Leadership in Research Communities*

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Abstract

We investigate the role of leadership as a mean for simulating more effective research in emerging communities in computer science (CS). Far most perceived criteria for being successful is the number of publications and citations. This, however, may promote quantity over quality and sometimes lead to closed cycles of research, which certainly does not serve any good for real scientific progress. Indeed some scientific communities make more relative progress than others, even under similar conditions. We argue that leadership plays an important role for guiding any community to the right direction.

Introduction

Science is a force that greatly influences public policy. Bad science leads to sloppy decision making. Society expect rational evidence and such evidence can only be obtained by following a strict discipline, namely scientific methodology.

We use the notion, scientific methodology, in a more operational sense, relating the activities of individual researchers in a community and within a discipline. When a new community is formed, it is often fragile. There is no hard and fast methodology or merit of scientific knowledge exists. If we are working in such a community then there is great burden of leadership that we must bear. Otherwise, we risk being extinct without contributing much to the society.

The need of leadership arises whenever highly uncertain risks are on the way to success. If risks are manageable by virtue of some realistic strategy then, theoretically, we only need good managers to succeed[1]. It is hard to specify what a leader will do, but it is commonly agreed that if a person with a certain set of qualities – the leader – is in the authoritative position over a strategy, which may have high uncertainty in its risk portfolio, will probably succeed. A leader provides vision, and get people ready to do right things. In

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[1]Bennis and Nanus draws the distinction between a manager and a leader: "Manager do things right. Leaders do the right things." [4]

words of Tony Robbins[2], “Effective leaders have the ability to consistently move themselves and others to action because they understand the “invisible forces” that shape us.”

Since the beginning of twentieth century, many different leadership theories emerged [4]. The question of leadership is normally studied in relations between leaders and their immediate followers or seniors, in the context of an organization and a culture. A great deal of the theoretical work focuses on *leadership traits*. These are the aspects that differentiate a leader from an average person, e.g., intelligence, communication skills and charismatic personality. The effects of different traits on the leadership greatly depend on the organization and the culture under consideration. For example, a leader in a technology-driven company may not be a leader in the politics, and the underlying cause for this is not necessarily the lack of political exposure.

This article may be considered as a step towards developing a theory of leadership in emerging research communities (ResCos). We start by defining the concept of *success* in the context of ResCo, and accept it part of premises for our main argument. We believe that our definition of success captures an essential part of intuitive notion of success. Nevertheless, we expect that not every one would be satisfied with its completeness.

In the rest of this article, we first define what we consider the required traits for a research leader. Later, we present our arguments to justify this hypothesis.

Success in a Research Community

Success may be defined in terms of finding the good solutions to the most pressing research problems faced by a ResCo. When one has a well defined problem at hand, finding a good solution is more of a question of being domain expert, being innovative and project management. Apparently, this notion of success has very little to do with any interesting leadership traits.

This simplistic view of success, however, overlooks two important aspects that are of particular interest to us. First one is the need for a well-scoped problem, which is a different concern from what is commonly known as a “well defined problem”. A research community may come up with a good problem formulation but with a wrong scope.

The second aspect is the most basic one, namely what problems are being prioritized in a community, which becomes more significant with the scarcity of available resources for the research. Both of these aspects, scope and priority, must be measured with respect to their potential value to human society.

By defining the success in this way, we indeed exclude the research based on pure mathematics. We believe that for such communities the earlier simplistic notion of success suffices and consequently is not interesting for this exposition. Undoubtedly, in the history, some of pure mathematics later turn out to be of direct practical significance for the society. Most notably, differential equations

[2]In TED Talks: *Why we do what we do, and how we can do it better*

and number theory are established formalisms for electromagnetism (Maxwell's equations) and public key cryptography respectively.

Leadership Traits

Every research activity entails a degree of uncertainty. Dealing this uncertainty is quite challenging when a relatively new community of researchers have to coordinate their activities, give priorities to certain problems and to define the relevance of research for society – without any formal organization.

In a research community, the conceived notion of success, in terms of impact-factor[3], may not be realistic. It's not difficult to find examples where two researcher have achieved different level of success in comparable amount of time, but they have the same or anomalous level of impact-factors (IF). As a concrete example, Whitfield Diffie and Martin Hellman are among the greatest leaders of modern cryptography, but their IFs are not among the highest[4]. Further, in a research community, there is only a loose notion of followers and seniors, as researchers normally do not enjoy the authoritative powers that a leader in many other fields do have.

The leadership in an academic ResCo is a quite distinct notion. This is so as we encounter a skewed notion of success, such as number of publications. Short term success is a poor indication of leadership. A research leader with low IF may be subjected to far greater risks, e.g., unavailability of research grants and to work against the status-quo, although the real success may become visible in long-run. Therefore, leadership within a ResCo demands a type of persistent behavior.

Leadership traits are the behavioral aspects that distinguish a leader from a non-leader. These are the proposed theoretical causes of why a leader is able to cope with uncertain situations and achieve success. In the following, we propose four such traits.

First one is the ability to do *semantic-oriented research*. Most of the theoretical research (especially in CS and the related fields) involves some kind of mathematical modeling. The reality is out there and researchers try to capture this in their models. These models provide the ability to understand the reality, to predict behavior and above all enable us to improve reality by interventions and inventions. Theory of relativity in Physics, periodic table in Chemistry and various types of formal systems in CS are examples of such models. It is quite tempting to involve oneself in the "beauty" of models and forget about what they really represent. We believe that research leader has the ability to establish semantic correspondence between reality and theory.

The second trait is the ability to do *inter-disciplinary research*. Here, the word *discipline* is used in a loose sense to include the notions of fields and subfields of the related knowledge of a ResCo. For example, this term covers

[3]Impact-factor is n if each of n publications get at least n citations.

[4]A rough approximation (based on Google™ scholar) the IF for Diffie is 18 and that of Hellman is 21 until 2010. For comparison, we may note that some of the other top researchers in the same field have IF 60 or more in almost the same period.

the case if one is able to work on user interface and human psychology. Most of us have our "comfort zones", in which we try to settle down. This behavior is quite understandable as it provides a less difficult path towards perceived success (i.e., IF). In practice, however, most of useful solutions for society do involve inter-disciplinary aspects.

The third is the ability to do *root-aware research*. A leader knows the roots of his theory and the methodology. This involves the knowledge of relevant scientific history – i.e., how and why a research community reaches on a particular methodology and research agenda. This enables one to understand the paradigm in which one is working. Sometimes a ResCo keeps following a path and forgets what was the purpose for forking on this path or what kind of impact it has on contemporary reality. For example, we believe that mathematical cryptanalysis, a path that originates around the period of World War II[5], has no practical significance today[6].

The last trait is the ability to do *charismatic dissemination* of one's research, in order to mobilize critical mass. There are many examples in literature where some method is discovered (and rediscovered) several times. In many cases, the main reason for this is bad dissemination. Typically, a researcher does not have enough resources on his disposal to fully develop his idea. Therefore, he needs to convince others, and poor documentation or "least publishable units" (LPU) do not help.

Potential Problems

A scientific methodology refers to the established ways and means of putting forward research ideas and theories, under a contemporary scientific paradigm. In fact, methodologies are rules of the game. A work based on the scientific methodology remains valid at least during the lifetime of its paradigm. Normally, it takes many decades before a major paradigm shift occurs. The research that is not compatible with scientific methodology, also referred as *pseudo-scientific research*, disappears quickly.

For example, we may analyze security of communication protocols without making use of any methodology that is considered appropriate for this purpose[7]. It is a pseudo-scientific result, even if we write tons of justifications why "we think" this is a cool method. It is still pseudo-scientific even if we show the soundness of method in a model that is not considered appropriate for this purpose.

Quality control determines what could be an LPU for a ResCo. Poor quality control adversely effects the scientific culture. One of the underlying cause for this problem is the phenomena of trepidation in minds of researchers to be

[5]Here we are referring to the cryptanalysis of Enigma machines.

[6]This is not merely our own point of view; Adi Shamir, a Turing Award winner and a key researcher in modern cryptography, also stated that the era of mathematical cryptanalysis is over in theory (public lecture, Crete, 2010).

[7]As in year 2010, an example of appropriate methodology is the computational complexity based provable security and inappropriate would be the BAN logic.

successful. Without some sort of control, one may try to publish more for creating more impact on expense of avoiding sound scientific practices. In worst case, quantity determines success and research grants.

One problem that may occur in a community is the narrow definition of a research problem. Any solution to the problem, no matter how convincing it looks, has no value in big picture. The problem is dynamic in nature. A well-scoped problem may become ill-scoped in future. One possible cause could be the lack of cross-disciplinary exposure of the key members of ResCo. For example, research on computer security would be ill-scoped research now-a-days if we ignore side-channels[8].

Sometimes a community is trapped in a vicious closed circle, as in a popular joke: A thinks that his research is useful for B, B thinks the same about C ... and finally C thinks the same about A. In other words, the researchers that are in such close circles produce results for each other, without being concern with the reality.

Relevance of Traits

In the following, we present our views on the philosophy of knowledge generation, borrowing some ideas from *constructivism*[9] in science
Knowledge is not data, knowledge is in models that explain how the different parts of data are connected. Of course, there is only one true model of reality. Over a period of time we may have competing theories about the true model. If a theory does not follow established scientific methodology then it should not be even worthy for this competition[10].

Normally, in an emerging ResCo, the model (for knowledge) is fuzzy. This can be compared with the extremely well defined models in some matured community, such as the model behind *string theory* in Physics. Note that fuzziness of a model is different from the accuracy of the model, i.e., how close it is to the true model. May be the string theory is a fictitious model, but it provides a kind of agreed framework for deciding what is acceptable (scientific) research among string theorists. On the other hand, if the model is fuzzy, we need a great deal of leadership in order to determine the scientific merit of research.

When a researcher proposes new knowledge, he (or the ResCo) has the responsibility to fuse it with the existing model representing knowledge. If we do not improve overall model then it means we are not making any scientific progress.

Without exception, the research agenda in any ResCo addresses a very small part of the true model, which we may refer as the *local model.* Sometimes it is not easy to define the local model in such a way that it can be the subject of independent research. If a ResCo fails to recognize this then many pseudo

[8]In many cases, it is much easier to attack a computer system from a side channel, such as power consumption, sound and electromagnetic emissions. Clearly, protection against these channels require cross-disciplinary research.

[9]Originally, constructivism is a philosophy of learning at individual level.

[10]Bruce Schneier's (1999) article *Snake Oil* is quite instructive in this regard.

research problems (the problems that do not have any meaning when the bigger model is considered) and pseudo solutions may pop up. One should never forget the authority of reality—real world observations, processes and their outputs have ultimate authority to judge the validity and usefulness of any theory.

Given the fuzziness in the notion knowledge along with challenge in determining the right scope in problem definition, any emerging ResCo depends on strong leadership for effective research.

Semantic-oriented research enables a ResCo to understand the relation between the theory and reality. Clearly, without making reality the basis of success, it is quite possible to wander in infinite worlds of pure mathematics. Often, in initial phases, problems are not well understood and the hypothesis to solve these problems are, at their best, as good as the understanding of real world semantics.

Dieter Gollmann[11] rightly states the following when he describes the problem of misinterpretation of intuition in models: "Crossing the boundary between reality and model is error-prone." This is precisely the same issue in the cautionary note: "As far as the laws of mathematics refer to reality, they are not certain, as far as they are certain, they do not refer to reality." (Albert Einstein)

In increasingly complex world, *inter-disciplinary research* makes the conversion of claimed knowledge – the research results of a ResCo – to "knowledge" more effective, and helps in creative problem solving. Containing oneself to a specific type of technique and method restricts one's perspective. This is a classic problem when one is obsessed with the process and tries to improve it without out considering what this process is for. After all, scientific problems determines what type of methods and models must be employed; and it is not the other-way around.

Many research communities represent a diverse group of professionals who have different point of view about the methodology of community. This is due to the difference of exposure to related fields, their own expertise and, above all, their desire to work in the field they know better. For example, it is not strange that people coming in cryptography from mathematical background may consider factoring of large composite numbers as most critical to the security, while people from engineering background may consider side channel attacks as the most critical. So finding common ground within a community is inherently difficult.

By improving the understanding of reality (by scientific research) does not always supplement the model of reality; in fact, it may happen that some parts of the model (esp. old beliefs and theories) get discarded. Old recipes do not always work. That is why *root-aware research* is important, as it helps to recognize the relevance of the local model (of a ResCo) to reality.

Perhaps, the importance of *charismatic dissemination* is more than obvious, and we do not discuss it any more. In the following, we summarize some general principles that a good scientific community must adhere to. These principles are based on the work of Feuer et al. [2].

[11] In: Authentication – Myths and Misconceptions (2001)

A scientific endeavor within a research community must contain a theoretical model as well as relevant semantic model that corresponds to reality. There should be a methodology, whether explicit or implicit, that determines what kind of theoretical models and what kind of semantics are acceptable as part of alternative research paths. Moreover, this methodology itself should be subject to constructive criticism and improvement. The actual results (and not their applications) should be general to be potentially applicable to wider communities. And finally, community must promote openness as far as possible — meaning individual must be open to professional criticism and revision on their work. These principles determine the so-called culture or norms of a community.

The development of a scientific culture rests with individual researchers. One of the main responsibility of key researchers of a ResCo is the nutrition of the scientific culture. To a large extent, the above principles also mandate strong leadership on part of ResCos.

Conclusion

Good communities are characterized by the leadership of their researchers. They develop better methodologies and strive for sustainable research progress. Normally, within a given scientific community there are self-governing norms that enable real scientific progress [FTS02].

The arguments presented in this article are generally applicable to every scientific community, although each discipline entails some special needs that may demand for focusing on some part more than other. Scientific culture is more important than any other thing – e.g., number of research papers being published – for a scientific community. Individual researchers have the final responsibility for creating such culture. In this regard, the researchers with strong leadership character play an important role. We believe they are more likely to achieve "real success", as their results are potentially useful for the society.

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