

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

Vladik Kreinovich¹ and Olga Kosheleva²

^{1,2}Departments of ¹Computer Science and ²Teacher Education
University of Texas at El Paso, El Paso, Texas 79968, USA
vladik@utep.edu, olgak@utep.edu

1. And Never the Twain Shall Meet?

- Industry and academe:
 - challenges are as old as science
 - as old as political tensions in trouble spots.
- What can be more applied than calculus?
- But 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 was unwilling to try it.
- Only when he beat them in dominoes they realized that he is smart and decided to try.
- During WW2, the atomic bomb idea was supported only after Einstein's interference.

2. And Never the Twain Shall Meet (cont-d)

- A Russian researcher who invented stealth technology could not get it implemented in Russia.
- Only when US picked it up from his open publication, it was implemented in Russia as well.
- From 19th to 20th century:
 - enormous progress everywhere,
 - but in terms of industry-academe collaboration, same old story.
- Clearly, this shows that this problem is complicated.
- So, it is time to take on this challenge.
- To deal with this challenge, we need to understand why there is a problem.

3. It Is Not About Whose Fault It Is, It Is About What to Do

- 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.
- 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.
- But someone – an adult – still has to repair the broke window.
- This is the adult attitude: the most important thing is what to do.
- It is easy to blame capitalists for global warming, etc.
- A much more challenging task is to come up with solutions.

4. So What Are the Reasons for the Challenge?

- 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.
- The 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.
- The 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.

5. So What Are the Reasons for the Challenge (cont-d)

- 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.
- But it started with “Let A be a σ -algebra”.
- In our Computer Science department, a capstone class is 2-semester Software Engineering:
 - students work with real customers;
 - 1st semester, they do not program;
 - all they do is try to formulate the problem in precise terms;
 - only in 2nd semester, they start coding.
- Why? because otherwise, their code is useless.
- This happens even in academe.

6. So What Are the Reasons for the Challenge (cont-d)

- 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.
- But this solution had a closed time loop.
- Goedel's solution violated causality.
- Need for causality was so trivially clear to Einstein that he did even bother to formulate it.
- But it was clear at all to Goedel.
- 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.

7. So What Are the Reasons for the Challenge (cont-d)

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

8. So What Are the Reasons for the Challenge (cont-d)

- Another example: 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.

9. So What Can We Do: Communicate

- First, 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:
 - 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.
- 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.

10. What Else Can We Academics Do?

- There are several levels of application.
- The first level is when a researcher knows a tool and used it.
- Sometimes it works, but often it does not.
- The saying is that if all you have is a hammer, then everything looks like a nail.
- The second level is a researcher knows several tools, and use the most relevant one.
- 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.
- Nobelist Eugene Wigner wrote a famous paper about unexpected effectiveness of mathematics.

11. What Else Can We Academics Do (cont-d)

- As examples, he gave:
 - quantum physics, where so-called Hilbert spaces turned out to be very useful, and
 - general relativity, where curved pseudo-Riemann spaces are the main tool.
- But Wigner had it backwards.
- Hilbert spaces were invented by John von Neumann when he was trying to describe quantum ideas in precise terms.
- Pseudo-Riemann spaces were invented by Einstein and his colleagues to describe his space-time ideas in precise terms.
- We need to have more applications of this level.

12. What Else Can We Academics Do (cont-d)

- 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.
- But 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.
- We need to better understand industrial problems.

13. What Else Can We Academics Do (cont-d)

- 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.

14. What Industry Folks Can Do

- 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, short-term you gain.
- However, long-term you lose.
- Current gain often comes from research done many years ago.
- A renowned mathematician G. H. Hardy wrote a book Mathematician's Apology.
- 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.

15. What Industry Folks Can Do (cont-d)

- This is one of the reasons why in WW2,
 - 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.
- 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.

16. It Should All Start at School

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

17. It Should All Start at School (cont-d)

- We need to have students solve real problems:
 - either at internships,
 - or in special capstone classes – like our Software Engineering.
- 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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