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Time to Raise Non-Trivial Sociological and Technological Collaborations in Research: Scientists' Views on Interdisciplinarity Approaches

Abstract

The complexity of contemporary social problems requires innovative responses that combine knowledge from various scientific fields. This objective is achieved by conducting interdisciplinary research, promoting the meeting of researchers from different scientific fields at the borders or even across borders of their branches of knowledge to form new ones. In addition to constituting new areas, new interdisciplinary research practices are proliferated to shape new questions. These are complex issues that spill over into the laboratory as they entail a large number of variables, problems that no field of research is prepared to resolve. Health, mobility, climate change, or the pandemic crisis are examples of epistemological innovation that only interdisciplinary approaches can attempt to address.The paper's empirical section is based on the analysis of information provided by a survey made in Portugal, involving scientists from various fields of work, hihligthing the conditions in which interdisciplinarity is possible, and the insitutional and policy changes needed to tackle with complex societal problems.The results point out a widespread common understanding of the need and relevance to foster interdisciplinarity among all areas, giving account of specifi measures that may anhance interdisciplinary work at the research settings.

1.Introduction

The term "interdisciplinarity" has been recurrently highlighted in documents issued by the European Commission on the framework of research policies and scientific innovation. National and international organizations in charge of defining research financing policies and programs have been almost ubiquitous in their support for it. The use of this term serves to raise funds and make explicit that research efforts in line with current trends are a necessary condition for approval, even though it may not bear any effect (Toomey et al., 2015). Thus, interdisciplinarity has often become more than a desirable approach — if it makes sense in a specific field of research. It has been vested with an almost mandatory process, which has brought out mixed consequences, including its underestimation. The concept is gradually losing its meaning in its aim to meet a dominant rhetoric, instead understanding a complex reality, that is, to unravel which conditions foster knowledge and a critical approach.

However, the increasing use of interdisciplinarity to answer the funding entities' call and ascribe a trending aspect to research makes the concept lose its depth and credibility — repetitive research agendas that do not bring to the table the merits of interdisciplinary research. The social sciences are often called upon to participate in research projects lead by fields related to engineering and hard sciences, responding to the guidelines to present proposals that insist on promoting the participation of social sciences and humanities, such as sociology, economics and history. Often, this prerogative is understood as a possible starting point for developing an interdisciplinary team. In practical terms,

however, this mode of promoting interdisciplinarity lacks the knowledge about how epistemic cultures work and to what extent scientists are willing to collaborate in research or the extent to which research institutions and policymakers engage to make interdisciplinarity work. As we see it, the prevailing rationale of knowledge hierarchy contradicts the framework of parity, which is necessary for its effective practice. Only in this way can the needed conditions be created for the synergistic integration of knowledge that defines interdisciplinarity. If the rationales provided by several studies are considered, it becomes evident that societal problems are complex, demanding integrated approaches that consider the centrality of people and socio-cultural elements to define methods and practices of intervention.

Current and relevant issues related to sustainability and disaster mitigation also encompass population, economic, and political dynamics, affected by many intriguing challenges for future consideration.Thus, interdisciplinarity is of great relevance and calls for a reformulation. By extending the concept of interdisciplinarity, this paper seeks to discuss the proposed idea of a non-trivial issue to problematize interdisciplinary and multidisciplinary collaborations in a social context, mainly from the social studies of science, as well as the experience of interdisciplinary research projects, which have addressed technological changes and innovations. From the literature review and a survey conducted in Portugal in February 2021, this paper will focus on how experts in technology and the social sciences establish such non-trivial problems, the demands for a successful collaboration, and the challenges they impose on scientists, institutions and policies.

2.Theoretical Framework

The dispute over interdisciplinarity began with the growing specialization of science in various branches and subject areas throughout the 19th century (Pombo, 2005). Although the search to strengthen knowledge has led to the development of methods and languages in various scientific domains, it has also caused tension in the collaboration between different subject areas (Klein, 1990). Since de 1970-s onwords, the concept of interdisciplinarity has entered the language of various disciplines, from the natural sciences and engineering to medicine and the social sciences. Other than the researchers' affiliated area, however, the concept does not often call for theories, methods, and practices shared by scientific research fields. Interdisciplinarity is not a novelty — academic areas are flexible and often combined to seek better answers to emerging issues. What is new is how, more recently, interdisciplinarity has played its role in the scientific community, through the collaboration of traditionally distant fields of knowledge, such as the natural and the social sciences. This is called "big interdisciplinarity," in contrast with "small interdisciplinarity," which requires cooperation among close fields of knowledge (Bridle at al. 2013). Increasingly, interdisciplinarity enlists, not only academics but also policymakers and other non-academic partners, who can be integrated in various ways. For example, stakeholders are invited to take part in defining research questions and elaborate scientific models, as well as play an active role in data collection.

The proposal for a new scientific culture highlights the need for interdisciplinarities such as the example of knowledge production 2 (Gibbons et al., 1994) or post-normal science, arguing, in this regard, through a variety of authors who stand by interdisciplinary science as a favorable impact on the

production of knowledge (Gibbons et al.1994; Schmickl and Kieser, 2008). More preemptive proposals discussed the risk that a strong emphasis on interdisciplinarity could undermine scientific disciplinary expertise and research requirement. Although these discussions on interdisciplinarity have been ongoing for several years (Klein1990, 2008), it is still open for debate. From an epistemological perspective, it is crucial not only to understand the final result but also to follow interdisciplinary practices. Thus, it is essential to realize the following: First, the nucleus of interdisciplinarity, that is, what is being combined. Second, the kind of interdisciplinary interlace, that is, how it is performed. Third, the type of aims, that is, why interdisciplinarity occurs (Huutoniemi et al., 2010) as well as the tensions and conflicts that have emerged between scientific fields along the process itself.

Mäki and MacLeod (2016) postulate that interdisciplinarity needs to be studied *in action*, that is, to investigate interdisciplinary processes while they are occurring, through empirical techniques and case-studies. Interdisciplinary interactions and influences require complex commitments, negotiations and decision-making, possible misunderstandings, communication failures, and disputes. Conceptual and methodological challenges require time as it is an ongoing process that involves the participation of several scientific fields, themes, researchers, and institutions, requiring wide dissemination of case-studies addressed at different scales.

McCarty (2016), in turn, suggests a concept of interdisciplinarity based on a shared approach to a non-trivial problem on which experts from different disciplines can work productively together. He exemplifies this idea with case-studies on the various subjects of the humanities, among other non-technical scientific areas. Danemark (2019) argues that one of the essential aspects of interdisciplinarity is to reach the combination of knowledge, underlining the importance of an "open and tolerant mind." There are paradigmatic examples such as "true openness to the approach, perspectives, and attitudes of scientists from other disciplines" (Rowe, 2008) and, contrarily, "different balance patterns and manage tensions between conflicting approaches" (Klein 2008). Danemark (2019) recalls several interdisciplinary research efforts in which collaboration is reported to fail repeatedly due to divergent scientific views. The failure mostly occurs when scientists come from manifestly different research fields and adds a reference to a particularly relevant research by Albert et al. (2008) describing the difficulties that emerge when "positivist biomedical scientists" cooperate with "non-positivist social scientists." It is also common to find reports from scientists involved in interdisciplinary investigations regarding complex disciplinary hierarchies. The methods they use are frequently questioned because, according to the so-called radical scientists of the natural sciences and engineering, they are subjective and therefore, do not meet the objectivity criteria. However, often, those who have "negative perceptions" about the social sciences are researchers that are not used to collaborating with social scientists, unlike those who have already take parte of these teams and show greater interdisciplinary familiarity, more tolerance, and understanding in other fields of inquiry. There are ontological reasons for using a variey of methods in different ways, which are called "methodological specificity and pluralism" (Danermark et al., 2019).

The result of the interdisciplinary research process is theoretical pluralism. The point is not to become an expert in another area of knowledge but to have some fundamental insights into other theories as collaborative work requires. Variable time is critical and is often overlooked in interdisciplinary research, even by the research team. It is essential to clarify that the non-trivial problems, according to

McCarty (2016), are by definition complex problems and facing them requires collaboration between experts in natural and social sciences. It is precisely the non-trivial issue that must be analysed in this way. Danermark (2019) says that even investigations with an unique focus must also strive beyond their disciplinary boundaries to reach more encompassing results.

In view of these ideas, this paper hypothesizes that the way scientists think and value interdisciplinarity deeply affects their practice and the way they can or support decision-making. It is also assumed that better planning and specific modes of analyzing societal problems shall integrate research programs as well as study plans in a wide range of study fields that, in turn, might demand better apprenticeship knowledge and training concerning the ways interdisciplinarity can be implemented and used.

2.Findings: scientists' voices and views on interdisciplinarity

In this paper, the authors mobilize different sources of information, mostly qualitative. Apart from the literature review, and documental analysis of research programs in the EU, the paper also considers the experience of the authors in multidisciplinary projects. The authors use the information provided by a short questionnaire made for researchers with experience in working in multidisciplinary projects in Portugal. The researchers were contacted in person and selected based on their expertise and proximity with interdisciplinary work involving social sciences between February 2 and February 10, 2021. The questionnaire was sent through Google Forms and consisted of three main questions: First, the advantages of interdisciplinarity in projects that involve research and innovation, engineering, science, and technology. Second, the three most relevant constraints to interdisciplinary projects. Third, challenges to interdisciplinarity in the near future. Although this study is exploratory, it answers some of the crucial questions in fostering interdisciplinarity in research and allows debate on its place in research and higher education institutions. Data were analyzed according to the thematic content analysis method and presented according to the reviewed dimensions.

Table 1. Respondents by scientific field of work

Field of work	N	%
Engineering	31	39,2
Sciences (STEM)	16	20,3
SSH	32	40,5
Total	79	100,0

Survey to portuguese scientists (2021)

3.Strengths of interdisciplinarity: building up different visions of future

Most of the respondents from different areas agree that interdisciplinary projects represent multiple advantages for tackling the complexity of societal problems (Table 2.). About 85% of the respondents assert that collaboration between scientific areas offers conditions to create "common languages," achieving a "systemic approach," which they consider is fundamental "to assure environmental, social and economic sustainability; harmonize languages, with a positive impact on society, increasing the possibility of innovation, with social impact." Herein, respondents argue that interdisciplinary projects allow scientists to develop "more robust solutions" that integrate several angles and dimensions of analysis, facilitating deeper analysis of the same problems. Besides these advantages concerning the construction of the problems to be dealt with, interdisciplinary projects are also seen as being beneficial from the methodological viewpoint.

Table 2. Type of strengths facilitated by interdisciplinarity

Type of advantages	**N**	**%**
Approaching complex problems	67	84,8
Fostering knowledge	4	5,1
Elaborating new problems	2	2,5
Improving research quality	6	7,6
Total	79	100,0

Survey to portuguese scientists (2021)

The combination of different scientific fields opens new avenues to explore the same problem by making use of different methods, augmenting the chances for developing “disruptive and innovative” methodological strategies. From the side of respondents of social sciences and humanities, interdisciplinarity means, in particular, the possibility of showing the "social and ethical dimensions of scientific practice, the comprehension of the social determinants of technology" and making it effective in concrete projects. One of the respondents says, for instance, that Philosophy has different important contributions to give to other scientific fields, including engineering, as it provides theoretical and methodological knowledge that makes evident the "secondary and collateral perverse effects that scientific and technological innovation can represent." Core concepts such as responsibility and innovation are considered to be of surmounting relevance for science and technology fields. This idea replicates in the majority of the answers provided by researchers from the social sciences and humanities that consider interdisciplinarity as a way to face complexity, augmenting the awareness about social implications and environmental consequences of certain types of decisions. Respondents often refer to the interest of interdisciplinarity in generating different visions of the future for science to deal with. This data is in line with the reflections made about the contributions of the social sciences and humanities, in general, and the social studies of science, in particular.

4 Constraints to make interdisciplinarity effective: issues of policy and style

Most respondents argue that key barriers to interdisciplinarity are linked with the lack of dialogue and communication between the scientists, as well as a lack of will, time and availability to work together in different projects and areas, and the absence of an integrative science policy that can start a dialogue between different scientific fields, collaborate in diagnosing problems and set out intervention measures. Table 3 includes the main constraints pointed out by the respondents.

Table 3. Constraints to make interdisciplinarity effective

Type of Barriers	N	%
Lack of dialogue between scientific fields	21	26,6
Lack of leadership	1	1,3
Lack of collaborative culture	19	24,1
Competition between scientific fields	5	6,3
Science evaluation policy	20	25,3
Another	8	10,1
Lack of academe competence	3	3,8
No answer	2	2,5
Total	79	100,0

Survey to portuguese scientists (2021)

They argue that researchers are not well prepared to make connections out of the scientific field and develop communication. Moreover, respondents mention the feebleness of a culture that valorizes the mixture of different viewpoints of the same problem. In their opinion, researchers are inserted in competitive cultures that tend to ascribe important value to specialization and individual projects. Thereby, "the majority of scientists do not have time to "talk" with colleagues from other scientific fields because they are at risk of losing the race with their peers". A researcher declares that science is still a stratified and divided world, marked by mistrust of scientists concerning each scientific field as well as the exclusive and rigid ways to perceive objectivity and certainty in science.

The respondents identify the absence of central interdisciplinary politics at the national level as a major structural consequence of the present-day evaluation framework. They assert that the evaluation is strongly sustained by disciplinary presuppositions preventing and dissuading researchers and institutions from collaborating. One researcher notes that the absence of political engagement at the

national and institutional levels leads to several difficulties in building an interdisciplinary culture. A core issue pointed out by researchers is the way research units are evaluated by panels that are not interdisciplinary; thus, such panels have enormous difficulties in evaluating interdisciplinary research outcomes.

Acceleration in science and the need to present results quickly is also mentioned as a motive for researchers giving up interdisciplinary collaborations. One researcher states that the “difficulty to frame projects in a specific discipline blocks the access to funds and publication." They also argue that the ways and means for funding, which consider interdisciplinarity, “are not recognized and there is a lack of work opportunities for those working in more interdisciplinary areas." The respondents also consider that interdisciplinary work is a result of a long process of learning and training that should emphasize the way study plans are elaborated, so they can integrate more diverse disciplines that contribute specifically. Reinforcing this idea about the weakness of interdisciplinary study plans, one of the respondents says that:

There are only a few researchers who are prepared to do interdisciplinary work because the education is strongly specialized and I am afraid that it will get even more pronounced. If an undergraduate has only been educated in mathematics, they will have difficulties in establishing a dialogue with other areas.

In sum, respondents identify two main sources of impediments to interdisciplinarity: on the one hand, the lack of willingness for collaborating with other scientific fields and the lack of skills, such as communication abilities, to do so. On the other hand, the absence of a robust science policy that actually can foster overall interdisciplinarity, both at the national level and within higher education institutions and research centers, involving both evaluation methodologies and academic cultures. The hegemony of certain areas, hierarchization of scientific fields, difficulty in understanding the other viewpoints, and inability to learn from the others are great sources of institutional inertia in the case of interdisciplinary symmetrical collaboration.

5 Challenges to reach interdisciplinarity in practice

The survey participants indicate that there is a need to promote more mechanisms for facilitating the analysis of the so-called "societal challenges" and lead scientists to analyze in-depth the possibilities of change to the extent innovation is fitting in with the prosecution of the common good. There is a general idea that science policy lacks globally effective participation from the researchers and is strongly determined by political and ideological objectives that miss the promotion and compensation of interdisciplinarity. Researchers pretend to be critical about the way “politicians establish certain goals according to certain "buzzwords," such as sustainability, social inclusion, decarbonization, or climate emergency without a strong scientific base, which has the perverse effect of conditioning the researchers to merely adapt their research projects to have funding”. In this process, interdisciplinarity is no more but a result of the researcher’s voluntarism.

Table 4. Challenges to make interdisciplinarity effective

Challenges	N	%
Methods, languages, and openness of mind for the construction of interdisciplinary knowledge	25	31,6
Knowledge building incorporating academics and non-academics	6	7,6
Time available for knowledge building	3	3,8
Robust criteria and indicators to build science at the service of society (inclusive and sustainable).	11	14
Equity and development of interaction between disciplines	10	12,7
Systemic thinking and critical social analysis	13	16,4
Others	10	12,7
No answer	1	1,2
Total	79	100

Respondents opine that science policy would gain if it could integrate diversity in different ways because one of the main barriers is a strongly conservative culture that restraints disciplines within themselves and prevents people from understanding the symmetry of different scientific fields from the viewpoint of their scientific value. Respondents mention several societal problems that should be tackled from an interdisciplinary perspective. One of them refers to the climate emergency, which they consider needs further debate, to become a concept that can be shared and serves the purpose of proposing effective measures. Respondents agree that interdisciplinarity cannot be regarded as a means to resolve the possible lack of understanding derived from the different scientific fields' participation. On the other hand, respondents assume that "interdisciplinarity is as much of a scientific value as any other so-called traditional area" because "the point is that there are complex problems (like the one mentioned above) that need multiple approaches." The complexities of current problems require interdisciplinary approaches for knowledge production based on a systemic perspective, grounded on social, ethical and environmental principles and is contrary to the fragmentation of scientific knowledge. Some advocate the need for a critical look; a scientist respondent argued that "although confronted with a landscape of growing social inequality at various scales, which means recovering social class as a category now neglected". The comments also stress the need to imbue all projects with a dimension to address the climate crisis.

The respondents' words highlight the fact that the construction of interdisciplinary knowledge goes beyond the aggregation of several disciplines that answer specific questions in a given scientific field (specialization). On the contrary, interdisciplinarity requires that "shared values and the capacity to respond to common goals prevail," necessitating a real openness to other scientific approaches. Moreover, it allows us to create sustainable solutions to major challenges not previously imagined. Interdisciplinarity is not an end in itself, nor does it solve the stereotypical conflicts, hierarchies, and views of scientific areas. Still, if developed consistently, it allows "to cross the borders of very different areas such as the natural sciences and the social sciences as well as implies accepting and feeling motivated to abandon the search for perfection made by deepening a specific theme. It implies accepting certain insecurity of not, at times, mastering the themes as deeply as we would like because it is in the crossing that advances occur." It is, therefore, fundamental to identify the links and overlapping points between disciplines and show that these connections may have coherence for the scientific problematization of complex phenomena. The variable time is explicitly expressed by 3 respondents, stating that in-depth interdisciplinary research requires time; it is a slow but rewarding process of knowledge development. It is worth adding that time is implicitly incorporated into many other responses when questioning the interdisciplinary development process. It is precisely a process, necessitating time and availability for its development.

One of the main challenges respondents point out is assuming that science and technology are not neutral. The scientists and people enrolled in innovation must anticipate and conceptualize design innovation and technology as social and political products. One area's criteria may not be the same for another area because: 1) the sustainability component and the social component are sometimes "overlooked" in technical projects, and 2) there is a need for more robust indicators to assess sustainability and the social issue in projects. A further expressed idea is that non-academic experts are actors who should participate in producing knowledge (public participation) when the innovation in question concerns them. This connection between society and citizens is an idea that permeates the discourse of the respondents, and it has even advanced the need for "translators" to bridge the different disciplines. It is argued that there is a need to review the "mindsets" linked to the conception of infinite progress and use of resources, clearly identifying the common goals that should go through ethical, social and environmental concerns.

The respondents' viewpoints include themes for which there is a convergence of crossing methodologies, visions, languages (ontologies) through the logic of knowledge fertilization. Such themes require abandoning the scientific jargon as opposed to having an open mind that is listed as equally crucial to construct interdisciplinary knowledge. It is a discourse that crosses the addressed scientific areas, hinting at openness from the natural and engineering sciences to the social scientists. The experience of complex problems underlines the fact that science is developed by the people for the people, which implies prevailing criteria that have social and environmental values. The respondents call for a balanced relationship among scientific areas, promoting a trusting share of knowledge so that different sciences can have their methodologies, research patterns and theoretical frameworks, and refusing a hierarchization of disciplines where the social sciences are usually the ones that trail behind. Scientists embed values, visions and experiences that condition the development of

knowledge, and this knowledge arising from social sciences is essential to shape science and technology.

6.Ways to move forward and improve interdisciplinarity

Respondents are very critical about how interdisciplinarity is developed in research contexts, inside research units, or in higher education institutions. Overall, researchers agree to the need to foster cooperation and communication among scientists from different fields. They advance several concrete measures, such as workshops and seminars that allow people to think and work together, imagining solutions for several societal problems. They say there is a need to build a culture of dialogue that is interdisciplinary because in "concrete projects it is essential to create, from the beginning, a culture of proactive meetings between all areas. It is important that, in a project, all areas see the project as a whole and not as a single sum of areas." There are researchers who say that there is a need to "promote doctoral thesis guidance teams to involve professors/researchers from different departments/research centers, with the possibility of originating themes for interdisciplinary projects to continue the work developed within the scope of theses." The theme should be the guiding element of the projects, research and team training; it should always be seen as an object with several facets. As advanced by scientists from very different fields, it is urgent to recognize an "interdisciplinary" area in tenders for R&D projects and academic scientific fields of research. In other words, not only the practice of genuine interdisciplinarity but also the creation of a specific area to accommodate interdisciplinary projects are proposed.

It is crucial to fight for the valorization of interdisciplinarity at the level of institutions and assessment panels. Respondents put forward concrete proposals that refer to:

i) promoting meetings between researchers,
ii) building spaces to share and discuss different works between teachers and researchers and debates among researchers, associated with "different cultures," and
iii) rewarding projects that include more than two fields, as a stimulus for sharing culture and knowledge.

Several researchers propose the integration of social scientists in natural sciences and technology-based projects, as well as the studies in science, technology and society — an area truly interdisciplinary — and activists who are non-academic experts to do the research, connecting both the disciplines as well as academia and civil society. We should not wait for the goodwill or despair of some scientists; the capacity for dialogue should be encouraged through academic training, at the level of the various degree levels. In short, "curiosity is not just a gift, it can also be stimulated."

One of the recurring themes in the respondents' proposals is the need to invest in advanced interdisciplinary training, thus, creating a group of researchers who know how to hold a dialogue with stakeholders from multiple areas and who can serve as a bridge between different members of interdisciplinary teams. It would be very productive, given the complexity of the problems we face today, to realize more intersections between social sciences and natural or engineering sciences. Furthermore,

the valorization of more transversal themes that promote interdisciplinarity argued by a large number of respondents and reflection groups on relevant societal problems may result in genuinely interdisciplinary themes and research proposals in the funding entities and schools (particularly within the scope of the doctoral programs). There is an urgent need to raise awareness of political decision-makers and evaluators of scientific panels. The process directly linked with the dynamics of interdisciplinarity is well-expressed in the idea of "learning by doing," maintaining an open position regarding contributions or ideas that do not seem immediately related or useful, while ensuring scientific demand and quality as well as respecting issues such as ethics, which are even more complex in interdisciplinary projects. The proposal of "introducing mandatory disciplines in at least one non-nuclear area of knowledge in doctoral programs" is advanced. Several scientists propose room for interdisciplinarity at the level of doctoral programs, or even at the level of graduate courses.

Doctoral theses are often mentioned as privileged knowledge-building spaces that accommodate scientific domains in dialogue. The need to fight for the recognition of the interdisciplinary scientific domain within research institutions is also emphasized. Orienting funding programs towards major societal challenges that can only be overcome in an interdisciplinary way is also largely agreed upon along with "valuing interdisciplinary and community-oriented work in career progression (nowadays, this dimension is almost irrelevant in tenders due to no incentive for interdisciplinary work), which also involves changing the practices of hiring career teachers." The valorization of interdisciplinary careers is still an open discussion, considering that career promotion calls are often based on a specialization matrix that can penalize or demobilize researchers who seek to investigate the interdisciplinary boundary in-depth. As demonstrated in the last decade, the inclusion of science and technology studies in interdisciplinary projects offers not only an irreplaceable critical perspective but also tools for the articulation between the engineering and science disciplines that take part in the projects. Another crucial point is to change the criteria for evaluating applications for FCT-MCTES funding projects as well as the hiring practices of career professionals.

7.Discussion

Social studies of science and technology, in particular, elucidate what and how science can change with regards to interdisciplinarity (Jasanoff, 1995). Overall, these studies stress the relevance of important requites that STEM areas, in general, should be aware of when preparing innovative projects to alter or transform social realities and supporting decision-making that actually can contribute to collective wellbeing in several domains. Examples include topics concerning the preparedness and resilience to catastrophes and implications of climate change, risk proliferation and insecurity. At its core, the investigation states that education in engineering and technologies should adapt the study plans, integrating matters dealing, in particular, with concepts such as culture, values, ethics, and collective goals. The aim is to avoid any unnecessary innovation that brings about undesirable implications, such as augmentation of social discrimination, stigmatization, social and gender inequalities. This is even more important in the case of engineering and technologies as these are at the forefront of the current digital revolution, dealing with disruptive issues such as artificial intelligence, big data, human-machine interaction and overall technologization of life. Social scientists have made their

points concerning the type of visions scientists are creating about the future and what responsibility they have in promoting such images and their implications on citizens and life, in general.

In accordance, interdisciplinary projects and study plans would question the purposes of orienting research and innovation towards social and communal wellbeing and needs. Most technically-oriented projects show difficulty in understanding the role and the relevance that citizens need to have while diagnosing and co-producing knowledge and innovation. Social studies of science have proposed many ways to deal with the trends towards underestimating citizen's needs, but the main one refers to participation. Multidisciplinary projects and teams dealing with the production of innovative solutions need to integrate participatory methods that purposely count the general public's and organizations' views on the ongoing process. A major issue in the social studies of science refers precisely to the social, emotional and political implications of innovations and how they would be resolved after being put in market circulation. Innovation should always mean something to people, tackling social needs to be directly useful and contribute to overall wellbeing. Therefore, one of the core aspects of promoting interdisciplinarity, particularly with the social sciences, is through enacting participative methods that provide means of listening to people and register their own opinion on the innovation, which can be applied just before any project begins, giving precious information for other scientif fields of work. Achieving such a goal often seems too easy as the concept of social engagement and social participation may be understood as a simple routinized manner of giving people information and obtaining the same from their evaluation and suggestions. In practice, however, it is a very complex path that demands a delicate process of selection and contact with people, as well as the designing and planning of several modes of actually listening to people and considering their opinion to diagnose and evaluate the data (obtained from several modes) and prioritize the actions to develop further research, or take concrete actions for intervention and develop innovative technological solutions. Most of the times this path can only be conceive with the interdependency between social sciences and the the other sciences.

8 Final considerations

Recent years have witnessed a deflating effect on interdisciplinarity and the development of discourses aimed at meeting the dominant rhetoric, which discourages criticism and knowledge fertilization, instead of striving to understand a complex reality. Notwithstanding, when put in practice coherently and consistently, while approaching an object of enquiry, interdisciplinarity transcends the *cliché* to enrich and produce new disciplinary areas. This paper intended to demonstrate how scientists view and evaluate interdisciplinarity across all scientific fields, as well as between social sciences and humanities, as a way of identifying and tackling societal complex challenges. Based on a literature review, and considering the results of a survey applied to Portuguese scientists working on interdisciplinary projects, this paper came across several important conclusions. It shows that scientists experience great uncertainty when embarking on interdisciplinary projects. The underestimation of interdisciplinarity, the importance of specialization in research evaluation, and the still hierarchical mode of understanding scientific fields greatly account for that experience. The results also point out a widespread common understanding of the need and relevance to foster interdisciplinarity among all

areas, particularly the social sciences. In this line, it becomes relevant that research centers and universities can consider the outcomes of the social studies of science, which have proposed that scientific and technological innovation have impacts on the society that must be anticipated, diagnosed, and evaluated (Adam & Groves, 2007). Moreover, such studies have dictated that planners and decision-makers must be aware of the non-intended effects of technologies in the social and organizational fabrics, as different social groups and individuals have different modes of understanding and using scientific knowledge and innovation. This is one of the pivotal reasons why in the past few years, several studies have pointed to the fact that science, technology and innovation are also culturally embedded; they respond to values and meanings people ascribe to them.

More importantly, several studies within the large field of social sciences, particularly the social studies of science, have signaled the ways social sciences can effectively contribute to engineering and technological areas in matters specifically linked to sustainability and visions of the future (Araújo, 2018). For several years, social scientists have struggled to show the social, emotional and economical rewards of developing innovation through direct engagement with the population on designing the solutions, keeping them as co-producers of innovative solutions or processes that will have an impact on society and their future (Jasanoff et al., 1995). Authors state that joint efforts between scientific areas and experts, both in research and innovation, are needed to overcome and make citizens' knowledge, aspirations and desires prevail against top-down approaches that separate and emphasize the views of scientists and experts over citizens' experiences (Okamura, 2019). Two important conditions must be fulfilled to make this path work. First, it is important to pursue personal and institutional efforts to deliver science and technology to society and citizens. Authors have put forward several ways of doing so, including the composition of interdisciplinary teams, the use of cross-disciplinary research methods, and fostering genuine communication between all actors involved in the research team and stakeholders. Second, it is important to consider the role of time for building and developing all the important ties that will allow the exchange of ideas and the information flow to expand (Felt, 2015). In this line, interdisciplinary research work is a matter of concern for the upcoming years, and it is particularly acute in the cases of small countries, such as Portugal, where additional efforts are needed to reduce dispersion. Research institutes and researchers have an individually important role to play in this matter.

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