Metatheoretical and epistemological investigation of the criteria of adequacy and optimisation of science communication to the general public

Cătălin Bărboianu, PhD

Research project

Introduction

Public interest in science has risen dramatically. At the same time, in the context of pressing global issues and accelerated scientific advancement, the academic community, governmental bodies, policy makers in any field, and media press must communicate the results of scientific activity to the general public. This double-faceted interest of acquiring scientific knowledge and communicating it has led to the growth of science periodicals and 'e-learning' platforms as media through which science is communicated and/or taught. However, this growth has been faster than the advancement of research dealing with science communication and education, which is still searching for an adequate foundation. As such, the real process of science communication is arbitrary, somehow chaotic, following the lines of ordinary discourse and the specific interests of the communicators[1], and is not guided by clear theoretical norms through which to ensure the correct understanding of the content and ultimately, of the scientific message.

Within educational science and communication science, the concepts of *scientific literacy* and *effectiveness of science communication* have been intensely debated in relation to the free types of education, but the research did not focus on the specificity of their target (the *general* public) in relation to the specificity of their object (science). In general, research maintained an exclusively externalist view for these concepts and associated them with the complexity and diversity of *teaching* science and less with the epistemic dimension of science *communication* as a transfer of understandable knowledge in particular conditions.

This project advances an internalist view on these concepts, aiming to answer the question of whether science *communication* (with a conceptual meaning that embeds understanding, message, and goal) to the general public is possible and in what form, within an epistemological theoretical framework developed around adequate concepts of understanding, scientific literacy, and effectiveness (of communication). The research should provide the criteria of adequacy of this *specific* communication and the basic theoretical norms that should optimise this complex process. The main premise of this approach is that adequacy and normativity for optimisation of this special communication can be neither defined nor elaborated as relative to subjective arbitrary elements featuring the social dimension of the phenomenon, especially the freedom of educational processes.

We propose to use the potential that the theoretical-philosophical disciplines such as logic, epistemology, and philosophy of science, of mind, and of language, and adjacently, history of science, have to contribute to the development of the proposed framework, so that it will accommodate well with the conceptual framework of educational and cognitive sciences.

One of the main goals is to adapt the general epistemic concept of understanding to the investigated context, which assumes a "constrained gradualisable understanding". Constraints refer to the specific conditions of both the communication and the audience (out-of-structure extraction,

[1] For instance, science periodicals seek to publish good "literary pieces" on scientific topics, their goal being to attract an audience by offering a pleasant and sharable reading experience rather than an accurate understanding of the topic.

length/volume limit, "staying-in" feature[2], audience's variable education background, etc.). Since the *type* of understanding required should be unique regardless of the constraints, we should focus on the communicated unit of knowledge – namely the popularised scientific text or discourse – which in its mere linguistic-logical-epistemic form is amenable to a theoretic-formal approach. The idea is to identify a certain "epistemic-readability" and logic of such a text which should make it understandable (in the sense of the new concept of understanding) under the previously mentioned constraints. (This "epistemic readability" is not required and is limited to syntax for other fields such as art, history, etc.) Then, we should explore ways to gradualise understanding so as to be consistent with the uniqueness of its type and its nature as a mental state.

Another important goal is to exploit the educational dimension of philosophy and history of science with respect to the foundation and methodology of science by identifying those fields, principles, and metatheoretical aspects able to contribute to a decisive answer to the following question: What is required for the reader/hearer to know *about* science in general in order to understand (in the investigated sense) a scientific discourse or piece delivered to him or her, under the mentioned constraints? And in what form should this required knowledge be implemented in or attached to the delivered text such that understanding is not fully dependent upon the reader's or hearer's educational background?

In such a conceptual and theoretical framework, an adequate definition of "non-expert" (or constrained) understanding together with the identification of the required foundational knowledge about science will entail the criteria of adequacy and norms for theoretical effectiveness for science communication to the general public. Within this framework, various hypotheses regarding implementation in practice can be tested empirically at a future stage with the tools and methods of educational sciences.

Research context and theoretical framework

Within educational science and communication science, there have been ongoing debates on the concept of scientific literacy. The concept was used both as an objective to be attained (for the reader/learner) and a gradual educational background required for this attainment. Aside from the obvious circularity, this dual sense renders the concept unclear for any theoretical treatment since this view lacks a clear distinction between the goal of teaching and that of communication. Communication is more pragmatic (in a certain sense) and should attain its goals independently of teaching.

Radically different views on the nature of this concept have been expressed. Roth & Lee (2002) see it as a property of collective activity rather than individual minds. But how can we have collective *understanding* of a scientific fact as a mental state, which is supposed to be individual? Liu (2009) sees it as *life-long* participation in science and scientific activities; while making the notion extrinsic and intrinsic, this view makes scientific literacy something unattainable, which is problematic for any theory incorporating it. DeBoer (2000) argues that we should define scientific literacy in terms of *specific* goals suitable for particular situations, along with the content and methodologies most appropriate for the students of a community. Norris & Philips (2002) claim that its sense should not be derived too much from the concept of literacy in its fundamental sense (concerning reading and writing) – and this is the view that the current research will support and incorporate in the intended framework.

[2] The limited text length precludes inclusion of all definitions of the concepts used (even at the first level of defining) and extensive scientific descriptions. The "staying-in" feature prevents the use of external resources and is entirely justified. Searching externally for definitions or descriptions, the reader will be lost in lengthy, time-consuming rooting through "wiki" resources. Analogous to these constraints for the e-learning case are the length-, time- and cross-reference-limitations of the courses.

Overall, most analyses of scientific literacy have made this concept dependent upon the historical context and community. Such dependency restricts a broader sense for the concept, required to embed both the object of learning (a unique, objective, non-interpretable science) and the target (the variable subjective community). It also prevents development of theoretical frameworks through which to provide objective norms for adequate scientific communication and learning methodology. For deciding whether science communication to the general public is possible and finding these criteria of adequacy, empirical research (and generally the use of the usual tools of educational science) on the learning communities is not enough.

More recent research focused on the concept of *effectiveness* of science communication rather than scientific literacy. The background of the research relied on the major premise that the topic is complex, interdisciplinary in nature, and dependent upon phenomenological factors, including social ones. This premise runs on the line of thought that, *like teaching*, there cannot be a unique approach to science communication (Weigold, 2001), and thus no recipe for success or effectiveness. The proposed research aims to challenge this premise in what concerns amenability to theoretical treatment and the existence of criteria of adequacy and optimisation, by advancing an internalist view based on philosophical concepts with that of constrained understanding at its core and radical conceptual distinctions. Of course, complexity is still endorsed, but in the internalist view, it is related only to the epistemic-philosophical and linguistic nature of the topic and not to its social dimension. Still, effectiveness can be discussed in relation to the social aspects of science communication in an externalist view where educational, life, and social sciences are called to investigate the topic – and the project will draw primary directions for such research. The "externalist complexity" of science communication and its effectiveness was seen to involve various general aspects: Cooke et al. (2017) employed the *management* of the communication and knowing the audience in quite a "rhetorical" way; Guenther and Joubert (2017) identified a *dynamic* of this kind of communication relative to the public understanding of science; Yuan et al. (2017) argued for the importance of *two-way* communication between scientists and the public, including interactive dialogical communication.

There was also research– still in an externalist view – providing explicit criteria for determining effectiveness: Druckman and Lupia (2017) showed there are certain conditions under which choosing particular *frames* yields more effective communication. Martinez-Conde and Macknik (2017) argued that *storytelling* and narrative style can help communicate science to non-experts and improve the chance of success in science communication while *plot-building* enhances understanding. Olson (2018) argued that scientists need *skills*, in talking to students and writing papers and funding proposals as well as in science communication to the general public, which requires *additional* skills. However, these skills were seen more as targeting the act of (two-way) communication and less so the *content* of the communication. The skills criteria strengthen the importance of the training of the communicators, which was even assessed through empirical studies [see, for instance, (Rodgers et al. 2018)]. All such criteria do not differ much from those involved in effective science *teaching*. Yet, researchers admitted that the complexity of science communication to the general public has a pragmatic dimension that can only be investigated systematically and in an interdisciplinary setup by adapting scientific methods to the practical constraints of science communication (Fischhoff, 2019).

Internalist perspective of science communication in a theoretical-philosophy framework

The proposed research aims at crystallizing this theoretical framework from an internalist perspective, where the required pragmatism is defined with the help of a special concept of understanding (what I previously called constrained understanding) and intelligibility, within a conceptual framework extracted from the philosophical disciplines entitled to investigate the topic – epistemology, philosophy of science, philosophy of language, philosophy of mind. Complementarily to the externalist

perspective, the research will focus on the *content* of communication as an epistemic unit independent of the complexity of both the act of communication and its audience.

Philosophy of science has a long tradition of making a tight connection between explanation and understanding, but only in the last two decades have researchers started to give *understanding* a substantial role in their theories (De Regt at al., 2009). Moreover, we should take seriously the possibility that scientific cognition is also affected by psychological manifestations related to some forms of understanding, including that of illusion (Ylikoski, 2009). Such problems increase the complexity of the topic and call on non-philosophical disciplines, such as cognitive sciences (including neurosciences) to investigate it. However, philosophy has its own arguments for answers to legitimate questions such as: What kinds of cognitive abilities are involved in understanding? What is the relationship between the understanding that explanations provide and the understanding that experts have of broader subject matters? Can there be understanding without explanation? (Khalifa, 2017, pp. 80 – 124).

The formal-theoretical approach I propose on epistemological grounds should be able to account for the pragmatism of the effectiveness of science communication and to provide criteria of adequacy that can be translated in the practice of science communication, despite its acknowledged (externalist) complexity. It should also be a unifying foundational element for the disciplines dealing with the topic further, since all have an epistemic dimension.

We should make the distinction between scientific literacy and science understanding, between science understanding and linguistic understanding, between science communication and science education. All these concepts are interrelated, and the general epistemological concept of understanding is constitutive for all; however, a special concept of understanding targets understanding of a communicated unit of knowledge.

In theoretical philosophy and linguistics, understanding is tightly related to *meaning* and *context,* not only in what concerns language, but as a general concept that involves valuable and distinguishable knowledge [see (Kvanvig, 2003, 2009), (De Regt and Dieks, 2005), (Grimm, 2014)]. But the meaning of scientific concepts, statements, and theories, and context of the creation, development, and application of science – all these are investigated within epistemology, foundations of science, philosophy of science, and of language. As such, not only the social and educational dimensions of science manifest themselves in science communication, but also the foundational aspects of science.

The necessity of turning to philosophy and history of science for science *education* has already been acknowledged [see the works of (Hills, 1992), (Matthews, 1994), (Mellado et al., 2006), (Höttecke and Silva, 2011), and others]. In-depth analysis of such arguments fairly offers an expectation to make them (or at least some of them) applicable to science communication also. McComas (2017) argued that the *nature* of science is the most important content issue in science teaching because it helps students *understand* the way in which knowledge is produced and validated within the scientific work. In spite of obvious distinctions, science teaching is also a form of science communication, and understanding is a key concept for the latter.

The object of the investigation here is adequate science *communication* under special conditions (and not as education within a traditional or official school setup), which has also a pragmatic nature. Therefore, a primary task is to identify and clearly delimit the concepts and knowledge zones from the philosophical disciplines dealing with science that can contribute to the conceptual framework of adequate science communication, and additionally from philosophy of language and of mind.

Theoretical aims and foreseen outcomes

Humanity has entered a scientific era of interdisciplinarity, but preparatory education lags far behind. Science education has for centuries been developed according to the school's official curricular

structure in which students acquire *ongoing* education, involving several disciplines and lasting several years. This is not the case with newer forms of education, whose target extends to students/readers with *final/*limited official education. Science periodicals or websites have the same kind of target. Hence, the general questions are these: what does it mean for a reader or hearer with limited education to understand (to a certain or acceptable degree) what is communicated as a limited scientific text or discourse, and how should its content be adapted, structured, referenced, and formulated so as to ensure understanding and the transfer of the intended message in the given conditions?

The main goal in order to address these questions theoretically is to define an adequate concept of constrained understanding with two features: it must be consistent with an epistemology of valuable knowledge, and it must be a component of a gradualisable general concept of understanding that corresponds to the *full* understanding of the expert.

By epistemologically regimenting the constrained unit of knowledge – the scientific text (as article/lesson/discourse) – in order to reach the criteria of its adequate communication independent of external factors, we can obtain a) a stable conceptual framework which redefines scientific literacy and effectiveness of communication on solid grounds and allows further theoretical and empirical treatment in an interdisciplinary setup, and b) an immediate algorithm of epistemic optimisation for the scientific contents delivered to the general public, with a wide potential for application into the realm of science journalism and e-learning.

Different theoretical research is needed to cover e-learning, where the premises regarding the constraints are different. An important aspect is to study in parallel, in collaboration with software engineers and computer scientists, how technologies (especially web-based) can contribute to, enhance, and ease the proposed optimisation, for all types of content deliverers.

The contribution to the new-education professions (science journalists, editors, authors, curriculum developers) should be crystallised into published materials (manuals, booklets, short courses). Developing a website dedicated to the scientific communication which delivers such materials and online support would be fruitful.

The project opens new veins of interdisciplinary research. The cognitive aspects of the constrained scientific understanding put forward the relation between the epistemic structures of the scientific (or mixed) language and brain's neural network. Advances have been made in neuroscience that relate the biological structures of the brain and the structural abstract of language [(see, for instance (Monti, 2017)]. It remains to be investigated how the other aspects of scientific understanding besides the linguistic are represented in the neural network and its physiology; the results of such investigation might in turn contribute to philosophy of science and of mind.

Methodology and directions of research

The research inverts the usual direction of inquiry within social sciences (from empirical to theoretical) and focuses rather on conceptual clarification *ab initio*, which is needed in respect to the subject. For interdisciplinary systematic coherence of the new theory, some concepts must be redesigned to be different from their current meaning.

The complementary directions of exploring gradualisation of constrained understanding are the following: 1) Identifying exhaustively all the epistemic contexts that define the nature of science understanding (among which are the logical, the theoretical, and the structural); investigating the involvement and potential of the foundational and methodological contexts via the educational dimension of philosophy and history of science; 2) Defining a kind of epistemic *intelligibility* of the unit of knowledge as an incomplete but valuable understanding, which is complementary to *conceptual* understanding. Intelligibility embeds the concepts of readability, logic of the language and arguments, and a system of internal referencing consistent with that logic[3]; further, we should investigate whether

[3] Note that the class of 'intelligibility as a primary (incomplete) understanding' is not vacuous; take the example of ordinary language, governed by syntax. We can say that we understand the sentence '*S* (as subject) does (or is) *P* (as predicate)' or it

other forms of incomplete understanding besides these two, with respect to the taxonomy of the contexts found, qualify as complementary components of the full understanding.

Understanding concepts in the common meaning requires the understanding of their *complete* definition and knowing their place in the larger structures of knowledge. Definition in science is relative to other constitutive concepts, and some concepts are defined through entire theories; therefore, given the constraints that prevent the development of such regression, it is not possible to define the constrained understanding using the concept of understanding in its common, broad meaning. The proposal is not to narrow the meaning of the concept of understanding, but to make it more dependent upon an adequate concept of intelligibility, which would stand as the "epistemic logic" that makes the truncated knowledge an understandable whole.

The investigation will run in zones in which the object of investigation interferes with the meta-object: we analyze the epistemology of the communication in close relation with and dependent on the epistemology of the communicated text; we analyze the adequacy of a language (popular-scientific) with a meta-language (scientific and philosophical) having several epistemic concepts (and their associated vocabulary) in common.

Regarding language – an essential element of the research – the investigation does not aim at creating a new language (although seemingly it does so) or modifying the language of science for incorporating into the common language, but rather identifying the *epistemic* language that is constitutive for the aimed concept of understanding of a scientific text and is consistent with both the two languages (scientific and non-scientific). This is why the adequate place for this investigation is within theoretical philosophy and not communication science or other related disciplines.

This argument constitutes the certainty – unexpectedly for some people – that theoretical philosophy can be as practical and applicative as it is perceived as abstract, and social sciences (in particular educational science) would benefit by its methods and content.

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is readable or intelligible even if we do not know much or anything about *S* or *P* (or whether *S* does exist), just on the basis of the syntax, which puts *S* and *P* in a certain (known) *kind* of relation. Once we come to know much about *S* and *P*, understanding of the sentence is enriched, still depending on syntax. Science is more than a linguistic construct, and the challenge would be to generalise the syntactic intelligibility to a more complex primary scientific intelligibility that would count for (full) understanding.

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