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Purpose and context

This article is the initial step in a first project in a program oriented to the following purposes:

1) To address two seemingly unrelated issues: *Meta-Education* (including continuous self-education) and *Peer-reviewing*.

2) To suggest a methodology based on systemic/cybernetic relationships between Co-researching and Co-Learning (Figure 1), which may increase the effectiveness of both Meta-Education and Peer-reviewing by cybernetically relating them with co-regulative negative feedback and feedforward, as well as with co-additive or co-amplificatory positive feedback.

3) To generate *internally integrated publications*. This would support *knowledge integration* processes for both authors and readers of the respective publication.

![Diagram](image)

**Figure 1:** Non-linear perspective for a scholarly publishing methodology. It is being implemented by means of the steps briefly described in Figure 2. The implementation meta-methodology is a combination of Methodological Action-Research, Action-Learning and Action-Design. Each one of these three methods is systemic/cybernetic one, because it is based on the *systemic/cybernetic relationships between thinking and doing*.

As this article’s topic is a trans-disciplinary one, the article collects contributions from different disciplinary, inter-, or trans-disciplinary perspectives. Consequently, it may, hopefully, provide support for knowledge integration on the important topic of “*Rigor and Inter-Disciplinary Communication*”.

The diagram of Figure 2 schematizes the steps that are: (1) suggested for the implementation of what is presented in Figure 1; and (2) detailed, a little bit, in (Callaos, 2020), in the context of

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1 Specifically, we are referring, in this article, to Participative Peer-to-Peer Reviewing (PPPR), in the context of “A Systemic-Cybernetic Model for Scholarly and Professional Reviewing and Publishing” (Callaos, 2012)

2 More details are provided at (Callaos, 2020, Meta-Education and Peer-review via Co-researching and Co-Learning)
the program oriented to “Meta-Education and Peer-review via Co-researching and Co-Learning. Figure 2 also provides the context for this collaborative article. It shows, with a gray box, the positioning of this article in the context of this first project in the program, described briefly above, and described in more detail in (Callaos, 2020).

According to Figure 2, the next step will be to use this collaborative article in a Call for Participation oriented to the next systemic/cybernetic cycle, which is a collaborative and integrated Special Issue of the Journal of Systemic, Cybernetics, and Informatics. The production of this special issue will also be supported by co-learning and co-researching processes, in the context of Meta-Education and Participative Peer-to-Peer Reviewing (PPPR) (i.e., applying the same systemic/cybernetic methodology used in this collaborative article; which will be one of the inputs to the special issue elaboration, as it is shown in Figure 2.

![Diagram of inputs, processes, and products](image)

Figure 2: Steps in which the systemic/cybernetic model proposed in figure 1 is being implemented, which have been described and reasoned in (Callaos, A Systemic-Cybernetic Model for Scholarly and Professional Reviewing and Publishing, 2012)

References


The purpose of this article is to trigger an Inter-Disciplinary Dialogic on the Topic of “Inter-Disciplinary Communication Rigor” which may be also called “Inter-Disciplinary Dialogic Rigor”.

The phrase “Inter-Disciplinary Dialogics” was inspired by Jeremy Horne’s article, following this one, entitled “Unedited notes on interdisciplinary communications – historical perspective, rigor and current situation”. In this short article, Jeremy Horne made a very brief historical account of issues related to “Inter-disciplinary communication”. In this context, he mentions “Aristotle’s Dialogic”. Here we are using the term “dialogics” in its general meaning (increasing consensus via collective construction of ‘logos’), which includes “Aristotle’s Dialogic”. In its general sense, Dialogic is the kind of communication implemented via Dialogue. Interdisciplinary Communication, as a dialogue, i.e., as a dialogical inter-disciplinary communication as presented with more details in (Callaos & Horne, 2013).

The articles following, and the final version of this article, were in part inspired by workshops, presentations, and discussions at the 2019 IIIS meetings in March and July, and in many ways, this collection should be viewed as written symposium, where Dr. Horne’s article and an early version of this article served as the foundation for interaction. As such, many of the keynote presentations (and their recordings) from those conferences, and the consequent invited articles in the Journal of Systemics, Cybernetics and Informatics [JSCI], can be thought of as complementing this “symposium”. See, for example, (Marlowe & Herbert, 2019) and (Herbert & Marlowe, 2019)

Wilhelm von Humboldt (1836) was one of the precursors who perceived the necessity of interdisciplinary communication or, more precisely, inter-disciplinary dialogues. He affirmed:

1 We are using the word “Rigor” in the context of “Intellectual Rigor”: logical and/or methodological rigor, i.e., subject and complying with logical and/or methodological rules, restrictions and standards. More details with regards the notion of “Intellectual Rigor” are barely given below

2 Interestingly, von Humboldt’s younger brother, the naturalist and scientific polymath Alexander von Humboldt, was very much of the same mind: “In September 1828, [Humboldt] invited hundreds of scientists from across Germany and Europe to attend a conference in Berlin. Unlike previous such meetings, at which scientists had endlessly presented papers about their own work, Humboldt put together a very different programme. Rather than being talked at, he wanted the scientists to talk with each other. ... He connected the visiting scientists on a more personal level, ensuring that they forged friendships that would foster close networks. He envisaged an
“With a clear and immediate sense of his immutable limitations, man is bound to regard truth as something lying outside him: and one of the powerful means of approaching it, of measuring his distance from it, is social communication with others. All speaking, from the simplest kind onwards is an attachment of what is individually felt to the common nature of mankind.” (Humboldt, 1836, p. 57)

This important relationships with Humboldt’s intellectual perspective was prompted by the following comment informally made by Professor Detlev Doherr to the first draft of this article, who provided the following reflection

“I wonder, how we could compare the situation of the intellectuals from the past to our todays situation. As it is known, Humboldt, had no change to think interdisciplinary, because most the scientific disciplines wasn't existing that time. And another topic is dealing with the interaction and interconnection of natural processes. How if not by interdisciplinary communication, can we detect natural processes and find our view of nature? Let me point out, that we have several views of nature depending on the scientific discipline, the social environment, and the time. Please compare the advantages of the astronomic research and detection of black holes! Nobody before Stephen Hawking had the power of imagination and intellectual property to detect such a phenomenon. Or the question of human intelligence, which we try to describe by machine logic and algorithms! I'm glad and I'm sure, that the nature is not so easy to understand as some of us believe! And we have only one way to find out more about our nature, which is the communication and power of imagination.”

Via analogical thinking, we might paraphrase Humboldt, suggesting that disciplines (or disciplinarians), with “a clear and immediate sense of [their] immutable limitations” [they are] bound to regard truth as something lying outside [them]: and one of the powerful means of approaching it, of measuring his distance from it”, in inter-disciplinary communication or dialogs.

Elsewhere, we have examined the meaning and the importance of interdisciplinary communication (Callaos & Horne, 2013) (Callaos N., 2017). Here we will, very briefly, refer to what is, or should be, rigorousness in the context of interdisciplinary communication. One frequently reads, or hears, that interdisciplinary research, education, and/or communication is not rigorous. This is far from the truth, if the communication is based on rigorous and critical thinking, and especially if it is based on a previous intra-disciplinary peer review, or the interaction of several works that have sustained such review, potentially in different disciplines.

We will show that, contrary to what some disciplinarians believe, a rigorous inter-disciplinary communication could even be more rigorous than intra-disciplinary communication. This is especially correct in situation C described below, which will be the means with which we will start the project of interdisciplinary written communication conceived as a complement to the interdisciplinary brotherhood of scientists who would exchange and share knowledge. ‘Without a diversity of opinion, the discovery of truth is impossible,’ he reminded them in his opening speech. (Wulf, 2015, p. 231).
verbal inter-disciplinary communication that the International Institute of Informatics and Systemics (IIIS) has been implementing through its conferences during 23 years.

We will describe the notion of “Intellectual\textsuperscript{3} Rigor” in a coming article, meanwhile we will use the term “rigor” in its senses of “strictness” and “validity.”\textsuperscript{4}

Intellectual Strictness requires thinking, and acting\textsuperscript{5} in close conformity to requirement, rules, logic, principles, and constraints; that is, thinking and/or acting in the context of restrictions. Because of ethical restrictions, as well as the need for the integrity in the research process, intellectual honesty is a necessary condition for intellectual rigor, though not a sufficient one.

In this article, “intellectual rigor” means logical, epistemological, and/or methodological strictness, i.e., playing by the rules and within the boundaries of the respective logic(s), epistemology/ies, and/or “methodology/ies”. Our intellectual stance in this article is Epistemological Pluralism, Methodological Pluralism, and/or Logical Pluralism. This pluralism is required because the subject matter is on the Rigor of Inter-Disciplinary Communication which necessarily require Inter-Disciplinary Thinking (which is internal communication that may require creativity), upon an equally rigorous foundation within its component disciplines.

Intellectual Validity requires “the quality or state of being valid” [i.e.] “well-grounded or justifiable: being at once relevant and meaningful … logically correct a valid argument valid inference … appropriate to the end in view: effective.” (Merriam-Webster, 1999) [Italics added]. This teleological connotation of the notion of validity is repeated in, at least, another dictionary. In (Dictionary.com), we find the definition of validity as thinking and/or acting oriented to “produce a desired result; effective” [Italics added]. Other definitions in other dictionaries can be conceived ad one kind of results. For example “being logically or factually sound; soundness or cogency,” (Oxford Dictionaries); “being correct or true” (Your-Dictionary); “being based on truth or reason, or of being able to be accepted” (Cambridge Dictionary). Consequently, validity is mainly characterized by restrictions and objectives, i.e., 1) restriction to rules, standards, logics, methods, semiotic system, etc. and 2) orientation to ends, objectives, telos. The latter would be measured by the degree of effectiveness of the associated thinking and/or action. An interesting comparison is to the meanings in software development: verification is used to prove that one has solved the problem correctly; validation, that one has solved the correct problem—corresponding to the specified requirements, constraints, and as far as possible, objectives. Consequently, \textit{the more restrictions are honored and the more objectives are met, the more rigorous is Intellectual Thinking and/or Communicating}. The more effective is thinking and communicating the more rigorous it is. \textit{In our case, the more people from other disciplines can understand an article, the more rigorous is in the context of inter-disciplinary thinking and communication.}

\textsuperscript{3} In this article we are using the word “intellect” in its general meaning, i.e., as the faculty of thinking, reasoning, knowing, and understanding in any of their conceptions or species, i.e. including, practical and/or theoretical thinking, explicit and/implicit knowing, qualitative and/or quantitative reasoning, logical and analogical thinking, etc.

\textsuperscript{4} We should be aware that, as Guba and Lincoln affirmed in (Paradigmatic Controversies, Contradictions, and emerging confluences, 2005), a “radical reconfiguration of validity leave researchers with multiple, sometimes conflicting, mandate for what constitute rigorous research.” (p. 205)

\textsuperscript{5} Communicating is one form of acting.
This short article has the purpose of providing context and communicating the reasoning required to collect more information, knowledge and opinion (Episteme and Doxa) with regards to the Rigor of Interdisciplinary Communication, in general and/or with regards to the three situations we briefly describe below. First, we provide a brief overview of the literature on “inter-disciplinary rigor”. This would support and enhance the context, we would like to provide, as briefly as possible.

To the best of our knowledge, the most comprehensive book on Interdisciplinarity was authored by Julie Thompson Klein (Thompson Klein, Interdisciplinarity: history, theory, and practice, 1990). About the 40% of the book consists of her references. With regard to interdisciplinary rigor, she wrote:

Interdisciplinary work is often attacked for lacking rigor. However, rigor is not diminished. Rather, it is shifted from disciplinary criteria to a new interdisciplinary objective, to what (Singleton, 1983) call a core sense of “interdisciplinary rigor.” There are no scholarly defined standards for judging interdisciplinary works but Stephen Schneider’s three criteria for disciplinary excellence are quite appropriate. Excellence of interdisciplinary research can be measured in terms of (1) disciplinary clarity, (2) clarity of cross-disciplinary communications, and (3) the utilization and combination of existing knowledge from many fields to help solve a problem or to raise or advance knowledge about a new issue (Schneider, 1977).

Bernikova and Redkin, in an article (included in this multi-author paper) entitled “Intellectual Rigor in Arabic Studies and Computer Sciences Communication” seems to have the perspective similar to that of Thompson Klein, i.e. inter-disciplinary rigor requires a different kind of rigor, a one than “minimization of requirements of each of the disciplines in the context if inter-disciplinary dialogue”. This may mean that we should pay the cost of decreasing the intra-disciplinary rules in order to increase the communication among disciplines. There is a tradeoff that should be made between intra-disciplinary and inter-disciplinary rigor. The latter requires communication among disciplines in order to deal with problems that require and effective communication among the disciplines involved in the solution of a real life problem. In our opinion, as we will see below, this tradeoff require more, not less, rigor because requires meeting the objective of solving a real life problem while increasing the intellectual restrictions, i.e., those required to have an effective inter-disciplinary communication. We will provide, below, more reasons and details with regards to this perspective.

Ekaterini Nikolarea, in another article entitled “Intellectual rigor” and beyond: Inter-disciplinary communication in a glocalized context (or inter-scientificity), also included in this multi-author paper, challenges the concept of intellectual rigor (in the context of a discipline) in inter-disciplinary communication and discusses “how it should be expanded” in order to include scientific thinking and communication “between at least two different linguistic [or semiotic systems, as we will see below, should] develop (1) uncertainty and stress tolerance for unknown scientific terms when trying to communicate their ideas in a different linguistic scientific environment; and (2) association skills, that is, skills in finding equivalences in two
different linguistically discourses.” These association skills are in our opinion most often analogical thinking skills (which provide input to logical thinking), together with skills for using metaphors and similes to express themselves to an audience from other disciplines. As we will see below, what Ekaterini Nikolarea is suggesting would increase the level of rigorousness of the communication as long as the the content has been previously reviewed by peers from the same discipline, that is, those proficient in the disiplinary semsiotic system and its associated research methodology. To add “uncertainty and stress tolerance for unknown scientific terms and association skills” is to add intellectual restrictions, skills and objective to the initial disciplinary research. This makes inter-disciplinary communicating more, and not less, rigorous, as long as this communication is effective. We will provide, below, more details and adequate reasoning with regards to this issue.

From a more general perspective, Jeremy Horne⁶, referring to an achievable rigor (not an ideal one warranting the Truth), suggests “Let’s settle for what philosophers uphold as criteria for objectivity – coherence, correspondence, and consensus. Scientists look to independent discovery of the same phenomena.” The latter provides the standard of consensus in the experimental sciences. But more generally, are we talking here about John Locke’s Consensual Truth, as C. West Churchman called it? (Churchman, 1971)If so, then let us add Singer-Churchman’s Pragmatic Teleological Truth, which is based on means-end logic (next paragraph). As long as we comply with further rational rules and restrictions, we will have a higher level of rigor, by definition of intellectual rigor. Hence, if we add to experimental methodological rules and to inductive logic restriction, the means-end logic, then we certainly would be increasing the rigor level of our thinking and, hence, the rigor of our communication. If, on the other hand, the initial artifact belongs in whole or in part, not to the experimental sciences, but (say) to the formal sciences, then the standards of those disciplines (for example, formal proof) will have to be considered instead of or in addition to experimental replication.

Professor Donald Ropes, in an article in this multi-author collaboration entitled “Interdisciplinary Communication as a Process and an Outcome: The Case of Transdisciplinary Research” makes an important conceptual distinction, related to our two above paragraphs. He differentiates among “1) declarative knowledge (épistémè), which is about the current state of the system, and can take the form of new testable hypothesis or contributions to theory 2) transformative knowledge (praxis or poïesis), which considers what the innovation should achieve and could be embodied in new products, services or policy insights and 3) transformational knowledge (phronēsis)”, i.e., practical understanding. In the context of this very important conceptual differentiation, to effectively combine épistémè and praxis, i.e., intra-disciplinary knowledge and an effective action oriented to solve real life problems, it is necessary to increase the intra-disciplinary rigor by the rigor of being effective in solving real life problems, which are almost always multi-disciplinary ones requiring and generating inter-disciplinary (verbal and/or written) communication. To the rigor required by inductive and/or deductive logics, it is necessary to add another rigor level required by means-end logic, or the Singer-Churchman pragmatic-teleological

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⁶ In a short research-based reflection article (in this multi-author paper) entitled “Unedited notes on interdisciplinary communications – historical perspective, rigor and current situation”, Jeremy Horne provides a very brief historical account of “Inter-Disciplinary Communication” in order to identify what rigor is or should be, in the context of inter-disciplinary communication. He provides analogies and metaphors to express why inter-disciplinary communication is a necessary condition for achieving a real rigor.
truth. To be effective applying the means-end logic necessarily requires phronēsis which means that a transformative knowledge should be created or a practical understanding should be achieved, especially with regards to the interaction of the created solution (policy, technology, methodology, etc.) with its social and human environment. As is apparent, this requires not just the rigor of intra-disciplinary rigorous knowledge, but also the rigor required by 1) means-end logic and 2) the necessary rigor of phronēsis, that is, practical understanding, or transformative knowledge. Technical and practical know-how are necessary conditions for applying any intra-disciplinary rigor to the solution of real-life problems.

In the context of the last three paragraphs, we notice the additional rigor required for being effective (no just efficient) in solving the kind of real life problem that Margit Scholl briefly describes in her article, in this multi-author collaboration, entitled “New E-Competences on E-Government in Education Require an Interdisciplinary Approach: Why Don’t We Do It?” The real-life problem Margit Scholl describes is a multi-disciplinary one that requires and generates interdisciplinary communication. The effectiveness of this communication depends on adding the rigor required to make an effective translation between the different disciplinary semiotic systems (which require additional creativity, though not necessarily originality) and this, in turn, requires épistémē and phronēsis. Once the inter-disciplinary communication has been effective, then it requires the additional rigor of being subjected to the means-end logic and a combination of technical and methodological praxis and social/human phronēsis with the users and/or potential users of the solution (e.g., an information system, a policy, an innovation, a procedure, a methodology, a technological device, etc.) in order to solve that real-world problem.

Consequently, in general, if we add the restrictions of 1) complying with Singer-Churchman’s pragmatic-teleological truth (Churchman, 1971), i.e., the Means-End Logic (e.g., achieve a goal, objective, or purpose) and 2) practical understanding (phronēsis) to the disciplinary rigor, what we get is more, not less, intellectual rigor. This will get clear in the below listed Situation C, of interdisciplinary situation, where after, and only after, disciplinary rigor had been judged via disciplinary peer review, then, and only then, an additional rigor (restrictions, rules) is added. This additional restriction or rigor is to comply with the Means-End Logic or the Singer-Churchman’s Pragmatic-Teleological Truth of the Systems Approach (Churchman, 1971), as well as with phronēsis (practical understanding in the case of real-life problem solving). This will provide additional, often illuminating, complementary reviews from researchers, scholars or professionals from other disciplines, as well as from users of the implemented solution if a real-life problem is faced.

It is our understanding that interdisciplinary communication is produced, in at least the following situations:

A. **Interdisciplinary research** via multi- or cross-disciplinary teams, where multi-disciplinarity is understood as informal juxtaposition of insights from two or more disciplines, and cross-disciplinarity includes some level of knowledge integration among two or more disciplines. This requires a minimum of common knowledge in order to communicate the members of the team. We would like to suggest that multidisciplinary team are related via insights and opinions (Doxa) while cross-disciplinary teams are also related via knowledge (Episteme)
B. **Transdisciplinary topics** or conceptual structures.

C. **Translating**\(^7\) (partial or total re-writing) of peer reviewed *intra-disciplinary* research and communication with the objective of interdisciplinary communication.

A case combining modes A and C can occur when the underlying research is already effectively interdisciplinary, but the exposition is placed entirely within a disciplinary framework. In essence, it then involves reversing the process of placing it in a disciplinary context, preserving the results and insights that arose while doing so, yet paying full and due attention to the interaction with other fields that may have been neglected, or confined to shadows within the language and concerns of the article’s field.

**Situation A** requires disciplinary rigor AND the rigor of strictly solving the problem for which the team was formed. This problem may be a technological, methodological or organizational innovation, a health issue, an effective medical diagnosis and remediation, a solution of a socio-political problem, etc. The best real-life test in meeting the additional rigor, beside the intra-disciplinary rigor, is the solution of the problem which can be observed by any peer and even non-peers. Consequently, effective multi- or cross-disciplinary teams are more rigorous. The rigorousness of their interdisciplinary communication can be observed, verified and validated by peers and, eventually, by non-peers.

**Situation B** requires *general disciplines* as, for example, Cybernetics, System Approach, Philosophy, Mathematics, Logic, Design, critical thinking, etc. and *meta-disciplinary approaches* as, for example, meta-science, meta-engineering, meta-research, meta-design, meta-education, meta-philosophy, meta-logic, meta-history, etc. Consequently, the intellectual rigor in situation B is the rigor associated to the respective discipline or meta-discipline.

**Situation C** requires both the disciplinary rigor verified by known and much used peer-reviewing processes AND another layer of rigorousness; which is to be restricted to what is common to different disciplines; which is, usually, an adequate use of the natural language and qualitative thinking. Both things do not lower the rigor, but increase it. **Disciplinary rigor should not be confused with disciplinary precision.** Using natural language may lower the level of disciplinary precision, but not be an excuse to lower the disciplinary rigor. The author of an article based on an intra-disciplinary communication should interpret and translate it into a more common language, which *might be less precise but not less rigorous*. More precision may include referring 1) to an article written for intra-disciplinary communication for those readers who are interested in more precision and/or 2) to appendixes attached to the same article and/or 3) to footnotes. Frequently, to interpret and translate intra- to inter-disciplinary knowledge requires comprehension, and not just understanding, of intra-disciplinary knowledge. Who is better than the intra-disciplinary article’s author to interpret and translate such a paper with the objective of making it accessible to other disciplinarians? Notice, please, that this adds another layer of rigorousness which is to be ALSO restricted to the means-end logic without violating

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\(^7\) We are using the term “translation” in its general sense or meaning, which will be briefly described below, i.e., in its meaning of translating between two Semiotic Systems, not necessarily between two natural languages which are a special case of two semiotic systems. Meanwhile, let us understand the term as an expressive metaphor referring to translation between two natural, or non-disciplinary, languages.
the respective disciplinary logic(s). This requires an additional mental effort and an additional creativity potential. This brings to mind a Charles Mingus’ famous phrase “Making the simple complicated is commonplace; making the complicated simple, awesomely simple, that's creativity.” Intra-disciplinary precision is frequently achieved with the cost of increasing complexity in what is being described in an intra-disciplinary communication. This is, in our opinion, a necessary condition for disciplinary scientific and technological advancement, but it is not a sufficient condition for relating disciplines, i.e. for any kind of knowledge integration required 1) for the partial integration needed for a specific real life problem solving or 2) for a more general integration required by the advancement of human beings as human beings.

To conclude this discussion, let us return to the words of Julie Thompson Klein. Referencing (Schneider, 1977) she affirms that “excellence is not to be measured in terms of disciplinary originality but, instead three criteria [mentioned above] that acknowledge the importance of disciplinary accuracy while allowing the creation of new meaning: disciplinary clarity, the clarity of cross-disciplinary communications and the combination of the existing knowledge to help solve a problem or to raise or advance knowledge a new issue … Ultimately, then, the [inter-disciplinary communication] depend[s] on the quality of both disciplinary and interdisciplinary communication, on a fuller reciprocity of “text” and translator” (Thompson Klein, 1990, p. 94). [Italics added]

In two articles resulting from keynote presentations by the second author at the IIIS July 2019 conference, written with Katherine Herbert (Marlowe & Herbert, 2019) and (Herbert & Marlowe, 2019) the authors consider the need for a multidisciplinary, interdisciplinary, and even cross-disciplinary perspective in education, research, and practice in STEM (Science, Technology, Engineering, and Medicine) fields, including data science. STEM professionals, it is argued, need to be able to work in interdisciplinary teams, on interdisciplinary problems, and to communicate with colleagues from other disciplines, both within and outside STEM, with managers and other business specialists, with foundations and government agencies, and with the general public. In each case, both the precision and rigor of the analysis may need to be preserved, but translated into a new domain. The articles also suggest that, with the increasing importance of data science, social media, automation, and the Internet of Things, as well as the rapid—if not always beneficial—progress of modern science, technology, and engineering, non-STEM specialists can benefit from integrating, and in many cases arguably must integrate, an understanding of STEM into their intellectual worldview, including an understanding of technical communication.

Yet even that does not encompass the full scope of possibilities for and constraints upon inter-disciplinary communication. In some cases, particularly in Situation B disciplines (to which we would add within the formal sciences much of Computer Science and some aspects of Data Science), there is the possibility of significant knowledge that is inherently intra-disciplinary, even if it has interdisciplinary ramifications. The results of Gödel, Turing, and other impossibility theorems obviously don't solve problems—in fact, they instead constrain the set of problems that can be solved, at least within specific if very general formal systems. The Heisenberg Uncertainty Principle is an example of a similar formal result in the natural science, as is Arrow’s Impossibility Theorem in the social sciences. And they are necessarily posed and demonstrated within the discipline or within the formal sciences.
In these cases, interestingly, our argument is in some sense reversed. While interdisciplinary formulation cannot add to the rigor of the result, it is very important in communicating the precision: where and how the results apply and where they do not. Too many popular and even academic works that have badly misinterpreted or even abused quantum physics, mathematical incompleteness or undecidability, and like results show the necessity of this work.

This is what we are trying to achieve by means of the above-mentioned situations, especially, but not uniquely, situation C, with the purpose of working out the initial steps with which we are planning to continue fostering interdisciplinary communication. For 23 years we have been trying to foster this kind of communication via conferences in which we tried to integrate traditional intra-disciplinary with inter-disciplinary presentations. The latter have, mainly, been done via verbal communications at plenary and conversational sessions, as well as via interdisciplinary workshops and participative panels, on the first day of the conferences. In this new phase we are trying to foster written interdisciplinary communication.

Translation between Two Different Semiotic Systems:

We frequently used, above, the word “translation”. We are providing, in this section, a very short description of the specific meaning in which we are using this term. A more detailed description would require a complete paper by its own, which is planned for the near future.

Disciplinary communication is based on what we might call Disciplinary Semiotic Systems with their own Syntactics, Semantics, and Pragmatics. Probably. Bernikova and Redkin, mentioned above, in an article (included in this multi-author paper) entitled “Intellectual Rigor in Arabic Studies and Computer Sciences Communication” refer to their research experience related to “translating” 1) between the semiotic system of a natural language (the Arabic) and the artificial languages of Computer Science and 2) among the different disciplines required for solving the kind of problem they face in their research. We suggest that their experience is similar to those who develop an information to support activities generated by professional from different disciplines. Information Systems analysts have similar kind of problems that require translation between natural disciplinary languages, artificial languages, i.e. among different natural and artificial semiotic systems. In Bernikova and Redkin case they should also achieve an adequate translation among different natural languages, i.e., Arabic, Russian, English, etc., as well between then and artificial languages.

Ekaterini Nikolarea, in an article included in this multi-author collaboration, provides a great metaphor, which is even, in our opinion a potentially a very effective tool for analogical thinking. She uses the term “Glocalization” to refer to what is needed for inter-disciplinary

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8 More details regarding this issue have been posted at (Callaos N., Higher Education or Higher instruction?, 2015)

9 The neologism “glocal” is an adjective related to characterizing “local and global” simultaneously. “Glocalization” is also a neologism that refers to the simultaneous coexistence of “globalization” and “localization”. Two seemingly opposite notions had been associated to “glocalization”: 1) “In the marketing context [for example], glocalization means the creation of products or services for the global market by adapting them to local cultures” (Blatter, 2013); 2) in “education has been proposed in the specific areas of politics, economics, culture, teaching, information, organization, morality, spirituality, religion and "temporal" literacy. The recommended approach is for local
communication. She shows “how the concept of “inter-disciplinarity” of a scientific field/domain in glocalized environment – … (1) draws upon different disciplines and recontextualizes its vocabulary to meet its specific needs and (2) carries polysemy of scientific discourse.” This is required for translation among disciplinary semiotic systems which make inter-disciplinary communication more, not less, intellectually rigorous, as long as a) the essence of the communicated contents does not go against what is accepted in the disciplinary semiotic systems involved and 2) the inter-disciplinary communication is effective. Adding inter-disciplinary effectiveness to complying with the disciplinary semiotic and methodological systems, increases the number of restrictions and objectives to the intellectual process, hence, by definition (and according to our above reasoning), it increases its rigorousness. An adequate translation between semiotic systems is required for the effectiveness of any inter-disciplinary communication.

A very known good example is the required Semiotic Translation in Mathematics Education. Presmeg et. al. (Semiotics in Mathematics Education, 2016), for example, affirms that one of these dimensions “is the relationship among sign systems (e.g., natural language, diagrams, pictorial and alphanumeric systems) and the translation between sign systems in mathematics thinking and learning.” (Presmeg, Radford, Roth, & Kadunz, 2016, pág. 26) [Italics and emphasis added]. The other dimensions of Mathematics Education apply as well, but for the sake of simplicity and the brevity required in this article, let us just mention this dimension as an example of “translation” between semiotic systems, which is the sense in which we used the word above. This example in mathematics applies to any discipline or disciplinary research to be delivered, orally or via written material, for inter-disciplinary communication with a multi-disciplinary audience or readerships.

We think it is necessary to provide some context to the rigor of Mathematic Education and other exact sciences, as related to their educational processes, especially because the context is not as simple as the above paragraph may indicate.

**Mathematics Education Vs. Mathematics as a Discipline.**

To provide context, especially in what relate and differentiate Mathematics Education and Mathematics as a Discipline, let us look at two different areas, which become three in computer science and, potentially, in other sciences.

The first is between the teaching of formal mathematics versus the practice of pure mathematics. Pure mathematics as a practice uses rigor as a toolkit and a validating instrument in the exploration of new intellectual territory—by expanding what is known about systems or by modifying definitions and assumptions to understand new systems (which may be specializations, generalizations, mutations, or tweaks of current systems). The results may be very small or large and consequential—and it is often hard to know how significant the results will be before the exploration has begun. Mathematical education, on the other hand, largely educators to consult global resources for materials and techniques and then adapt them for local use. For example, in information, it involves advancing computer and media understanding to allow students and educators to look beyond their local context.” In many cases these two opposites are polar ones, i.e. they may complement each other, have cybernetic relationships and, hence, generate synergies. This is, in our opinion, the case of inter-disciplinary communication and it is our interpretation of what Ekaterini Nikolarea is proposing.
inherits its intellectual rigor, and typically provides limited challenges with fixed targets to the student, who admittedly has to demonstrate the same rigor in carrying out those exercises. Even in undergraduate research in mathematics, the results may not be known, but the roadmap is usually well-understood, although there are occasional wonderful exceptions, either in the student or in the results.

The second is between the teaching of applied mathematics and the practice of the same. Teaching of applied mathematics most often presents a set of techniques and then asks students to solve problems using those techniques. At best the student may have to choose among methods, and/or determine the applicability of a given method. The difficulties typically are a combination of seeing tricks and carrying out computations. The practice of applied mathematics, on the other hand, looks first for appropriate models, and validates their applicability (at least “mostly”) up front. It then looks for the appropriate relationship (differential equation, matrix formulation, statistical tests, …) and tries to solve the problem in one or more ways. Finally, it validates the final solution, and where possible, looks for fragility in the initial information (what changes would have required or resulted in a very different solution?) and possible follow-up explorations. [On the other hand, one has to admit that there are programs—at the United States Military Academy (West Point) for one—that give freshmen and sophomores largely unconstrained engineering/applied mathematics problems and ask them to explore formulations, approaches, and (partial) solutions using the full scope of their knowledge and their courses.]

Finally, in computer science, in addition to the logical theory of programming and of computability, and the application of computer techniques to software development and other problems, there is the system dimension—physical hardware, architecture and organization, networking, and program translation. Practice entails considering and developing physical, structural, and low-level programming alternatives for components such as processors, memory, processes and threads, communication, and more. On the other hand, while teaching this material may ask students to consider tradeoffs among existing alternatives, or to build or emulate parts of the system, students are rarely if ever developing new components or combining them in novel ways, except perhaps under faculty direction.

In sum, although the mathematics being taught is constrained by the same requirements and rules as the mathematics being developed by researchers, the processes are by no means equivalent, and the rigor in the development of mathematics is far more of a barrier in research than it is in education.

This can be compared to research in the non-theoretical areas of science, where upper-level undergraduates may be using most of the same techniques and procedures as the researchers, and may even participate (largely in a role as technicians) in carrying on that research.

It may also be conceived that the development of mathematics has different kind of barrier in research than in education. Let us offer a very brief reasoning regarding this issue.
Tons of books and articles had been written on the methods of analysis and synthesis, since the Greeks started thinking and writing about on methods in Geometry. Briefly, analysis is a method of discovery and synthesis is the proof, in other words: analysis is the method of discovery of the truth and synthesis is the method of its presentation. Consequently, the methods followed by mathematicians in pure mathematics are basically (but not uniquely) that of analysis while the mathematics education needs to present the discovered truths to the student, then it is basically a synthetical one. Having clarified this difference, we now need to also clarify that analysis and synthesis may be conceived as two sides of the same coin. Since they require, define, and complement each other, they could be conceived as polar opposites. They also could be conceived as related in cybernetic loops including co-regulative (negative feedback and feedforward) and co-amplificatory (positive feedback (loops)).

Analysis and synthesis require each other in such a way that authors, like Lakatos, present them as one method, in the context of a heuristic thinking (as contrasted with algorithmic one). Lakatos points out that this ‘combined’ heuristic method of ‘analysis-synthesis’ was the essence of what was recommended by ancient Greek philosophy, especially in the area of Geometry. He resumes this hybrid and heuristic method (in what he named as an associated rule of analysis and synthesis) in the following text (that might be perceived as one of the clearest ways in which the analysis-synthesis method has been stated, in few words).

“Draw conclusions from your conjecture, one after the other, assuming that it is true. If you reach a false conclusion, then your conjecture is false [reductio ad absurdum]. If you reach an indubitably true conclusion, your conjecture may have been true. In this case reverse the process, work backward, and try to deduce the original conjecture via the inverse route from the indubitable truth to the dubitable conjecture. If you succeed, you have proved your conjecture... The first part is called analysis, the second part is the synthesis.” (Lakatos, 1997, págs. 72-73) [Author’s italics, emphasis added]

The decomposition process of complex lemma/theorems (whose truth is not intuitively evident) into simpler components (which represent indubitable truths: axioms, first principles, lemmas that had already been proven, etc.) should be followed by a compositional process through which we can construct the complex theorem to be proved from simple (or simpler) indubitable truths. So, unless we are can have a falsehood proof, via ‘reductio ad absurdum’, synthesis must necessarily follow analysis in geometrical and mathematical proving processes. Analysis is a method for discovering truths, and synthesis is the proof, the demonstration of the truth of a complex idea by means of its derivation (composition) from simpler (usually self-evident) truths. Analysis and synthesis are each necessary for discovering and demonstrating truths) and both, together, are sufficient for any proof.

In Science, in general, Tom Ritchey (Analysis and Synthesis On Scientific Method - Based on a Study by Bernhard Riemann , 1991) affirms that “Analysis and synthesis, as scientific methods, always go hand in hand; they complement one another. Every synthesis is built upon the results

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10 For example, Michael Beaney (Definitions and Descriptions of Analysis, 2014) presents 56 definitions and descriptions related to the methods of analysis and synthesis in the context of different philosophies and epistemologies and given by the most known and reputable philosophers of Science and epistemologists.
of a preceding analysis, and every analysis requires a subsequent synthesis in order to verify and correct its results. In this context, to regard one method as being inherently better than the other is meaningless. (Ritchey, 1996, pág. 1)\textsuperscript{11}

The interpretation made by Ritchey is related to the following Riemann’s text, which we will copy below in order to assure to the reader the correctness of Ritchey’s interpretation of such a reputable mathematician as it is the case of Riemann.

“Purely synthetic and purely analytic research, when taken in the precise sense of these terms, is an impossibility. Every synthesis rests upon the results of a preceding analysis, and every analysis requires a subsequent synthesis in order that it may be confirmed or corrected with reference to experience. With the former, synthetic procedure, the universal laws of motion are simply the result of a previous, assumed analysis.” (Riemann, 1866) [Quoted by (Ritchey, 1996, pág. 16)] [Author’s emphasis, underlining is ours]

Consequently, in the case of mathematics, we suggest the following relationships (Figure 1) between the practice of pure mathematics and teaching mathematics. We also suggest that analogous relationships are (implicitly or explicitly) present in between the practice in other disciplines and its respective teaching.

Sukjin Kang identified, in a short article included in this multi-author contribution, similar relationships in Aesthetic Communication Rigor. As it can be noticed this short article increases the importance of synthesis relating initial synthesis to new ones with cybernetic loops that might be co-regulative feedback or feed-forward and/or synergic co-amplificatory positive feedback. The latter is what increases the creativity level in Art Practice and Art Education.

Sukjin Kang’s short article is really an inspirational one, in spite of being short. It may certainly trigger analogies and many reflections, as well as reflexions (meta-reflections), in potential authors and readers from other disciplines. If we conceive education in any discipline as a practice that combine Art and Science, then it is easy to imagine the fertility of Professor Sukjin Kang’s short article for analogical thinking, which is an important source of the creativity required as input to logical thinking.

\textsuperscript{11} Tom Ritchey bases his study on Riemann and, as it is well known, he affirms that “Riemann is known primarily for the so-called Cauchy-Riemann equations, Riemann surfaces and Riemannian geometry, Riemann’s differential equation, the Riemann integral, Riemann’s zeta-function and the Riemann hypothesis. However, the basis for most of his discoveries seems to rest upon his fundamental development of the theory of complex functions. The methods he developed in this area led him to other discoveries in analysis, geometry, number theory and even hydrodynamics -- subjects which today are thought of as belonging to more or less separate areas of study… Riemann’s fundamental ideas on geometry were presented in his famous Inaugural Address of 1854, "On the Hypotheses which lies at the Foundations of Geometry". This short, non-technical work is undoubtedly one of the highlights in the history of science. In it he analyses the basic assumptions which underlie geometry and develops unified principles not only for the classification of all then existing forms of geometry, but also for the creation of any number of new types of space. He later developed the basic analytical tools, which Einstein would subsequently use, in his theory of general relativity.” (1996, pág. 3)
Disciplinary Communication” requires an adequate blend of Art and Science as well as of Art. This adds to the above reasoning of why an effective inter-disciplinary communication is more rigorous than that of the associated discipline(s) as long as the communication had been previously peer reviewed in the respective discipline(s). If a written inter-disciplinary communication had not previously been reviewed by disciplinary peer reviewers, then we cannot conclude that it is more rigorous but it has a different kind of rigor, as long as it 1) is effective and 2) does not go against already consensually accepted scientific truth in the associated discipline(s). This adds astonishment to what we noticed above, regarding to what seem to be consigning the notion of Synthesis to oblivion.

In the 1956 Bloom’s taxonomy, synthesis was second to the highest category recommended in the six Educational Objectives (Knowledge, Comprehension, Application, Analysis, Synthesis, Translation between Semiotic Systems)
and Evaluation). In the 2001 Bloom’s taxonomy was revised by a group of psychologists led by led by Lorin Anderson (a former student of Bloom). In this new version, synthesis disappeared as educational objective or cognitive skill to be met in educational processes. This is really perplexing.

But, what is really astonishing and alarming is that synthesis would not even appear in the Delphi Report oriented to identify the “Purposes of Educational Assessment and Instruction”, but ‘analysis’ certainly did appear identified among the six principal cognitive skills (Self-Regulation, Explanation, Inference/Querying, Evaluation, Analysis, Interpretation)

This is really unbelievable, especially because the report is oriented to Critical Thinking. This report was produced by 47 researchers/experts (most of whom are philosophers) after several rounds of the Delphi Method during 20 months of a consensus forming process, in order to find a consensus report regarding the cognitive processes that should be addressed in Critical Thinking. The result of this Delphi consensus procedure has been reported in the much known “The Delphi Report”. 13

Synthesis cognitive processes support and are generated in science education, especially in Mathematics and Formal Sciences. There’s no proof with no synthesis. How anyone can teach a proof without presenting it? How can be presented if not by synthesis? How could it be any education, including mere instruction, with no presentation of proofs? How it is expected from the students to handle real life problems; which by nature are multi-disciplinary one with no cognitive skill to relate and synthesize different knowledge obtained from different disciplines where synthesis is oriented to the solution of the real life problems, including research, educational, professional, existential, social and even familiar and personal problems?

Education and meta-education (including self-education) necessarily require cognitive skills for making adequate relationships, hence synthesis, and this in turn requires the cognitive skills of translating between different semiotic systems. A necessary condition for any translation is the skill to construct, synthesize, in the targeted semiotic systems, including other disciplinary semiotic systems and common language, which is the language of patients, clients, users, students, colleagues, etc.

In the context of the above-mentioned dimension of Semiotics of Mathematics Education, any communication of a disciplinary research oriented to a multi-disciplinary audience is an educational process, where academics and researchers from one discipline are teaching academics/researcher/professionals in other disciplines. Academics from a discipline are informing academics from others, as Robert Hammond would say, (Experts Informing Experts, 2017) and often themselves learning through the effort of making the translation. Consequently, inter-disciplinary communication processes, in face-to-face or virtual groups, are necessarily collaborative educational processes; these, in turn, are among the main means of meta-education, i.e., education in real educational processes where education is not reduced to one of its means, as it is the case, for example, of instruction. 14 An adequate education necessarily

13 An executive summary on this report can be found in (Facione, 1990)
14 A detailed differentiation between Higher Education and Higher Instruction has been posted at (Callaos N., Higher Education or Higher instruction?, 2015)
requires an effective translation between disciplinary and natural language semiotic systems, at the three semiotic levels: the syntactic, the semantic and the pragmatic levels. Likewise, in the translation required for inter-disciplinary Communication. Consequently, effective educators in Higher Education should be well trained to make the additional intellectual effort required to translate between disciplinary and inter-disciplinary semiotic systems.

This semiotic translation requires an additional act of creativity, which adds to the originality required by disciplinary research. Originality requires creativity, but creativity does not necessarily require originality. Reverse Engineering is one of the many examples of a high degree of creativity with no originality, because it does not originate new products. Interpretations of scientific experiments require creativity but not necessarily originality, unless they end up in a new experiment that leads to new knowledge. Translation between semiotic systems necessarily requires understanding in a Semiotic System A, in order to make the intellectual interpretation required for a semiotic construction in the semiotic system B. Both interpretation and construction are creative acts. Consequently, an author whose disciplinary article has already been peer reviewed in the respective discipline requires an additional creative act to translate it for inter-disciplinary communication. This means that this article is both: 1) more rigorous, because of what we explained above and 2) more creative when it is delivered for inter-disciplinary communication.

More rarely, the translation and the creativity may occur in the other direction. It may be useful or interesting to translate and generalize results of an article in one discipline or even from an interdisciplinary project using a general discipline (Situation B) into the idiom of that general discipline. For example, social science research may use graph theory to model relationships, so in a sense already be interdisciplinary, and observed properties of those models might generalize to interesting (and rigorous) mathematical results. This can give rise to another virtuous feedforward cycle, with the disciplinary results now available for further interdisciplinary work.

Consequently, why this kind of articles should not be appreciated in the promotional academic systems? Why is it that “Interdisciplinary work is often attacked for lacking rigor” as Julie Thompson Klein (1990) affirms? Does not this unjustified academic belief increase the probability of intra-disciplinary inbreeding and other forms of academic incest? Isn’t that worse than the called academic incest when a student takes his/her undergraduate degree, Master and PhD at the same university—especially if these studies are almost entirely intradisciplinary? Isn’t that worse than when the called academic incest when a PhD holder teaches in the same university or department in which he/she earned his/her PhD? And won’t this have a narrowing effect on that individual’s teaching, and his/her relationship with peers outside the department?

Similar remarks apply to the researcher who is not in the professoriate. Almost every field now interacts with technology and data science, and has significant ethical, philosophical, and social concerns beyond the researcher’s own discipline, to the extent that it becomes a social, moral, and professional responsibility to develop an interdisciplinary perspective. This topic requires another article oriented to desirable and, even, necessary (in some situations)
of cybernetic relationships between disciplinary and inter-disciplinary\textsuperscript{15} Some of these cybernetic loops are co-regulative (via negative feedback or feed-forward) and co-amplificatory and, hence, synergistic loops (via positive feedback).

References


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\textsuperscript{15} A related work is in progress. An unfinished and unedited article with regards to intra-disciplinary incest and the cybernetics loops that would avoid it can be solicited from the first author of this article.


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Unedited notes on interdisciplinary communications – historical perspective, rigor and current situation

Rene Descartes (1637/1912) is the early-modern reason for scholars to miniaturize information. In 1637, he wrote that in order to understand anything, we need “… to divide each of the difficulties under examination into as many parts as possible, and as might be necessary for its adequate solution. (Ibid., p. 15) … by showing we cannot conceive body unless as divisible” (Ibid., p. 76). In modern terms our knowledge space can be reduced at least to a size of $1.61619926 \times 10^{-35}$ meters, Planck scale. We can describe anything with Planck-scale granularity, each “particles” related to the next, and in groups. This is called “reductionism”. Then, we classify our finding by taxonomies. Descartes was standing on ancients ground, with Aristotle and is Physica divided up the natural world. Seemingly inevitable consequences were seen to result from particularization, a familiar story about the Tower of Babel a case in point, people literally babbling to each other in an environment characterized by the cacophony of languages. With the explosion of scientific and technological development corresponding to the unfolding Industrial Revolution, people were having increasing difficulty talking to each other.

Gottfried Leibniz (1646-1716) with his characteristica universalis was a forerunner of those wanting to universalize knowledge through making it intelligible enough for sharing. A milestone was reached with August Comte saying:

As a result of this discussion [survey of fields of study], positive philosophy is thus naturally divided into five fundamental sciences, the succession of which is determined by a necessary and invariable subordination, founded, independently of any hypothetical opinion, on the mere comparison of the corresponding phenomena: these are Astronomy, physics, chemistry, physiology, and finally social physics. This classification presents the most remarkable property of marking exactly the relative perfection of the different sciences, which consists essentially in the degree of precision of knowledge, and in their more or less intimate co-ordination (Comte, 1830, p. 31)

Further, “The object of all true Philosophy is to frame a system which shall present a systematic view comprehend human life under every aspect, of human life, social as well as individual” (Comte, 1848/1908, p. 8). Comte was one of many thinkers who viewed nature and humanity in an interconnected way, the former assuming organicity from the latter. It may be argued that this century in many ways these people were reacting to the mechanization brought on by the Industrial Revolution. Thomas Marlowe, one of the co-authors, of the article above, commented that [“Interestingly, Alexander von Humboldt, at the transition between the gentleman-scholar polymath and the Industrial Age scientist, was a strong believer in the interaction between the sciences, including the social sciences.”]
Rousseau, Hegel, Bluntschli, Saint-Simon, Durkheim and Spengler represented the trend. The linear, lifeless model of the world espoused by the likes of Descartes and the Industrial Revolution, superseded by the 19th century, was again to undergo a crisis from which it never has recovered – Einsteinian physics and Heisenberg uncertainty. Even Einstein was to remark that God “does not throw dice” (Born, 1971). Yet, a new age of angst has emerged, scientists wondering where and how their findings will fit into the grand scheme of things. Without data I do still speculate about there being two groups, those retreating into the corners of specialty (a world with which they are most familiar and can feel secure) and those who realize that to face new realities have to come together, communicate, and collaborate. So, what of those with community consciousness?

Herein is core of humanity collectively seeking the truth, each person affirming her/his own truth through that of collective humanity and humanity expressed by each individual. Buddhism has a similar scheme of individual egos in the “next life” merging with the Universal Consciousness, this consciousness expressing itself through the individuals. I think of a bubbling soup, where each bubble is an individual with a very transient life but the soup outlasting everyone. When entropy takes its final toll, the soup will cool down, each individual ever having lived being a part of it. How, then, does the individual come to grips with what is on this planet?

Let's take a page from Plato. It is problematical at best whether we can step outside of ourselves (our cave) to observe “the truth”. Reading Edwin Abbott's 1884 *Flatland* will suggest why. It is a dimensionality problem. In the same way two-dimensional beings cannot know how and why a raindrop falls through their world, we as four-dimensional beings cannot look at ourselves except through ourselves. Even if there were a being telling us the truth or if the truth simply “sat there”, we still would apprehend it in the same limited way. Nevertheless, we want to observe our dimension as keenly as is possible.

Ideal rigor will guarantee the truth. Also, it is everlasting, but we all know about entropy. Well, let's settle for what philosophers uphold as criteria for objectivity – coherence, correspondence, and consensus. Scientists look to independent discovery of the same phenomena. Peer review is supposed to follow this idea with blind reviews. I won't get into the problems of peer review, but suffice it to say that it is another ideal contributing to what I might call “truth distribution”.

Statisticians are keenly aware of their implementation of induction. Eye physiology lends itself to interdisciplinary philosophy, as each rod and cone assembly grabs a photon from our visual panorama, sends it to the rod and cone assembly, where an electron is bumped out of an atomic shell, thus activating the synapse to send a signal to the brain for processing. Obviously, no single rod and cone assembly is sufficient, but millions of them, each taking a sample to be processed by the brain to give us the whole picture. Newsprint is like this, with each dot playing its part to help present the whole picture. Survey research – in fact, all of statistics is based on the principle of extrapolating a whole from samples. Now, look at the gazillions of fields of study, each with their specialized domain. Obviously, each domain, like a single rod and cone assembly does not capture the whole. Now, let's get back to Comte for a second. Each area of endeavor is related to the others, and if these allegorical assemblies of rod and cone structures is to function, they have to communicate with each other through the brain. The more disciplines the greater integrity will
there be in apprehending the whole. As an aside, there physical reasons that we never will be able to apprehend everything (as in space being digitized and interstices simply unknown) – perhaps another aspect of our never being able to leave that cave. We never will know THE truth (something in its entirety).

Let me take another analogy – language, itself. Starting with the imperfection of a word being at best a mapping of a symbol and its utterance to an idea, we look at the web of words relied upon to describe our world. This web by its very nature invokes an interdisciplinary regime, “interdisciplinary” assuming a more generic meaning of interdependence. Each word can be defined by others. Blue cows eat grass. Each word has a set of others. Look up the definition of “blue”. In turn, each of those words has a definition. Some paths will take you through optics, angstrom units, and so forth. Oh wait, you have to do the same thing for “cows”. Then, it is “eat”, and so forth. You have an exponential task ahead of you, but we do it every day effortlessly. Hands clapping is another aspect of interdisciplinary thinking, albeit a real basic one. No sound is produced by one hand, save, perhaps, for the rushing of air.

Unity of difference is one way of characterizing interdisciplinary thinking. A stark example is the unity of opposites, as in it being impossible to think of an individual without an accompanying property. In the phenomenal world, difference is essential, as in not being able to see anything in a room where all the objects have the same color and shading. Given the physical necessity of interdisciplinary thinking and its ability to provide rigor (the tendency to give a better idea of what the whole is), where do we stand in the process?

We see lots of signs around us. Most graduate schools require at least one member of the dissertation committee be from another department. Look under “interdisciplinary conferences” and many entries will appear. We have project-oriented teaching, where students will work on a larger problem that necessarily brings in a number of disciplines. Today, we are seeing more attention paid to the need for interdisciplinary communications, as in encounter groups.

Diversity movements reflect the view that strength comes through difference. From Plato's dialogues and Aristotle's dialogics through extended and formal efforts to promote interdisciplinary approaches to communication and learning we can be more oriented toward process and organic learning, an affirmation of life, itself.

References

Sustainable development is a goal many societies aim for in one degree or another. For my university, promoting sustainable development is a key strategic goal. In the business faculty where I teach, we are committed to helping local and regional organizations to learn how to make sustainable development financially viable by working together with them on sustainability-orientated innovation in a research setting. Sustainability-orientated innovation, briefly defined here as ‘innovation aimed at creating sustainable products and services’ [1,2] is about creation processes in which technologies, institutions, directions of investment and the exploitation of resources are made consistent with present and future needs. Sustainability-orientated innovation (SOI from now on) is in itself technically complex in that it takes place in high-pressure markets with many unknown variables such as future needs and limited resources. Adding to the technical complexity is the social aspect of innovation, where individuals’ interactions are contingent on numerous contextual factors and as such can be highly unpredictable. The point is that SOI is in itself a highly complex process that tries to solve a highly complex problem. Because of this complexity, collaboration among individuals from different academic disciplines as well as non-academics is crucial for successful SOI or solving sustainability related issues. Collaboration among academics and professional during each step of the research process is a key trait of TR and directly related to IC. In figure 1 below, the notions of complexity and stakeholder diversity are shown. The graph shows that as the complexity of a problem increases, stakeholder diversity increases and the type of research that is effective for solving the problem also changes.

Looking at IC from a process viewpoint, it can be defined as the interaction among individuals from different academic disciplines. For example during a research project focused on SOI. However, IC can also be conceptualized as a result of interaction, for example some type of research artifact. In regard to interaction, communicating across disciplines can be very challenging for researchers.

If we look at the etymology we see that the term ‘discipline’ originates from the Latin words *discipulus*, which means pupil, and *disciplina*, which as a noun means teaching. As a verb, discipline means training someone to follow a rigorous set of instructions, but it also means punishing and enforcing obedience. Disciplinary boundaries exist because they create some
coherence in terms of theories, concepts and methods that allow the testing and validation of a hypothesis according to agreed rules. These rules are different from discipline to discipline making them to some extent incompatible. Thus, communicating with others from a different academic discipline necessitates the crossing of borders, which can only be done when there is some sort of common ground regarding theories, methodologies and discipline - specific discourses. Crossing these borders bring individuals into new situations where they are out of equilibrium. In order to regain equilibrium, individuals will need to adapt and learn by integrating new knowledge from other disciplines. TR takes this a step further by requiring individuals to also integrate new knowledge from actors from outside the university.

Interdisciplinary communication as an outcome of interaction in a TR setting can take on different forms that comprise various and differing types of knowledge. This includes 1) declarative knowledge (épistémè), which is about the current state of the system, and can take the form of new testable hypothesis or contributions to theory 2) transformative knowledge (praxis or poïesis), which considers what the innovation should achieve and could be embodied in new products, services or policy insights and 3) transformational knowledge (phronēsis). This is knowledge about the socio-technical aspects of innovation and how to actually bring it to fruition. The main barrier to IC in regard to outcomes has to do with these different types of resulting knowledge and whether or not they are produced in a rigorous manner. Because TR necessarily crosses methodological borders, new knowledge claims can be seen as less rigorous than those resulting from mono-disciplinary studies. It is for this reason there is an academic focus on intra-disciplinary communication aimed at producing highly rigorous declarative knowledge.

Notes


van Kleef JAG. Learning to learn for innovation and sustainable development: a conceptual model. 2014.
Dr. Lillian Buus, VIA University College, Denmark, Special Consultant, Educational use of digital media and ICT focus on developing learning designs.

Collaboratively Designing for Learning

In a Design for Learning approach, there is a need for the participants to be collaborative and creative in the design process, but it can be a challenge to facilitate this kind of processes and activities. To effectively meet this challenge requires more rigor than required by individual designs, because it has to meet the usual rigor in design plus 1) the rigor of being effective collaboratively in the group of participants and 2) to effectively add group creativity techniques (e.g. synectics) to individual creativity techniques. It is important to notice that the more objectives and/or the more restrictions (or rules) to be met in the design, the more rigorous is the required thinking.

Furthermore, to adequately manage collaborative and creative process, it demands knowledge in ways to handle inter-disciplinarity, dialogue and conversations based on diverse interests, and the ability to establish a shared language among participants. To enrich the learning design output and the learning design process, participants will be invited from different domains like educators, developers, technology people, and if possible management. All of them invited to design for learning in an inter-disciplinary setting. This inter-disciplinary diversity in participants enhance and enrich the learning design using negotiation of meaning (Wenger, 1998), collaboration (Georgsen & Nyvang, 2007), and creative design processes (Conole, Galley, & Culver, 2011). An interesting approach would be to unfold the way in which these three parameters (collaboration, communication and inter-disciplinarity) affect the learning design process. This will be based on one of the case studies described in “Designing for Learning in an Interdisciplinary Education Context” by Buus et al. (2019). Taking these perspectives into account, when dealing with learning design, it can also be seen in parallel to the characteristics of inter-disciplinary communication, as Callaos and Horne (2013, s. 28) describes them. All of these require even more rigor in thinking and doing, because there are more objective to meet and potentially more restriction to frame the design process.

Facilitating this kind of collaborative processes can be underpinned by an action learning approach, which will generate iterations based on the dialog and feedback from the participants and users. This approach also underpins the need for rigor inter-disciplinary communication in design processes.

A way to see this illustrates figure 1, as a possibility to have loops and iterations in the learning design process. In this process, it will be essential to have dialogue and feedback to be able to handle and adjust on the learning design. Therefore, it becomes important to facilitate collaboration and the inter-disciplinarity to enrich the output of the learning design process. What can be added is that any individual thinking requires internal communication, group thinking requires external communication, which therefore has more restrictions, e.g., a need to negotiate meaning (Wenger, 1998), build on a shared language. Inter-disciplinary communication adds more restrictions and the required learning process adds more objectives.
Consequently, inter-disciplinary communication oriented to collaborative and creative design adds both: restrictions/rules and objectives-to-be-met than the design made by an individual according a given discipline. Since the disciplinary requirements and standards have also to be met, then it is evident that inter-disciplinary communication in the context of collaborative and creative design requires more rigorous internal and external thinking as well as more effective doing than just intra-disciplinary rigorous research. The latter is a necessary condition, but it is not sufficient any more in inter-disciplinary communication, let alone for inter-disciplinary communication for collaborative and creative design.

![Diagram: Illustrating a learning design process as an action learning approach.]

It will be interesting to unfold these important aspects (communication, collaboration and interdisciplinarity) in the design process further and compare with the characteristics of inter-disciplinary communication.

References:


There can be no doubt that all the staff in public administrations require new e-competences in practical aspects of e-government (Sondermann 2016; Hill 2011). However, these competences should go beyond the simple ability to make an application operable, specialist IT knowledge, and the skilled handling of IT tools (Schuppan, 2009). Studies in Germany show that the specific knowledge required for e-government to function is not adequately incorporated into the educational system, either in university courses or in advanced training programs (Lück-Schneider & Schuppan, 2017). The educational landscape in e-government is highly fragmented (Becker et al., 2016). In a study from 2014, 53 percent of administration-related programs made no reference at all to e-government (IfG.CC, 2014). The relevant courses in business computing and law connected with e-government deal with the digitization of administration as a “niche topic,” and trainings at the advanced or postgraduate level also teach different competences, mostly with a legal focus (Becker et al., 2016).

If e-government is covered in individual courses, it is often treated as a supplementary topic and is not adequately linked to strategic reform issues or related in any depth to the potential and functions of IT (Lück-Schneider & Schuppan, 2017). Where e-government is the main focus of study, IT solutions take center stage in what are essentially computer science courses, so that it is not clear to what extent IT solutions and administrative functions are related to one other (Lück-Schneider & Schuppan, 2017). Issues connected with IT design, organization, and law are not addressed in the context of administrative modernization or state transformation (Lück-Schneider & Schuppan, 2017). In order to interlink computer science and administrative content, interdisciplinary perspectives must first be developed. If the content orientation of study programs is to reflect cultural change and modernization projects, then interdisciplinary ways of thinking and working in education and/or courses of study are essential and must be given intensive support (Lück-Schneider & Schuppan, 2017). Schuppan’s competence studies in Germany (2009) showed that there is a demand not only for new specialist competences but also for skills such as the innovative faculty of abstraction, networked thinking, and interdisciplinary cooperation, suggesting that mixed competencies are necessary (Schuppan, 2009).

However, to date, there has been little scientific discussion between the realms of academia and practice on the subject of these new competences (Schuppan, 2009). Moreover, Schuppan’s investigations (2009) showed that skills for self-organization and self-reflection are increasingly required at both the implementation and management level. This will require a reorientation of staff and the training of specific skills in all fields, which is also reflected in calls to adapt
general nontechnical management curricula (Lück-Schneider & Schuppan, 2017). We should change our approach to teaching by discussing and evaluating questions, problems, and interpretations through the lens of different disciplines. We know that. Why don’t we do it?

In a lecture, several professors or lecturers from different disciplines would have to deal with the selected topic at the same time. We do not do it, because interdisciplinary teaching is complex and cost-intensive in an age when the focus is on experts with silo thinking. In Germany, a so-called curriculum standard (CNW) has existed since 1977 as a definition of how many hours of teaching, exercises and support are required for the training of a student in a particular study program at universities. The higher the standard of the curriculum, the more staff are needed on the degree program per student (see Erdfelder, 2007). This type of interdisciplinary learning is simply too expensive. Real interdisciplinary teaching is not provided. Alternatively, several lecturers could quickly agree on one topic and tackle it from different angles. Although this would not really constitute “teaching in tandem” per se, it would be cheaper—however, it contradicts the constitutionally guaranteed freedom of research and teaching.

References:


Abstract: Innovation and/or research performed by Inter, Cross, and Trans disciplinary teams requires individuals to develop an understanding of how their discipline relates to other disciplines. Such understanding is obtained primarily by effective verbal, non-verbal, and written communications. However, due to each domain’s institutional and psychological complexities, gaining adequate understandings of multiple disciplines can be problematic and at times seemingly impossible. This can lead to failures of the intents and goals of Inter, Cross, and Trans disciplinary teams. This reflection paper will propose an approach to ease gaining of understanding between individuals from different disciplines in an affective domain context, and possibly lay a foundation for applying affective domain rigor to how understanding between individuals occurs over time.

Keywords—metaperspective, attitudes, beliefs, values, Interdisciplinary, Crossdisciplinary, Transdisciplinary, communication, Interdisciplinarian, Intradisciplinarian, Semiotic System, affective domain

1. INTRODUCTION

Although this reflection paper can relate to the concepts of Interdisciplinary, Crossdisciplinary, Transdisciplinary, for brevity, only the concept of Interdisciplinary is discussed.

In Julie Thompson Klein’s book Interdisciplinarity: history, theory, and practice (Klein, 1990) “Interdisciplinarity has been variously defined in this century: as a methodology, a concept, a process, a way of thinking, a philosophy, and a reflexive ideology.” In the book, interdisciplinary uses include: “a means of solving problems and answering questions that cannot be satisfactorily addressed using single methods or approaches. Whether the context is a short-range instrumentality or a long-range reconceptualization of epistemology, the concept represents an important attempt to define and establish common ground.” The representation of interdisciplinary as an “important attempt to define and establish common ground”, infers the use of effective communication processes such as verbal, non-verbal, or written communications between individuals, also known as Interdisciplinarians, in establishing common ground understandings between their respective disciplines.

Based on the premise of Interdisciplinary need to establish common ground understandings between their respective disciplines, a closer look at how understandings are accomplished is

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1 This article is a second edition of (Peoples, 2019)
warranted. Interdisciplinary understandings begin with an individual discipline-based field of knowledge. This knowledge is formed by Intradisciplinary communications by Intradisciplinarians within a specific discipline. In forming a knowledgebase utilizing Intradisciplinary communications, a system of concepts, the symbols representing the concepts, and the relationships between the concepts forms and evolves over time. As a domain knowledgebase evolves, a bias unique to discipline is established, reflecting how the knowledgebase forms unique agreed upon meanings of existing concepts, and generation of additional concepts, symbols, and relationships. These biases usually take the form of attitudes, beliefs, and values toward the concepts, symbols used to represent concepts, and relationships between the concepts contained in the existing and evolving knowledgebase.

In studying the evolvement of a domain knowledgebase, the field of Semiotics emerged. In the article *Elements of Semiotics*, Prof. Louis Hébert of the Université du Québec à Rimouski, basically describes Semiotics as “the field of study that is concerned with signs and/or signification (the process of creating meaning)” (Hébert, 2019). It can be argued when Semiotic techniques identified by a discipline are implemented by Intradisciplinary communications, a unique Disciplinary Semiotic System is formed (Callaos & Marlowe, 2020). Inherent to the Disciplinary Semiotic System are the attitude, belief, and value biases formed by Intradisciplinarian communications. It can be argued these attitudes, beliefs, and values form perspectives unique to a discipline, a reflection of the affective domain of a discipline.

When Interdisciplinary teams are formed, one of the greatest obstacles to the team’s success is establishment of common grounds. Key in the establishment of common grounds are translations between the Disciplinary Semiotic Systems of the unique disciplines involved in the Interdisciplinary team. Translations between the Disciplinary Semiotic Systems involved are usually accomplished by effective communication between Interdisciplinarians representing their respective disciplines. The communication process can be fraught with misunderstandings between Interdisciplinarians during, or as a result of communication processes. What seems to be missing in the translations of Disciplinary Semiotic Systems are the inherent attitude, belief, and value perspectives of the concepts, the symbols representing the concepts, and the relationships between the concepts when communicating content from one Interdisciplinarian’s knowledgebase to another Interdisciplinarian from another unique discipline. A methodology is needed to allow the communication process measure inherent attitudes, beliefs and values of a concept from a sender’s viewpoint (Interdisciplinary team member from a unique discipline) to a receiver’s (Intradisciplinarian team member from a another unique discipline) in a manner where the sender’s view of the receiver’s viewpoint of attitudes, beliefs, and values of the concept are properly aligned in an affective domain context. In some disciplines, this conceptual methodology can be termed metaperspective. In the above contexts, this paper will introduce a theory to measure and align attitudes, beliefs, and values between Disciplinary Semiotic Systems in obtaining metaperspective in an affective domain context.

2. BASIC THEORETICAL METHODOLOGY

This theoretical computational methodology to measure metaperspective in an attitude, belief, and value context is based on the work of Martin Fishbein’s measuring beliefs as applied to attitudes (Littlejohn, 1983, pp. 142-144), and on the work of Milton Rokeach’s utilization of attitudes,
beliefs and values to measure change of a person’s behavior and self-regard (Littlejohn, 1983, pp. 151-157),

A. Base Algorithm
A computational based algorithm is required to capture an individual’s attitude, belief and value affective domain perspective on a concept, including the concept itself, symbol used to represent the concept, or concept relationships.

\[ P_0 = \sum A B V \]

Where \( P_0 \) = The person’s perspective of Concept 0

\( A = \) Attitude: the person’s attitude of a concept

(Attitude in this context is defined as a predisposition to act in a positive or negative way toward the concept)

\( B = \) Belief: the person’s belief the attitude towards the concept is true

\( V = \) Value: the person’s degree of importance placed on the concept

Please note there may be multiple (N) number of separate ABV observations for an individual concept.

B. Obtain Data for Algorithm
To obtain data for the algorithm, a series of Likert scale questions and answers based on attitudes, beliefs, and values for the concept is generated. The answers to attitude, belief and value questions would be pre-determined with a numerical value assigned to each answer. For example, for each question, an implementer may provide 5 answers. Each answer would be assigned a number, in this case 1-5. The numbers assigned to each answer given would be summed, resulting in a number representing a person’s attitude, belief and value perspective for a concept under consideration, \( P_0 \).

C. Expansion of the Base Algorithm for Interdisciplinary Team Use
To compute metaperspective to reflect obtaining common ground understandings of attitude, belief, and value affective domain perspectives for concepts in a communication process within an Interdisciplinary environment, the base algorithm must be slightly expanded and modified.

\[ S P_0 = \left( \sum A B V \right)_x = R P_0 = \left( \sum A B V \right)_y \]

Where \( S P_0 \) = The sender’s perspective of Concept 0

\( A = \) Attitude: the sender’s attitude of a concept

(Attitude in this context is defined as a predisposition to act in a positive or negative way toward the concept)

\( B = \) Belief: the sender’s belief the attitude towards the concept is true
Value: the sender’s degree of importance placed on the concept

\[ x = \text{Sender’s discipline} \]

Where \( RP_0 = \) The receiver’s perspective of Concept 0

\[ A = \text{Attitude: the receiver’s attitude of a concept} \]

(Attitude in this context is defined as a predisposition to act in a positive or negative way toward the concept)

\[ B = \text{Belief: the receiver’s belief the attitude towards the concept is true} \]

\[ V = \text{Value: the receiver’s degree of importance placed on the concept} \]

\[ y = \text{Receiver’s discipline} \]

\( y \)

\( SP_0 \) and \( RP_0 \) are necessary for the algorithm to accurately identify the sender’s and receiver’s attitude, belief and value affective domain perspectives for a concept under consideration in an Interdisciplinary communication process. This allows the communication process measure inherent attitudes, beliefs and values of a concept from a sender’s viewpoint (Interdisciplinarian team member from a unique discipline) to a receiver’s (Interdisciplinarian team member from a another unique discipline), in a manner where the sender’s view of the receiver’s viewpoint of attitudes, beliefs, and values of the concept are properly aligned in obtaining “common ground” in an affective domain context. Using evaluative techniques in D. Evaluation of Data, it is theorized a form of metaperspective can be achieved in an affective domain context.

Subscripts \( x \) and \( y \) are added to clearly identify the sender’s and receiver’s domain. Having this type of domain information can be useful in long term pattern analysis for the effectiveness of the communication process used to obtain common ground, and to identify potential domain conflicts over time. If identified, future potential conflicts between domains may be identified and planned for during Interdisciplinary team interactions.

D. Evaluation of Data

Using techniques for obtaining data described in sub-section B. Obtain Data for Algorithm, data is collected for the sender and receiver sides of the algorithm. In a perfect world, the sums on both sides of the algorithm should be equal, indicating a sender’s attitude, belief and value affective domain perspective for a concept under consideration matches the receiver’s. In theory, metaperspective on gaining a common understanding for a concept under consideration in the context of the affective domain is achieved.

In the below example, a number representing a sender’s attitude, belief and value perspective for a concept under consideration matches the receiver’s attitude, belief and value perspective for a concept under consideration, 12. In this case, metaperspective in an affective domain context is achieved.

\[ SP_0 = (12)_x = RP_0 = (12)_y \]
In reality, it is expected the sum on both sides of the algorithm will be different for the first communication attempt. In the example below, the number representing a sender’s attitude, belief and value perspective for a concept under consideration is 12, while the receiver’s number representing attitude, belief and value perspective for a concept under consideration 0. In this extreme example, metaperspective on gaining a common understanding for a concept under consideration in the context of the affective domain is not achieved.

\[ SP_0 = (12)_x \neq RP_0 = (0)_y \]

It is theorized if data is collected on the sender and receiver over time, the expected the sum on both sides of the algorithm will become closer to each other. In the below example, assuming the data is collected at 1-week intervals over 4 weeks, where numerous effective communications occur between the sender and receiver each week, as data is evaluated, the sum on both sides of the algorithm should become closer, indicating partial common ground understanding of attitude, belief and value perspectives for a concept under consideration in the context of the affective domain.

Week 1:
\[ SP_0 = (12)_x \neq RP_0 = (0)_y \]

Week 2:
\[ SP_0 = (12)_x \neq RP_0 = (3)_y \]

Week 3:
\[ SP_0 = (12)_x \neq RP_0 = (7)_y \]

Week 4:
\[ SP_0 = (12)_x \neq RP_0 = (10)_y \]

It is theorized the sum on both sides of the algorithm will rarely be equal. That being said, data collected over longer period of times in the contexts of x, and y, and in the context of the concept under consideration, patterns emerge indicating a range of numerical “closeness” for sums between both the sender and receiver. For example, in the domains of Mathematics and Biology, a 4 may be the acceptable range for obtaining a partial common ground understanding of attitude, belief and value perspectives for a concept under consideration in the context of the affective domain.

\[ SP_0 = (12)_{Mathematics} \sim RP_0 = (8)_{Neuroscience} \]

It should be noted in all of the above examples, metaperspective is achieved by the sender and receiver. By having the sum data on both sides of the algorithm, the sender’s view of the receiver’s viewpoint of attitudes, beliefs, and values of the concept become known, and vice versa. Using this knowledge, the sender and receiver can explore communication options to better understand differing viewpoints in the context of the affective domain, and as a result, gain a better understanding of both common ground, and uncommon ground.

3. CONCLUSIONS

In our increasingly complex world, one of the potential problems of gaining “common ground” understanding between 2 individuals is ignoring the affective domain. The proposed
methodology is conceived to address the affective domain aspects of identifying and creating “common ground” between Interdisciplinary, Crossdisciplinary, and Transdisciplinary, team members as innovation or research occurs. The methodology is conceived to allow the communication process measure inherent attitudes, beliefs and values of a concept from a sender’s viewpoint and a receiver’s viewpoint, in a manner where the sender’s view of the receiver’s viewpoint of attitudes, beliefs, and values of the concept are properly identified in an affective domain context. In the situations where teams create new products or knowledge, the proposed methodology can be used to identify affective domain aspects of the attitude, belief, and value perspectives for newly generated concepts, symbols representing newly generated concepts, and the relationships between the existing concepts and newly generated concepts.

Additionally, the proposed methodology has other uses. The methodology can be used in learning, education and training situations where measurement of the affective domain is necessary. Currently, as in the past, the affective domain in learning, education, and training activities is often ignored. For an example of the propose methodologies use in the context of classroom instruction, the algorithm can be modified to reflect a teacher and a student for concepts being taught and learned:

\[
    \text{Instructor } P_0 = \left( \sum ABV \right)_x = \text{Student } P_0 = \left( \sum ABV \right)_y
\]

In this situation, a pretest consisting of a series of Likert scale questions and answers based on attitudes, beliefs, and values for the concept would be given. It is theorized the differences between the sums on each side of the algorithm will be large:

\[
    \text{Instructor}_0 = (12)_x \neq \text{Student}_0 = (0)_y
\]

At the conclusion of instruction, a post-test using the same Likert scale questions and answers is given to the student. It is theorized the sums on each side of the algorithm will become closer than the pretest:

\[
    \text{Instructor}_0 = (12)_x \sim \text{Student}_0 = (9)_y
\]

Although there are many other uses for the proposed methodology, research utilizing the methodology is needed to evolve and test its fitness for measuring the affective domain in determining metaperspective.

References


Clear logic is an essential requirement for interdisciplinary communication. However, in and of itself, clear logic is insufficient for interdisciplinary interactions. Citing Dr. J. Bronowski’s comment, Norbert Wiener points out that the success of math should be judged both aesthetically and intellectually (Wiener 95). Aesthetics is a part of any intellectual communication and interdisciplinary communication also requires a sense of beauty and emotional intelligence.

"Integrative rigor" is essential in interdisciplinary communication. This aesthetic rigor is fully depicted in Greek art according to Nietzsche. It is the melding of Dionysian and Apollonian, the intuitive and the orderly, heart and reason, and the subjective and the objective, producing the beauty of merging contradictory values and concepts. In informatics and cybernetics, a seemingly non-subjective logical work is frequently inseparable from subjective mentality. Norbert Wiener, a pioneer of cybernetics, discussed the analogy between an unsolved scientific problem with emotional tension. A mathematical problem was so closely united to this tension that separation was impossible (Heims 155). Wiener found a difficult problem, and fell into a depression, which stimulated him to devote himself to the problem. Even the most factual of all sciences has its link with emotional tension through analogy, and in this equivalency Wiener found his regained psychological homeostasis. This psychological rigor may not be easily recognizable, yet can be traced in a seemingly non-subjective logical work.

Another constellation of aesthetic rigor addresses the issue of simplicity. The outcome of interdisciplinary interaction should be searched and represented with clarity and simplicity. Often quoted passages such as Kelly Johnson’s KISS (Keep it simple, stupid), Ludwig Mies van der Rohe’s “Less is More,” and Leonardo da Vinci’s “simplicity is the ultimate sophistication” show the principle of simplicity in disciplinary and interdisciplinary studies and practices. Yet simplicity should be realized without impairing the beauty in complexity. Frequently complexity is not only acceptable but also necessary. A history of informatics and cybernetics shows the necessary beauty of complexity. Escher, fractals, knowledge-free proofs and cryptographic protocols need aesthetic consideration. During the foundational stage of cybernetics, Norbert Wiener, John von Neumann, Claude Shannon and other scholars interested in control and communication theory maintained that information is a pattern defined by the probability distribution of coding elements, not the message itself. A simple linear mindset would not have supported the proposition that information is identified with both pattern and randomness, for the opposite side of a pattern is the absence of a pattern, or randomness. A development of information theory was possible with an integrative insight that pattern and randomness merge

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1 Norbert Wiener was an American mathematician whose research in stochastic and mathematical noise processes significantly contributed to the field of electronic communication, electronic engineering, and systems control. In this sense, problems of math and success of math mentioned above are not only disciplinary but also interdisciplinary.
together in order to be reorganized for a higher level of complexity. Occam’s razor which pursues the simplest solution can be attractive to some engineers and designers. Yet, interdisciplinary communication often welcomes non-commonsense complex beauty.

Gordon Pask’s illustration of men in bowler hats also demonstrates the beauty of complexity. A number of men in bowler hats creates an observer who is observed by another observer. The observer becomes a part of the system being observed, for feedback loops through the observer. Thus, not a single piece of information crosses the border separating the system from its environment. Without falling into solipsism, Heinz von Foerster developed the conception of reflexivity, never evading the most problematic and complex constructions in science (Foerster B 5). By exploring the significance of the observer in cybernetics, Von Foerster subverted the premise of Descartesian dualism and opened the second stage of cybernetics. As Donald A. Norman stated, being complex is beautiful, and simplicity is frequently not the opposite pole of complexity (Norman 53). Systems thinking offers the overview of the whole structure under complex situations. Instead of having a snapshot of linear cause-effect chains, the interdisciplinary aesthetics prefers complex relationships.

Aesthetic rigor is hard to conceive without the concept of creativity. As Wiener points out, the value of art as information is judged by the new perspectives that cannot be found in the works of the previous era. In the past, the motivation of interacting with the world by creative works was preserved, yet now our study becomes a matter of gaining social position by getting degrees. Easily replicable precision is preferred in (inter)disciplinary education instead of finding something new and powerful. Since there is nothing new, there is nothing to communicate. The desire to find something new to say and to discover a new way of saying are the sources of all life and interest (Wiener 134). Finding a new way of saying requires emotional intelligence, and Daniel Goleman listed initiative and change catalyst as leadership competences with emotional intelligence (Goleman 255-256). Leaders in interdisciplinary studies need to excel in initiative, and to create opportunities for the future. If necessary, conventional rules can be changed, as Norbert Wiener and Von Foerster challenged the status quo of their contemporary intellectual climate and attempted to probe an unprecedented synthesis of the organic and the mechanical.

Creativity requires an insightful person who has the willingness and capacity to change an existing system and produce new ideas or products. Yet creativity cannot be reduced to merely a mental activity, or an insight that occurs in the head of a special person. As Mihaly Csikszentmihalyi posited, creativity can be regarded as a co-related system of three parts: domain, field, and person (Csikszentmihalyi 27). Domain is an area that consists of a set of rules and procedures. Wiener established a new domain, called Cybernetics, through interdisciplinary interactions, and Von Foerster demonstrated his insight that the observer of a system can be constructed as a system to be observed in the domain of Cybernetics. Additionally, a new domain requires gatekeepers who select and decide which idea or product will be included in a domain. The Macy conferences worked as a gatekeeper of interdisciplinary communication under the direction of Frank Fremont-Smith in New York in the mid-twenties. Its main aim was
to find a circular causal signaling loop in biology and society. Cybernetics has since expanded into fields covering robot engineering, systems control, computer engineering, electrical engineering, neurophysiology, psychology, business management, etc. In this sense, the nature of aesthetic value of interdisciplinary communication is relational creativity or co-creativity. In brief, creativity in interdisciplinary communication requires an insightful person. Yet creativity requires more complex systems, for interdisciplinary creativity is more than an insight arising from a genius.

Nagib Callaos and Thomas Marlowe say “Intellectual Strictness requires thinking, and acting,” pointing out that communicating is a form of acting (Callaos). It may be added that intellectual strictness requires feeling and acting. Humberto R. Maturana insists that love is an indispensable stabilizing factor in constructing a social system, proclaiming that each individual becomes “an observer through the experience of love” (Maturana xxix). From the stage of observation, communication of organization of living systems requires the emotion of love. In the recurrence of active interactions, a communicator respects the other as a partner in the dimensions of living. The Interdisciplinary interactions should be rigorously based upon love in order to establish the desirable systems in which an observer wants to live. This is what interdisciplinary communication exists for.

One significant component of emotional intelligence required for interdisciplinary communication is developing others with empathy for others (Goleman 256). Offering timely and constructive feedback is the core of cultivating people’s capabilities. Building knowledge through interaction for the growth of the Other is the ultimate beauty of interdisciplinary communication. Interdisciplinary communication requires a high standard of emotional rigor. The first passage in Adam Smith’s The Theory of Moral Sentiments describes the ethics necessary for the aesthetic rigor in interdisciplinary communication: “How selfish soever man may be supposed, there are evidently some principles in his nature, which interest him in the fortune of others, and render their happiness necessary to him, though he derives nothing from it, except the pleasure seeing it” (Smith 3). The future Interdisciplinary interactions should be rigorously based upon empathy, or the concern for the Other. The consequence of this interaction should be not only truthful but also beautiful. The pursuit of beauty without the truth is empty, yet ruthless pursuit of the truth without the beauty is blind in interdisciplinary communication.

So long as communication means not only understanding the other but also doing something for the other, interdisciplinary communication should value the affective domain field. Without sharing “cultural milieu,” “personal milieu,” and “belief milieu” (Forester A 4), neither productive interactions nor the genesis of knowledge is possible. The affective domain matters in communication, and Heinz von Forester points out that “it is the listener who interprets an utterance” (Forester A 4). The significance of understanding the affective domain context is more important in practical disciplines in which the emitter of the communication wants to influence the recipient’s behavior. Peter Drucker, the father of business management, maintains that “it is the recipient who communicate” in defining communication in business (Drucker 262). Interdisciplinary communication requires an attention to understand a recipient’s language.

2 “Emotion” and “Motivation” have the same root, to “move”, or to “act.” According to Adam Smith, ethics is in line with feeling, rather than reason. This sentimental ethics is fully developed by his friend, David Hume. Philosophy can be divided into speculative and practical, and morality belongs to the practical area. Morality influences our passions and actions, thus go beyond calm and indolent area of understanding.
Drucker also argues that “most perfect communications may be purely shared experiences without any logic whatever” (Drucker 265). Effective communication requires the shared purpose, the shared experience, and the shared values. That is why the utterer of communication needs to pay attention to what the recipient expects to see and hear, and to talk in his or her terms. Respecting affective domain field and talking in the Other’s terms require emotional intelligence and affective domain rigor.

The title of the first chapter of *Cybernetics, or Control and Communication in the Animal and the Machine* is “Newtonian and Bergsonian Time.” It is a dialogue between physics and biology, and between inanimate objects and living organisms. This highly challenging and interdisciplinary chapter starts with a German “poem” instead of any proposition or principle, which implies that any mature interdisciplinary dialogue requires aesthetic values. And this poem suggests that Wiener would like to establish cybernetics as a new discipline with beauty and creativity. Recently “distributed cognition” is widely used in interdisciplinary science papers. Surely cognition is composed of multiple agents, and crews of a ship can work as distributed machines for better navigation as Edwin Hutchins’ study demonstrated (Hutchins 251). This paper suggests that “distributed creativity,” a coined term, can be useful in denominating an aesthetic nature of interdisciplinary communication as the art of steermanship. An internally integrated process of creating a new knowledge through a series of feedbacks and cybernetic loops is underway. The focus of creative interdisciplinary communication shifts from “who has an idea” to “how to systemically generate idea.” The aesthetic point lies not in hailing a superheroic scientist inspired by Muses but in joining art performance in the stage of interdisciplinary studies with passion. And this new pattern of creating beauty and creativity should be rigorously founded upon moral sentiments as well as emotional intelligence.

Heinz von Foerster points out that “for whom do you tell it?” is not the right question in communication in Cybernetics. His alternative suggestion is “with whom are you going to dance your story, so that your partner will float with you over the decks of your ship, will smell of salt of ocean, will let the soul expand over the sky?” (Foerster B 297, italics mine). For co-creating activities with dialogics, language in the sense of grammar, syntax, or semiotics is not sufficient. It needs “dance of language” (Foerster B 295). Dancing is a language of fascination, performance, amour, and magic that cannot be explained, and its function is to extend our body. The appearance of language is monological and describing, whereas the function of language is dialogical and creating. Dialogue requires conscience, and within Other-oriented ethics knowledge is built by knowing together (con-scire). The epistemology of communication may start when communicators see themselves through the eyes of the other. Yet constructive communication is impossible without aesthetics of dancing between the communicators to expand their body and soul over the sky.

Dancing has been traditionally classified as art rather than science. Yet as the leading second-order cyberneticians including Von Foerster and Gregory Bateson adopted it as the language of disciplinary and interdisciplinary interactions, the boundaries between art and science is narrowed down and even blurred. In other words, now dance of language is not only for an artistic territory but also for a scientific one. Especially when interdisciplinary studies enter the territory of observing of observing, modeling of modeling, and communication of communication, this dance of language gets more prominent and significant. As scientific
landscapes changes from reductionist trivialism dominated by classical physics to non-trivial monism with highly complex structure led by evolutionary biology and the sciences of complexity, more concern has been given to the reflective change in the process of learning, and the learning in the context of the context as the preconditions of reflexive knowledge. Dancing may not be necessary when carrying out the specific deductive operation or simply responding by correction of errors within a set of alternatives is good enough. Yet when science requires meta-thinking or met-meta thinking in a monism with highly complex interdisciplinary structure, aesthetic perception of wholeness and language of dance are inevitable. Imagination as well as rigor is necessary to reflect on reflection and learn about learning itself, and thus to create continually changing context in cybernetic relationships in interdisciplinary studies. Science without beauty does not require “aesthetic rigor.” Science with higher cybernetic loops requires aesthetics, and in this case, rigor does not contradict with imagination. In a higher cybernetic circle, rigor goes with imagination. When Gregory Bateson argued that “rigor alone is paralytic death, but imagination alone is insanity” (Bateson 219), he gave a warning to both naive solipsism and easy reductionism.

Some rigors relevant to a poet or a mystic can be applied to a scientist in a higher cybernetic level. This may be called as “aesthetic rigor.” And this aesthetic rigor with the language of dancing can be expanded into a global scale, connecting every swirling disconnected data in informatics. C. P. Snow, a British scientist and artist, deplores the split of the humanistic outlook and scientific outlook, and the lack of dialogue between them. The gap between two gets miserably widened and is even potentially dangerous: with an increasing specialization, both scientists and humanists suffer from inquiring details of the other part. Academic world is tear apart, falling into a deeper gash with futile monologue. Aesthetic rigor concerns with theory and practice of interdisciplinary communication and works as the cure to the two culture disease. Aesthetic rigor, in this sense, is not only inter-disciplinary but also trans-disciplinary.

References

Introduction

The requirements of modern science imply interdisciplinary research that allows a comprehensive analysis of the object to be studied. At the same time, each discipline has its own approaches to research conducted over the years, a system of terms and concepts, and its own intra-disciplinary evidence based practice. The combination of different methods and approaches not always ensures the intellectual rigor of ongoing research at an inter-disciplinary level. As a rule, priority is given to one of the scholar disciplines according to which "rules and regulations" the study is conducted, or it could be noted, that there is minimization of requirements of each of the disciplines in the context if inter-disciplinary dialogue. The aim of the current paper is to find the most effective methodology for conducting inter-disciplinary research at the intersection of Arabic and Computer Sciences and to answer the question How Intellectual Rigor May be Achieved in Inter-Disciplinary Communication? On the example of our recent publications and different scholar projects, we demonstrate the problem solving with the regard to multi- and inter-disciplinary research. Despite certain contradictions of a methodological nature that arise in the process of inter-disciplinary communication, it is the use of mathematical methods that often allows us to verify the results of researches in the field of humanities, to ensure the speed of data processing and their reliability. Assessing the effectiveness of this kind of interaction, the authors analyze the relevant level of intellectual rigor.

Intellectual Rigor and Interdisciplinarity in Historical Perspectives

Interdisciplinary interaction is not a new phenomenon, but goes back deep into history. Beginning from the first decades of the hegirah the scrupulous study of the Qurʾān required an interdisciplinary approach in the analysis of the sacred text and participation of not only theologians, but also linguists, as well as historians and specialists in Islamic Studies. Besides that, it was in the beginning of the 7th century when commission from five scholars implemented methods of statistical analysis while calculating the number of characters (323 015) and words (77 439) in the Qurʾān [1]. Considering the issue of intellectual rigor in relation to ancient Arabic Studies, it seems that it was a comprehensive multi-disciplinary approach that ensured the quality of the research. For example, the author of the phonetic treatise of the beginning of the 11th century Avicenna (Ibn Sina) was a physician, which allowed him to describe in detail the characteristics of sounds and the places of their articulation. And today the exclusively linguistic field of research, i.e. phonetics, explores not only the linguistic functions, but also the work of the articulation apparatus, as well as the acoustic characteristics of sound phenomena. Therefore,
phonetics is also associated with non-linguistic disciplines, such as the anatomy and physiology of speech formation and speech perception, on the one hand, and with the acoustics of speech, on the other.

Multifaceted scholar activities of a researcher are considered to be the hallmark of the ancient times and the Middle Ages. It seems that the history is repeating itself and now we are witnessing reflection of the past but on a new stage of social development.

In this context, the following example can be given. Language is always seen as a reflection of social development. An analysis of the functioning of special terminology in the Arabic language confirms the close interaction of various fields of study in a historical perspective. Thus, the term kalām (کلام) is the key concept both of the Arab-Muslim philosophy and the Arabic linguistics. The same may be said of the concept of fiqh ﻓِﻘْﻪ, which is primarily attributed to the field of the Islamic law, but also to linguistics - fiqh alluğa ﻓِﻘْﻪُ ﺍﻟﻠﱡﻐَﺔِ – language grammar. There are many examples of this kind. On the one hand, they emphasize the fact of the interaction of individual disciplines, on the other hand, they verify that this homonymy is not just a coincides, since it helps to conduct comparative researches and to provide better understanding of the corresponding phenomena.

**Humanities and ICT**

Progress in modern science and technologies, the complexity of current scholar tasks require the usage of innovative methodologies including those based on interdisciplinary research. In the present case scholar analysis involves experts in the fields of relative or different sciences who perform multidisciplinary research that addresses various clusters of texts or artifacts analysis and their further classification.

One of the advantages of this approach is not merely an overlapping either combination of various scholar methodologies, or simply adding human efforts and skills, but amplifying benefits of each of the research attitudes involved. On the basis of objective analysis, it allows to put together all the related scattered qualitative and quantitative data, to discover interdependences and ties among different objects and, finally, as a result, to get the complete picture of the phenomenon under research. The mentioned before is fully correct in relation to today’s Arabic and Islamic studies. The inter-disciplinary approach makes it possible to address issues that previously were out of scholars’ sight or could not be solved by means of traditional methods or conventional attitudes.

Though inter-disciplinarity is on the cutting edge of modern methods of research a number of questions still remain. What are the criteria for the evaluations and conclusions, or how to keep the necessary balance among different methodologies applied? How to find common grounds for terminology and understanding of analyzed objects while tackling this critical issue?

**The Case of Arabic Studies and Computer Science Communication**

The first and very tentative steps of the use of digital methods in the analysis of the Arabic texts date back to the 50-60s of the last century, however on a regular basis, innovative methods have been applied only during the last few decades.
One of the recent projects of this kind was a research aimed at modeling and visualization of media in Arabic which is also an example of international scholar cooperation and multidisciplinary research [3]. The project was carried by linguists and mathematicians on the material of Arabic media, using a new method named the Mean Rank Dependency that allows pinpointing possible changes in social conditions reflected by the alterations in the style of the language of Arabic newspapers. Similar ideas related to the need for a combination of methods of linguistic analysis and mathematical modeling we also put forward in a number of our publications. In the run of these projects along with the problems of pure linguistic and mathematic character we had to find common grounds and terminology, and to develop our own sub-methods of research.

The importance of taking into account the so-called intellectual rigor at an inter-disciplinary level may also be exemplified by the analysis of the development of machine translation technologies. This task does not lie solely in the hands of mathematicians, but to a large extent depends on linguists, who are able to take into account all the nuances of the Arabic language formalization. Analysis of available software applications, based on morphological analysis of word forms, let us suggest that they deal with only a limited number of algorithms for Arabic grammar description. Thus, some applications cannot provide correct translation of the verbs in feminine, subjunctive mood, while the translation of the same word forms in masculine are processed correctly. If there were a software that contains algorithms, which describe at least 70% of the inflectional paradigms of Arabic, the language processing errors would be reduced to a minimum [2]. Thus, some applied researchers do not always correspond to the current state of the Arabic language linguistics.

**Conclusions**

Interdisciplinary communication involves the development of a special language of communication and research methodology that best meets the scientific rigor of each side of communication. This approach should be consistent, logical, and taking into account the entire scope of available knowledge on the topics addressed. In order to determine compliance with the level of intellectual rigor from the perspective of the various disciplines within which the study was conducted, a comprehensive expert assessment is required, provided by representatives of various fields of science.

**References**


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“Intellectual rigor” and beyond: Inter-disciplinary communication in a glocalized context (or inter-scientificity)

This paper will challenge the present concept of “intellectual rigor” in an inter-disciplinary communication and discuss how it should be expanded so that, on the one hand, scientists that move between at least two different linguistically discourses (i.e. in a glocalized context) can develop (1) uncertainty and stress tolerance for unknown scientific terms when trying to communicate their ideas in a different linguistic scientific environment; and (2) association skills, that is, skills in finding equivalences in two different linguistically discourses. On the other hand, peer reviewers, especially those who are monolingual (i.e. only English-speaking ones) and do not have any knowledge of OTHER scientific discourse(s) and socio-cultural context(s), should develop the necessary skills and understanding of what is entailed in not just an inter-disciplinary communication but rather in an inter-disciplinary communication in a glocalized scientific context.

1. Inter-disciplinary communication in a glocalized context

1.1. The inter-disciplinarity of various fields: An inter-disciplinary challenge

Geography, Social Anthropology and History, Cultural Technology and Communication, Sociology, Marine Sciences (to name a few) are interdisciplinary fields of study that combine Social and/or Natural Sciences in the study of a broad variety of social and environmental phenomena, such as urban, regional and rural development, tourism development, migration, social exclusion, globalization, geopolitical conflicts, land degradation, desertification in a historical context. Thus, scientists of these fields must be equipped with the necessary knowledge, expertise and skills to analyse and recommend feasible and sustainable solutions to contemporary spatial, social, economic and environmental problems (Kneale, 2003).

1.2. The inter-disciplinarity of various fields: An inter-disciplinary challenge for non-English scientists

It is precisely the inter-disciplinarity of fields such as: Geography, Social Anthropology and History, and other disciplines that become a multi-leveled challenge for non-English (e.g. Greek) scientists. And it is a challenge for them, because they usually have to search for and read a substantial number of references written in English (the global language) and use the

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1 For the notion of glocal and globalization, see R. Robertson (1994, 1995, 2004, 2006 and 2013) and Nikolarea (2005 and 2019). Within the present context, globalization is understood as diverse types of interrelationship and interdependency between local and global linguistic and cultural processes, which reveal the impact of the global (English as lingua franca) upon the local (e.g. Greek).
knowledge acquired to the spoken and/or written local language, which is the language of instruction.

Nevertheless, during this process of moving back and forth between the two different linguistically discourses and glocal knowledge-based environments, scientists may face difficulties in understanding specialized texts written in English due to the polysemy of a variety of terms and the lack of bilingual specialized dictionaries.

Now, considering that most of these scientists are strongly interested in presenting their own research in international conferences and having it published in international journals, whose language of communication is English, then there are two sets of questions that can be raised: (1): How can non-English scientists move with ease between glocal knowledge-based environments and communicate their research when they face the challenge not only of the lack of bilingual specialized dictionaries but also the polysemy of a variety of inter-disciplinary terms, which - because they draw upon different disciplines - are now being re-contextualized and assuming a totally different meaning in the specific inter-disciplinary field? And if it so, then (2) how can peer reviewers become aware of the aforementioned difficulties that non-English scientists may have encountered, while writing a scientific paper, and what the latter claim may read “unfamiliar” and seem not to conform with their perception of “intellectual rigor”?

2. Inter-disciplinarity: A topos of “Inter-scientificity” and a challenge for “Intellectual Rigor”

2.1. Inter-disciplinarity: A topos of “Inter-scientificity”

In this section we will try to illustrate through one example how “inter-disciplinarity” of specific disciplines in a glocalized environment becomes a topos of “inter-scientificity”, a neologism, which was coined and introduced by the writer of the present article, first, in 2004 (Nikolarea, 2004) and then was discussed more thoroughly in Nikolarea 2006 and 2019.

Within the present context, we think that the neologism “inter-scientificity” should be explained. Although the second compound of the term is ‘scientificity’, this term is not used in a positivistic way but rather to indicate the application of linguistic methods and principles either to overcome problems of ‘untranslatability’ of scientific or domain-specific terms or to solve the problem of linguistic asymmetries between a pair of different linguistically scientific fields – for example, English: Greek, English: Spanish, Arabic: Greek etc. The problems of ‘untranslatability’ or linguistic asymmetries are usually created by the polysemy of scientific discourse in a glocalised context – that is, when the global (English) meets and interacts with the local (e.g. Greek). They are also common issues in Translation Studies that should be dealt with by translation scholars and practitioners (Maginot, 2015), and solution should be found if ‘scientific’ communication between two different linguistically scientific discourses (thus, ‘inter-scientific’) can be achieved. Nevertheless, what is common practice in Translation Studies is almost totally unknown in other scientific fields at non-English universities and in peer-reviewing in international journals published in English, due to the fact that scientists and

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2 A similar claim is made by an ESP teacher of Marine Studies in Italy; see Reguzzoni 2006: 13-16.
**peer reviewers** (all **parties involved**) are not trained (as translation practitioners are) to recognize these issues.

Therefore, in an non-English teaching context and in an international peer-reviewing context, ‘inter-scientificity’ is meant scientists and peer-reviewers’ ability to move with ease between at least two linguistically different scientific contexts and comprehend inter-scientific differences not only across disciplines but also across different linguistic systems and cultures, without de-contextualising scientific discourse from its respective linguistic, socio-political and cultural context(s). Thus, ‘inter-scientificity’ can be considered a skill or a competence that all **parties involved** acquire as to how they can distinguish between various readings of a polysemous terminological entity (or **polyseme**) and can use this **polyseme** accurately in at least two linguistically different scientific discourses.

To illustrate what ‘inter-scientificity’ means in actual use and how complex and challenging is for all **parties involved**, we will offer one example of ‘inter-scientificity’ in Figure 1, which we have repeatedly encountered it in our academic environment (i.e. in translating scientific papers into English, editing papers for international publication and in teaching ESP/EAP classes for the last twenty years).

### 2.1.1. An Example of ‘inter-scientificity’

In our discussions with Social Anthropologists and students of Social Anthropology at the University of the Aegean, when we mention the term affinity, people are usually stupefied and cannot understand what we mean. These responses usually make us realize that we are too presumptuous. We assume that colleagues and students would know the four Greek equivalents of this frequently-used English term, and that they would be able to select the correct equivalent by matching their respective meanings with the specific context in which the word occurred.

Thus, our colleagues and students’ stupefaction has made us aware that this frequent word in English scientific discourse is polysemic in Greek, as shown in Figure 1.

**Figure 1: Greek polysemes of **affinity**

| Affinity: (1) Συμπάθεια, (2) Αγχιστεία, (3) Έλξη, (4) Χημική Συγγένεια |

Now, we can see that, whereas in English one **single word** or one **lexeme** (i.e. affinity) denotes both general and technical meanings, in Greek **four different words** or four different **lexemes** or **polysemes**, as shown below, are used: (1) Συμπάθεια or “liking, fondness” for general meaning; (2) Αγχιστεία is literally translated as “non-blood relationship” usually by marriage or by ties other than those of blood (it should be distinguished from consanguinity) - [a term that is used in Social or Cultural Anthropology]; (3) Έλξη The third polyseme is literally translated as “Attraction” [and it is used in Chemistry]; and (4) Χημική Συγγένεια is literally translated as “Chemical relationship” [and it is used in Chemistry and Physical Anthropology].

So, Greek scientists and, especially Anthropologists, should: (1) know that, when Affinity is used in different linguistic environments, it may have four equivalents in Greek [see Figure 1, 3

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3 ESP: English for Specific Purposes and EAP: English for Academic Purposes.
(1), (2), (3), (4)] and (2) identify which meaning this term acquires in a given scientific environment; that is, if Affinity is used in its social/cultural anthropological sense [see Figure 1, (2)] or in its physical anthropological sense [see Figure 1, (4)]. The Greek scientists’ ability to identify which meaning Affinity acquires in a scientific (con)text and transfer it to their language of instruction (i.e. Greek) appropriately is an issue of ‘inter-scientificity’.

A further difficulty is that, whereas in English affinity can also be used as an adjective in a specific linguistic and scientific environment, in Greek it cannot. Therefore, the term affinity has been proven to be a complex case characterized by multi-leveled interpretations and uses in both languages as well as by grammatical and syntactical asymmetries across languages and scientific discourses.

Furthermore, we have observed that there have been two more issues involved:

(1) The linguistic context (oral and written) may not necessarily help us understand the meaning of affinity.
(2) Despite the fact a scientist may consult a general bilingual dictionary, s/he may not select the right meaning or lexeme either because s/he may not know how to use a bilingual dictionary or because s/he may not be aware of the other lexemes (and meanings) of the term.

2.2. Inter-disciplinarity: A challenge for “Intellectual Rigor”

2.2.1. Non-English Scientists vis-à-vis ‘inter-scientificity’ and “intellectual rigor”

As we have discussed in Section 2 of the present study, non-English (and sometimes English; see footnote 6) scientists in inter-disciplinary fields encounter the issue of ‘inter-scientificity’, despite the fact that sometimes they may not be fully aware of it. It is also evident that scientists in interdisciplinary fields at non-English Universities face challenges that derive primarily from new academic requirements and market demands that force non-English scientists to communicate their own research that is done in and for a local community and is written in a local language (e.g. Greek, Spanish, Arabic) to a global scientific community in the global language (i.e. English).

Now, if “intellectual rigor is a process of thought which is consistent, does not contain self-contradiction, and takes into account the entire scope of available knowledge on the topic, leaving no room for inconsistencies,” (“Rigour” https://en.wikipedia.org/wiki/Rigour) then how can an non-English scientist who is not aware of ‘inter-scientificity and the multi-levelled linguistic asymmetries it generates take into account all the available knowledge and leave no room for inconsistencies?

If a scientist is not aware of the issue of ‘inter-scientificity’, then, by definition, s/he cannot recognize from a cognitive point of view (Nikolarea, 2019) if there are any inconsistencies derived from linguistic asymmetries in his/her own effort to communicate his/her local inter-disciplinary research to a global inter-disciplinary community in English, the global language. If

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4 At this point, we should emphasise that English Social/Cultural Anthropologists and Physical Anthropologists may also have the same difficulty as their Greek counterparts with identifying which meaning Affinity acquires in a given scientific (con)text, thus encountering the same issue of ‘inter-scientificity’. The difference lies in the fact that English affinity is just one term with four different meanings, whereas in Greek there are four different terms.
it so, then the non-English scientist runs into the risk to be misunderstood, his/her own research may be rejected on the premises of logical fallacy and, thus, no inter-disciplinary communication is achieved.

Therefore, one of the pressures that globalisation puts on non-English scientists is the demand for ‘inter-scientificity,’ a competence which can only be acquired through awareness and training. Therefore, we propose that non-English scientists, while they are undergraduate and/or graduate students, should be trained in how to carry out research into:

(1) authentic materials written in English so to develop very advanced analytical and combinatory skills;
(2) scientific bilingual terminology (Burdon 1988; Sager 1990), which demands:
   a. very advanced analytical skills; and
   b. very advanced synthetic skills;
(3) machine translation (Nagao 1989), which demands both very advanced analytical skills, comparative and contrastive skills, if the scientist is to assess and correct the machine-translated text and use it in his/her paper.

Therefore, it becomes conspicuous that non-English scientists should be trained in ‘inter-scientificity’ by translation and terminology scholars (Baker 1997; Burdon 1988; Sager 1990) and lexicographers, because only in this way they will be equipped with the necessary skills and understanding to develop:

- uncertainty and stress tolerance for unknown scientific terms; and
- association skills, that is, skills in finding equivalences in two different linguistically discourses.

2.2.2. English and non-English Peer-reviewers vis-à-vis “intellectual rigor” of a paper and inter-disciplinary communication in a globalized context

But if ‘inter-scientificity’ with its the multi-levelled linguistic asymmetries challenges the exercise of ‘intellectual rigor’ in a non-English scientist’s writing, this concept also challenges the exercise of ‘intellectual rigor’ in peer-reviewing papers written by non-English (international) scientists but from a different point of view.

‘Inter-scientificity’ challenges “intellectual rigor” in a peer-review as to how far a peer reviewer can go beyond certain “scientific conformities and conventions” and explore the “unchartered waters” of an innovative paper that is sometimes and somehow presented in an “unfamiliar” (un+family; umheimlich – anoikeio [an+oikos]) or a “strange” way; a scientific discourse that may incorporate “invisible” linguistic and cultural issues.

An English (especially a monolingual) peer reviewer is usually unaware of the issue of ‘inter-scientificity’ and the multi-levelled linguistic asymmetries it generates, which – in their turn – can also become carriers of cultural asymmetries. If it is so, then, when a peer reviewer tries to be as intellectually rigorous as s/he can, s/he can fall into not just an intellectual fallacy but

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5 It is worth noting that the English “unfamiliar”, the German “umheimlich” and the (ancient) Greek anoikeio [an+oikos] cognate from “family” and/or “home” [oikos].
rather to a cultural fallacy, because s/he is not able to detect or recognize incorporated “invisible” linguistic and cultural issues and, thus, s/he may reject prima facie (i.e. from the outset) a scientific paper or research that can be innovative and worth being published.

What we then can claim is that, a peer reviewer should: (1) become aware of the issue of ‘inter-scientificity’ and the multi-levelled linguistic and cultural asymmetries it carries; (2) be open to and flexible with a scientific discourse expressed in an “unfamiliar” or “strange” way; and (3) make constructive suggestions to the non-English writer as to how s/he can improve and make more communicable his/her own paper. Thus, the peer reviewer can help the non-English scientist achieve a global inter-disciplinary communication s/he strives for.

3. Final thoughts and suggestions

Considering the complexity of ‘inter-scientificity’ and the multi-levelled linguistic and cultural asymmetries that it may generate, we should claim that the concept of ‘intellectual rigor’ should be expanded so that, on the one hand, scientists that move between at least two different linguistically discourses (i.e. in a glocalized context) can develop (1) uncertainty and stress tolerance for unknown scientific terms when trying to communicate their ideas in a different linguistically scientific environment; and (2) association skills, that is, skills in finding equivalences in two different linguistically discourses. On the other hand, peer reviewers, especially those who are monolingual and do not have any knowledge of OTHER scientific discourse(s) and socio-cultural context(s), should develop the necessary skills and understanding of what is entailed in not just an inter-disciplinary communication but rather in an inter-disciplinary communication in a glocalized scientific context. Should the concept of ‘intellectual rigor’ be expanded in this way, it will help, on the one hand, non-English scientists communicate better their ideas in a glocalized environment, and, on the other hand, peer reviewers understand better what is communicated to them in articles written in English by international scholars whose mother tongue is not English.

Finally, we are convinced that a ‘safety pin’ in the process of peer review is the introduction of non-blind review – as done recently in the 13th International Multi-Conference on Society, Cybernetics and Informatics (IMSCI’19) which was organized by the International Institute of Informatics and Systematics – because non-blind reviewers usually come from the same linguistically and culturally scientific context and can help, even enlighten, the assessment of a paper written by a non-English scientist in English.

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Elsewhere, we are working on a more detailed article with regard to what “Intellectual Rigor” is (Callaos N., The Notion of Intellectual Rigor: A Systemic/Cybernetic Approach, 2020). Let us here, in this first section, make a brief description of it, along with some specific questions that may support the kind of analogical thinking that would help in expressing the ideas of the following sections. Let us start some questions, in order to continue, with an initial example, along with few associated questions, related specifically to this initial example and, then, finish up this section with more questions.

Is quantitative research more rigorous than qualitative research? Is it vice versa? Is the positivist paradigm more rigorous than non-positivist ones? Is it vice versa?

Do questions like these make any sense? Are we talking about the same kind of intellectual rigors? If not, why, then, we compare them as formally and informally has been done? Do different intellectual productions have different kind of rigors? If, so what are commonalities may we abstract from these different kind of rigors? To try an answer to this question is the goal of this section, which is necessary to meet before addressing the issue of the Intellectual Rigor in Information Systems Development.

Francis Okyere (2016) encapsulated the volumes that have been written on positivism and non-positivism as follows, “While positivism uses validity and reliability as tests of rigor, anti-positivistic research assumes a different stance. Anti-positivist thinkers strive for criteria pertaining to trustworthiness rather than absence of bias. They endeavour to achieve credibility (instead of internal validity), transferability (instead of external validity), dependability (instead of reliability) and conformability (instead of objectivity).” (Okyere, 2016, p. 131)

Now, let us suppose that we can produce an article with 1) internal/external validity and reliability, as well as with 2) trustworthiness, credibility, transferability, dependability, conformability, i.e. with both kinds of rigors: the positivistic and the non-positivistic one. Then, wouldn’t such an article have more rigor than those required just by the positive paradigm or by just the non-positive paradigm. As we will see below this kind of intellectual multi-rigor is associated to information systems development.

Now, let us expand the context of the next section.

Leonardo da Vinci’s motto was “Ostinato Rigore”. As it is very known Leonardo Da Vinci was “Italian painter, draftsman, sculptor, architect, and engineer whose genius, perhaps more than that of any other figure, epitomized the Renaissance humanist ideal … His notebooks reveal a
spirit of scientific inquiry and a mechanical inventiveness that were centuries ahead of their
time.” (Heydenreich, 2019). Jorge Allende interpreted Leonardo Da Vinci’s notion of "Ostinato
Rigore" as relentless rigor, which “consists in the disciplined application of reason to subjects
related to knowledge and or communication.” (Rigor – The essence of scientific work, 2004)
[Italics and emphasis added]

Since Leonardo da Vinci’s work encompassed a high diversity of intellectual faculties (Science,
Art, Humanism, Engineering, etc.), we may certainly take his conception of “Rigore” as applied
to any intellectual field. This would mean that we can conceive “intellectual rigor” as the
“disciplined application of reason to subjects related to knowledge generation and/or
communication.”

Based on Leonardo da Vinci’s integral, integrative and integrated intellectual production, Jorge
Allende adds the following:

“Rigor is  “strict adherence to the truth, it is to disrobe ourselves of our prejudices and
enthusiasm when we interpret our results, it is to search for all possible explanations of
what we observe, it is accepting a result that demonstrates the fallacy of our most
precious hypothesis … Rigor is in the essence of scientific work, in each one of the
stages of the research work … Investigations start with questions [which always are
related to a purpose] that we ask ourselves about the universe, human beings, and nature
that surrounds us … In science, communication is essential since it is the interface
between the research authors and the rest of the world … This communication has to be
rigorous in order to comply with the main purpose of publications” (Allende, 2004)
[Italics and emphasis added]

It is evident, then, that “Intellectual Rigor” (in any, or most, intellectual fields) may be defined
by objectives and restrictions¹, as, for example, strict adherence to the Truth, to semiotic systems
(disiplines), methods, etc. i.e. to ends and means. This is why a general definition of “intellectual
Rigor” should be based on the “Means-Ends Logic”. A disciplinary semiotic system is a means
for achieving a Truth, according to an epistemological value. Different kind of truths is sought,
according the purposes of the seeker and, consequently, different means may apply. Means have
usually restrictions, besides the restriction of the intellectual and physical environments,. Consequenly, “Intellectual Rigor” should be defined in terms of the:

1) purposes, objectives or goals of the intellectual, (inquirer, researcher, artist, scientist,
      engineer, academic, professional, writer, etc.),
2) the effectiveness and/or the efficiency of the means used, in
3) the context of the restrictions of:

  • the means (e.g. disiplines) and

¹ This is the meaning of “Intellectual Rigor” used in this article, It is a working hypothesis based on abstracting
what is common to all the definitions we have found, up to the present, in different intellectual activities: Science
(including experimental and social sciences), Mathematics, Philosophy, Engineering, Art, Technological Innovation,
Quantitative and Qualitative Research, etc. This is why we consider that this meaning is related the genre which
species are the ways in which different kind of rigor has been defined in different disciplines.
• the environments in which they are being applied (e.g., human, financial, managerial, technical, instrumental resources).

Now, before starting the next section of this article, let us ask some question, as analogical examples of what will follow in this article

• Which scientific discipline is more rigorous? Is this a valid question?
• Is Science more rigorous than Engineering? Is it vice versa? Are these valid questions? Do they make any sense?
• Who is more rigorous between a scientist and a Buddhist Monk? May both be equally disciplined and, hence, equally rigorous?
• How about a highly disciplined Buddhist Monk who happen to be also and excellent mathematician?
• What about a reputable physicist, while doing physics, and a great mathematician while doing mathematics? What happen of s/he applies her/his math to his work in physics or vice versa? Wouldn’t this combined work be more rigorous? Isn’t bi-rigorousness more rigorous than mono-rigorousness?
• Isn’t more rigorous to be able to meet more objectives with with a larger number of restrictions?
• How may we apply the above answer to inter-disciplinary communication?

**Rigor and Information systems development:**

An effective development of information systems requires intellectual rigor in different faculties of the intellect. It needs, at least, to meet the required rigor of 1) Computer Science, 2) System Engineering (including Software Engineering), and 3) an effective Logos of the related business and/or organization, i.e., at least, the Logos related to:

• Users of the future system, and
• The client contracting the system’s development.

In other words, it requires, at least, intellectual rigor in three dimensions:

• Episteme (know-why),
• Technē (know-how), and
• *Phronesis* (practical knowledge).

The later requires *Ethos* (trust), *Pathos* (empathy, emotion) and *Logos* (includes logic and language).

The identification of users’ and/or clients’ requirements requires also *Doxa* (opinion) and not just *Episteme* (justified belief) or knowledge, in general. Consequently, to be effective in information systems development, intellectual rigor should be followed in almost all dimensions of the intellect, or functions of the intellect (nous, using Aristotelic terms).

Each of these intellectual functions has their own *objectives and restrictions* in order to achieve the general purpose of developing an *effective* information system, especially if it is going to be
made, (Poiesis), produced with an accepted and feasible efficiency. In contemporary terms, we may say that scientific, technological, and practical rigors should be adequately combined in the context of the rigor of a Singer/Churchman’s (Churchman, 1971) pragmatic-teleological truth’s rigor.

We suggest that a general definition (or, at least, description) of “intellectual rigor” should be congruent the objective(s) of the knower/doer in the context of intellectual and environmental restrictions. We are using the term “environmental restriction” in its general meaning, as related to the different standards, methods, and rules of the different semiotic systems required for the development of information systems. Consequently, scientific rigor should be met, as well as engineering, technological, and managerial rigors should also be met. The larger number of rigors is met, the more rigorous is the corresponding thinking/doing activities, because they have more objectives to meet in the context of more restrictions (methods, standards, rules, budget, time, resources, power struggles among users, uncertainties, etc.). This is the main reason why the required effectiveness in inter-disciplinary communication is a necessary condition for an adequate trade-off between effectiveness and efficiency (efficacy) in any project of information systems development.

But, meeting effectiveness in inter-disciplinary communication is not a sufficient condition in these kind of projects, because it is also required, to be effective (hence rigorous) in Phronesis (practical knowledge), Poiesis, Ethos, Pathos, and Logos (language and logic, including means-end logic).

In general, the solution of real life problems requires more rigorous thinking/doing than scientific rigor alone, or just technological rigor. These rigors are necessary for real life problems, but an effective implementation of the respective solution requires to also comply with other kind of thinking/doing rigors.

Developing an information system is a complex process which necessarily requires a complex (systemic/cybernetic) methodology, i.e. set or related, or relatable, methods along with their respective research methods and techniques, that may be adaptable to different computing technologies, business models, human environment, organizational cultures, unexpected contingencies, uncertainties and all what characterizes the real world.

To bridge the abstract with the concrete requires adaptation to the diversity that characterizes concreteness as well as to its changing environment. Consequently, The mono-rigor of a specific discipline, be it in science or in technology, may have the required adaptability and flexibility, to adapt the diversity and the dynamics of concreteness. Rigor is, by definition, rigid. Consequently, we need an interrelated set of actual and potential rigidnesses in order to get the required adaptability and flexibility. This does not mean less rigor, but more rigors in order to relate different intellectual rigors in order to achieve an objective while restricted to the changing constraints of what is concrete. Hence, we are referring here to the notion of meta-rigor which is what we get with a systemic/cybernetic methodology of thinking and/or doing. Even Science alone requires an intellectual multi-rigorous approach, because the required pluralism of Science as a Whole. Shouldn’t Peer Reviewing methodologies be aware with regards this issue? Shouldn’t they be supported by multi-disciplinary perspectives? Shouldn’t that be multi-rigorous
and not mono-rigorous? Shouldn’t they be based on meta-rigorous, i.e. the rigor of relating different rigors? Should they be conceived in the context of a Means/Ends Logic, i.e in a Pragmatic-Teleological Truths as, for example, Singer/Churcham’s (Churchman, 1971).

We may, potentially, make the following conclusions of this section:

1. Inter-disciplinary communication, to be effective, should be more not less rigorous, because it should fulfill the objectives and restrictions (standards, methods and rules, truth definitions or notions) of different disciplines.

2. Thinking/doing methodologies, for developing information systems, requires interdisciplinary communication, as necessary but not sufficient condition. Hence, they require even more rigor, in order to meet the other objectives and restricted to more conditions, especially those related to financial, human, technical, and instrumental restrictions, as well as the emergent system requirements (objectives) and restrictions; which characterize dynamic environments, as usually are the human, managerial and physical environments of organizations.

3. Hence, to the different rigors of the different disciplines, more rigor should be me in the implementation of any information system. Consequently, an effective development and implementation of information systems require to rigorously relate different kinds of rigors on thinking and in doing. To rigorously relate different kind of rigor might be named meta-rigors. A systemic network of different rigorous processes of thinking and doing is meta-rigorous, as long as it is effective, i.e. meeting the objectives sought in the context of both kinds of restrictions: those of thinking and those of doing.

3. We may suggest that, in general, real-life problem-solving requires more rigor than the required on the different disciplines involved. It may even require meta-rigor if the solution needs also to be implemented. This would require human beings, who may not have a disciplinary background and, hence, non-disciplinary communication might be required. Furthermore, it is probable that the solution would affect or impact human beings, and/or have human beings as its users. Consequently, Ethos, Pathos and logos should also be objectives with its respective means and (to be met) restrictions

4. An example of this kind of solution are methodologies for implementing artificial intelligence interacting with human intelligence. Artificial Intelligence is a very comprehensive inter-disciplinary field that requires and generates inter-disciplinary communication. So, it requires multi-disciplinary approaches, which, by definition, are multi-rigorous and, hence, to rigorously relate them (in the context of means-end logic and real life restrictions). This would require meta-rigorosity, especially if it is going to be implemented in an environment where human beings are among its components. So, it is to be suggested that it would require not just more rigor, but also rigor at a second level, i.e. rigor in relating, not just, different scientific disciplinary rigor, but also the required rigors in Techne, Phronesis and Poesis, beside the Epistemic rigor of each of the involved scientific disciplines. Consequently, Artificial Intelligence should meet the requirements of different scientific and technological rigors but it also should meet the
rigor of other intellectual endeavors if it is going to be implements and effectively embedded in human being contexts.

The Software Crisis

Another example could be found in the area of software engineering; which, actually, involves more disciplines than what it is perceived. This kind mis-perception is, in our opinion, one of the reasons and main cause of the so called Software Crisis, where no significant improvement has been achieved in the thinking/designing/implementing software systems, since the term “software crisis” was coined in the first NATO Software Engineering Conference in 1968. The observed lack of efficiency and effectiveness in software development has been shown by the Standish Group in the last 18 years. The Standish Group’s studies included more than 70,000 projects in information technologies. Figure 1 resumes the most general results during the period of 1994-2015.

![Software Crisis Graph](image)

Figure 1: The statistics of the Standish Group in the last 18 years. It is evident that there has been no improvement since the phrase “Software Crisis” was coined since 1968.


Elsewhere, (Callaos & Callaos, 2014), we noticed that

a. There has been no significant change since 1996 for the projects that succeeded (i.e., delivered on time, on budget, and with the required features and functionality); which percentage had been about 30% for about for about 20 years. The average is 29.333% since 1994 and in 2015 is 29%. This is really astonishing.
b. There has been no significant change since 2000 regarding failed projects (i.e., projects that were cancelled prior to completion or delivered and never use); which percentage had been about 20% for about 16 years. The average in the time period 1994-2015 is 22.8% and in 2015 is also 19%. This also astonishing.

c. A similar situation can be observed by noticing the percentage of challenged projects (i.e., that were late, over budget, and/or with less than the required features and functionality). The differences between years had been larger but the general situation still about the same that for the successful and the failed projects, The average in the time period 1994-2015 is 47.93% while in 2015 is 52%. Notice that in 1994 the percentage of challenged projects was 53% and 21 years later is 52%.

Isn’t perplexing that we are in the same situation we were 21 years ago in spite of all the research, the experience, and the technological innovations in the field that emerged in the field during this time? Should we continue solving the problem in the same way we have been trying to do it for at least 21 years? Is the problem a technological one? Couldn’t it be a human one? Can’t we guess that the source of the problem is a human communication as well as a cognitive, notional and conceptual one? Shouldn’t rigor be redefined here focusing on the objectives and restrictions and not just on the means?

A research made by IBM\(^3\) identified five areas influencing project success or failure

- Project management (54%): Activities defining and controlling the IT project
- Business (21%): Aspects of the project dealing with project funding, internal rate of return and business data
- People (14%): The team that carries out the IT project
- Method (8%): The dimension involving approach, procedures and tools (notice the confusion of methods with other notions, which are related but not the same as the notion of method)
- Technical (3%): Aspects of the project regarding hardware and software, testing and interfaces between components

What is very clear in the IBM study is that the Human Dimension of the problem is more important than the scientific or technical dimensions. Consequently, any solution should address the human subsystem in both: a) the developing phase as well as in b) the maintenance and operational phase. This would require to take into account the Human Intellect as a whole and not just its functions in Episteme (know-why) and Techne (know-how). Other intellectual dimensions (or functions should be addressed as well), i.e. Phronesis (practical knowledge). The latter (as we mentioned above) requires “Ethos (trust), Pathos (emotion) and Logos (including logic and language). Identifying requirements of the users and/or the clients require also Doxa (opinion) management.”

Consequently, it is evident that the solution of this very important problem cannot be reduced to the fields of Computer Science and Systems/Software Engineering. As we showed in several

\(^3\) (Seven Reasons IT Projects Fail - Avoiding these pitfalls will help ensure success, 2012) and (Five Areas Influencing Project Success or Failure, 2012)
articles and more than 100 empirical tests, via of professional and academic projects and 30 years of direct experience and complying with legal contracts, with the respective budgets and estimated times, other disciplines should get involved and, consequently, 1) the inter-disciplinary communication requires more diversified and complex processes and 2) other intellectual rigor should be met, including Phronesis, Ethos, Pathos, and Logos. The Logos require several semiotic systems, an adequate translations among them and, consequently, different kind of intellectual rigor; which should be related systemically in the context of a larger Logos based on the Means/End Logic and Singer/Churchman pragmatic-teleological truth and epistemology. More details regarding this issue can be found in the already mentioned publication (Callaos & Callaos, 2014), as well as at previous publications of other aspects or perspectives on this important issue.4

References


