [6].
- Pseudo-Riemannian spaces were invented by Einstein and his colleagues to describe his space-time ideas in precise terms.

What we need. We need to have more applications of this level.

First example: applications of statistics. This is a typical problem, e.g., in applying statistics. Statisticians ask industry folks about desired level of false negatives and false positives. They ask for it because their tools require it.

However, industry folks operate in economic terms, in terms of gains and losses. To make statistics more useful, we need to develop tools that minimize losses and maximize gains without forcing the users to come up with p-values and other numbers which are meaningless to them.

Another example. In general, we need to better understand industrial problems. Piero Bonnisone, who moved from academe to GE, told about his first industry experience. He was asked to design a control algorithm for a washing machine. He came up with a great efficient algorithm, but GE did not use it. Why:

- it saved some money on energy consumption, but
- it did not fit in the chips they used, and having to buy more complex chips would eliminate the gains.

6 What Industry Folks Can Do

One of the main problems. One of the big obstacles is that many folks in industry think *short-term*. If you fire all researchers who do not provide immediate profit, then:

- short-term you gain, but
- long-term you lose.

Current gain often comes from research done many years ago.

First example. A renowned mathematician G. H. Hardy wrote a book *A Mathematician's Apology* [2]. In this book, he said that he was proud of his results in number theory, even those these results were never applied and will never be applied. A few years later, his results led to modern cryptographic algorithms – that provides security and privacy to the web.

Second example. This is one of the reasons why during the Second World War, Germany – that was initially way ahead in nuclear research – lost the race to design the atomic bomb. The reason was that they prohibited all research that would not lead to useful results in a year.

Werner von Braun was successful with his rockets only because he was hiding them from inspectors.

Other examples. Why are Googles and Microsofts and Apples so successful? Because they allow their folks to spend at least one day a week on something not immediately useful. Many commercially successful ideas started this way.

7 It Should All Start at School

We need to train people better. Conflicts appear because people are not trained properly. When one of us complained to the then university President about an unfair newspaper article, she said that:

- the journalists are not vicious, they are ignorant,
- we the universities are preparing them,
- it is our job to teach them better.

How to train better? So how can we teach better so as to decrease the industry-academe gap?

- We need to teach all the students the basics of economics – since in industry, the goal is economic.
- We need to have students solve real problems: either at internships, or in special capstone classes – like our Software Engineering.

Then, we will succeed. And if we do it right, maybe a wolf and a lamb will not lie together, but at least industry and academe will collaborate more successfully.

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