Disordered Reflections

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Only that which has no history can be defined.
Friedrich Nietzsche.

Ideas that are in vogue often end up like dead leaves.
Anonymous.

The profusion of things hid the scarcity of ideas and the erosion of beliefs. (in *Les Années*).
Annie Erneaux (Nobel Prize 2022)

At a certain point in my career[1], I asked myself the very natural question, namely "What is my job as a university professor and researcher?" This question quickly branched out into more specific questions such as *What is teaching in a university?* and *What is research in a university?* As a professor and researcher in informatics, another question rose just as naturally:*What is informatics?* After a long period of reflection I define Informatics as the science which has algorithms at its core.[2].

This question directly implies another one, namely *What a university informatics curriculum should include?* These questions may seem naive, perhaps denoting a lack of maturity (or a late maturity...) of the author, but so whatever! Without answering all these questions, the following text offers some attempts to provide a few answers.

First, let us note that “teacher-researcher” is a compound word which, although not appearing in dictionaries, is more than just a juxtaposition of words. It also defines a state of mind that makes its two components difficult to separate. It is unfortunate that the profession of teacher-researcher is not associated with a specific indivisible word.

[1]This article finds its origin in an article that appeared in 2016 in volume 9 of the *Société Informatique de France* (SIF).

[2]My research area in on distributed algorithms, that I define as the *science of (formalized) cooperation among a set of independent computing entities*. While they address different contexts, distributed computing and parallel computing ares ometimes confused. Parallelism addresses efficiency of computations. Roughly speaking its aim is to look for data independence in order to process simultaneously batches of independent data (any problem solved by a parallel algorithm could be solved (of course very inefficiently) by a sequential algorithm.

Research and Universities

Research is one of the *raisons d'être of universites*, and this is independent from time and place. Research at universities is the gasoline of teaching. This constitutes the fundamental difference of teaching in universities and secondary schools. Research is an *adventure*, personal and collective, of an intellectual nature. By the word *adventure* I means that research is not defined by a predefined roadmap. Its goal is to deepen our understanding of the world around us and of the artifacts we create to acquire this knowledge. Moreover research is also a quest of a certain universality. We must never forget that words *universe*, *universality* and *university* have the same lexical root!

To achieve its goals research relies on curiosity, determination, wisdom, personal knowledge of its actors, as well as on serendipity (in the sense of an unexpected encounter between prior knowledge, state of mind, and a specific context). A large part of research consists of incremental advances[3]. Those advances form fertile ground from which breakthroughs emerge and then, taken together, enable paradigm shifts (In the sense given by Thomas S. Kuhn in his book *The Structure of Scientific Revolutions*). One of the difficulties of research is to provide this fertile ground without getting bogged down in it. Indeed, it was not by constantly improving the technology of candles that electricity was discovered, understood, and mastered. Research requires time and patience.

In many countries university professor positions are permanent positions (tenure) and this is not coincidence. It dates back to earliest Chinese mandarins: the permanence of their position guaranteed them the time for reflection rather than impulsive and hasty action necessary to maintain and govern the empire. The permanence of the position is a necessary condition for establishing a long-term perspective, without being (too) constrained by the hiccups and vagaries of the short term. "*Time to market*'' must not be the diktat, nor the criterion defining all research themes, nor the analytical grid presiding over their evaluation.

The sentence "*No one enters here unless he is a geometer*" engraved on the pediment of Plato's Academy sums up a state of mind specific to scientific research. There is certainly a continuum from research to its directly visible impact on society, and therefore from teacher-researcher to engineers. (I use here the word "engineer" in the industrial sense. There are, of course, "research engineers"[4] whose work is essential to research, and whose societal impact is not directly visible in products.) For the teacher-researcher (and unlike the engineer), applications are more important for the new questions they raise than for their direct impact on the economy.

The duality of teacher-researcher/engineer is similar to the duality of historian/journalist. The work of the former consists, in their chosen period of study, of analyzing and connecting events, and putting them into perspective, with the aim of providing us with a reasoned, comprehensive, and coherent view of a given period (past or contemporary). Depending on the schools of thought to which historians belong, it is possible to have different analyses and presentations. For citizens, this plurality is one of the guarantors of democracy. The work of the journalist is linked to current events and therefore to present facts. It consists essentially of informing us (and also sometimes taking a critical look at the facts presented) [5].

[3] Incremental is used here in the sense of not constituting a rupture, and does not imply a lack of creativity.

[4] Again, there is no specific word to designate a particular activity.

[5] It is striking that some periods with an enormous historical impact were very short-lived (e.g., –from a western

Like a historian, the work of a teacher-researcher in science consists of exploring and deepening scientific fields in such a way that not only do knowledge advances, but the fundamental and necessary aspects are also taught to students. Trained with the appropriate concepts and methods, each generation of students brings companies with new ideas, new methods, and new knowledge, such that after ten generations of students, these successive waves bring about real industrial revolutions in companies. This process of percolation constitutes the real and visible impact of universities on society, an impact that proves itself every day.

What is a Good Article?

PhD students sometimes ask the question: what is a good paper? What a question! Early in my career (when I was younger), my answer was largely syntactic. Among good articles, I counted those that had received awards granted only to papers published at least x years earlier (for instance, $x = 10$ for the Dijkstra Prize). Some of these articles have stood the test of time (a nontrivial achievement) and have often had a profound impact on their scientific communities.

Over time, however, my perspective shifted from syntax to semantics. Today, from my point of view, a good article is one that makes me slightly jealous that I did not write it myself (or I was not a co-author) of it! Of course, jealous is meant here in a friendly sense. Such an article is well written and develops ideas that we find interesting, sometimes even profound. This is the hallmark of good articles: readers make them their own, assimilate them, and pass on their essence to students.

An Anecdote on the Primacy of Results

Invited as a guest speaker in a conference a few years ago I chose to give a presentation on the *patterns* found in distributed algorithms. As an introductory example, before turning to distributed computing, I presented the well-known pattern in sequential computing proposed by William George Horner (1786–1837) for efficiently evaluating polynomials.

While browsing the web (thanks Wikipedia!), I discovered that this method had previously been proposed by the Italian philosopher and mathematician Paolo Ruffini (1765-1822). A more thorough bibliographic research led me to discover that Horner's method had already been used by the Chinese Zhu Shijie (1270-1330), who used the name *fan fa* to refer to it in his book titled *The Jade Mirror of the Four Unknowns* (1203). I also discovered that this book included a presentation of the so-called "Pascal's triangle" (1623-1662).

Books on the history of science provide many other examples. As a scientist humorously said, the value of a result could be measured by the number of times it has been rediscovered! Maybe we should teach not only science but the history of the science we are teaching. This will make students aware that science is not a mysterious artifact but a "product" of human beings.

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point of view- the age of Pericles, the Italian Renaissance, or the French Revolution), all of which may be viewed as paradigm shifts.

And Innovation in all of This!

The widespread use of the word *innovation* in recent times seems to have turned it into a mantra, supposedly capable of warding off nearly all the problems generated by the junk economy.

Politicians who allocate research funding must justify to voters that public money is being well spent, which is entirely legitimate. Unfortunately, this often leads to a vision of research restricted to its most visible and immediately accessible aspects, those conveniently labeled *innovations*. And media amplification completes the picture. Unfortunately, this means that their vision of research is very often limited to its most visible and accessible (?) aspect to the general public[6] This is then amplified by media coverage, and that's all!

As university professors know from experience, the reality is of course much more subtle. There are many innovations that never leave the research laboratories. Furthermore, not all research necessarily leads to innovation that is visible to the general public, and some research results only find applications a long time after they have been discovered (lasers and touchscreen glass are interesting examples of this). Innovation most often comes from a (well-trained!) engineer or researcher who combines scientific expertise with a keen interest in working with technological tools.

> *A science created solely for the purpose of applications is impossible. Truths are only fruitful if they are linked together. If we focus only on those from which we expect an immediate result, the intermediate links will be missing and there will be no chain*. Henri Poincaré, in *Science and Hypothesis* (1902).

Teaching at a University

Like yin and yang, university research and teaching are inseparable. Research is the realm of uncertainty. We tackle a problem without knowing what the outcome will be, and once published, a result becomes part of the past, carefully preserved in DBLP and in one's CV [7]. To caricature, for a teacher-researcher, the most important problem is almost always the one she or he is trying to solve.

Teaching, by contrast, largely belongs to the realm of certainties. We teach established knowledge, adjusting it slightly from year to year depending on curricula and on what we ourselves have absorbed from recent research. Naturally, this sense of certainty erodes as one moves from undergraduate studies to the research-oriented master's level.

When we consider the teaching/research duality, teaching is almost always on the side of certainties. We teach known things, which we modify partially from one year to the next depending on the curriculum concerned and what we have ourselves assimilated from the research results relating to this curriculum. Of course, the notion of certainty deteriorates and eventually fades away as one progresses from the first years to higher education. [8].

[6]Today, words such as *blockchain* and *AI* often play this role. It is interesting to observe that the notion of "chain of blocks" used to build a total order on transactions was introduced in the early eighties in a failure-free context (this was named *distributed state machine replication)*. Moreover it is also worth noticing that the initial target application of blockchains was money transfer, an application that does not need a total order on all the money transfers.

[7]Unfortunately, so-called negative results are too often considered second-class citizens, despite their illuminating value.

[8]This is a far cry from multiple-choice questions...

Thinking about teaching and having a vision for it are things that cannot be improvised and are at the heart of the teaching and research profession. Teaching consists of stimulating students' intellectual curiosity and giving them the desire to learn (which may seem obvious but is far from easy...). The student's desire to learn is much more important than the teaching method used (regardless of any innovations associated with it).

Teaching requires reflection and vision, it cannot be improvised. As Leslie Lamport has pointed out, teaching cannot be reduced to an accumulation of facts or case studies. Henri Lebesgue (1875–1941) described university teaching as "thinking aloud in front of students." Teaching students how to reason, and how to adopt a scientific—and therefore critical—mindset, lies at the heart of higher education. Schoolchildren are not taught to read and write using washing-machine manuals (which are very used tools), but through the works of great authors. One might argue that this is inefficient, since few will become novelists. Yet reading beautiful texts enriches imagination and instills a sense of structure and flexibility—properties inherent to any language[9]. These experiences define asymptotes that elevate our own writing and thinking. Ultimately, teaching consists of stimulating students' intellectual curiosity and fostering their desire to learn —an objective that may seem obvious, but is far from easy. This desire is far more important than any particular teaching method, regardless of how innovative it may appear.

> "*For me, the first challenge for computing science is to discover how to maintain order in a finite, but very large, discrete universe that is intricately intertwined. And a second, but not less important challenge is how to mould what you have achieved in solving the first problem, into a teachable discipline: it does not suffice to hone your own intellect (that will join you in your grave), you must teach others how to hone theirs. The more you concentrate on these two challenges, the clearer you will see that they are only two sides of the same coin: teaching yourself is discovering what is teachable.*" Edsger W. Dijkstra, *My Hopes of Computing Science*, EWD 709 (1979).

[9]Never forget that *languages* are the most useful tools used by humans and even some animals.

Conclusion

Although immediacy, speed, and competition are seen in today's society as (market) values, it is important to note that we do not think any faster today than our ancestors were thinking twenty-five centuries ago, at a time where history, democracy (in a particular form), mathematics), algorithms, etc. were "invented". In a form or another there were universities a thousand years ago (e.g. Platon Academia and Confucius temples in China) and there will still be universities in a thousand years. We are aware that we belong to an old, large and great family. We feel at home in almost any university in the world, and we feel solidarity with our colleagues present and those who came before us, regardless of their beliefs and particular cultures. We are with them in a spirit of exchange and knowledge, not economic competitiveness.

A Vocabulary Remark

I always use the word *Informatics* and try not to use the word *Computer science*. This is due to the following observation made by many colleagues, namely informatics is not the science of computers, exactly as biology is not the science of microscopes and astronomy is not the science of telescopes. We do not have to confuse the tool and the target.

The case of *Computing science* is different. As advocated by Gottfried Wilhelm Leibniz, each concept must have a *one word* name and a definition (as done in any dictionary). So Informatics (name) is the science of algorithms (definition) and the word computing has to be understood as an algorithm at work.

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