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It's not all about funding: Fostering interdisciplinary collaborations in sustainability research from a European perspective

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Abstract

Sustainability research benefits from having an interdisciplinary orientation, as understanding and developing solutions to the grand challenges we confront is not the domain of any one discipline. Even though often falling short in practice, this ideal has undergirded the efforts of sustainability research, and promoted the increasing recognition of the relevance and unique insights that social science has to offer. Pointing to a significant imbalance in funding allocation between the natural and social sciences, Overland and Sovacool, in this Journal, recently challenge the notion that these two represent increasingly equal partners for sustainability research. Although we applaud and are in fundamental agreement with their arguments, we contend that framing of respect and recognition in terms of funding alone may be misleading, and can replicate and reproduce the exact imbalances that it seeks to redress. This Perspective aims to complement the insights of Overland and Sovacool by making an examination of the kinds of organizational and institutional factors preventing a fuller integration of social sciences within sustainability research. Writing from the perspective of social scientists involved in interdisciplinary research projects, this more bottom-up perspective sheds light on: the ongoing imbalance between the social and natural sciences, how and why the status quo is reproduced for structural and cultural reasons, and how transformation along the two dimensions can be achieved. The resulting solutions are relevant for not only other social scientists, but all concerned with developing robust and constructive answers to societally pressing questions.

Keywords: Sustainability research, Interdisciplinary collaboration, Transdisciplinarity, Social science, Funding, Research policy

Introduction

Sustainability research, though far from the oldest or most established of fields, has in the course of a notable history been reasonably successful in pushing for greater recognition of the necessity of, *inter alia*, climate change mitigation and the transformation towards economies and societies which are less environmentally impactful. And where it has been fortunate, by the efforts of researchers, practitioners, policymakers and society, to shift the agenda and change the conversation, the types of concerns on which those engaged in sustainability

research have focused have also been fortunate to shift. If we glance back at the key concerns from two decades prior, we find a principal emphasis on outlining and defining the core premises of the vision of 'sustainability science' [1,2], viz. as "a field defined by the problems it addresses, rather than by the disciplines it employs" [3]. What thus matters most to the aim of sustainability, and the actors therein engaged, is foregrounding the grand challenges we face, developing knowledge of what is taking place and how things may be improved, and fostering transitions to more sustainable systems and practices. However, 'sustainability science' in this sense has remained a niche within the broader field of sustainability research – by which we denote all research activities addressing or relevant to the issue of environmental sustainability, including those that do not necessarily adhere to the ideal of 'sustainability science'.

Energy Research & Social Science has, from its founding issue [4–6] through to the present [7–10], been one of the fora where the discourse on the requirements for sustainability research (with a special focus on the subfield of climate and energy research) has taken place. Having been established as a riposte to the lack of social science research in the energy domain [5,11], it has devoted sizable attention to the role and unique insights offered by social science and the broad agreement on the importance of inter- and transdisciplinary[1] research for tackling the 'big problems' of sustainability [8–11,14]. We explicitly highlight the neglect of ethical, legal, and social implications (ELSI), e.g. for privacy and inequality [15], limited interest in certain areas of energy research [8–10], and marked coolness to institutional processes and dynamic interactions between society and technology [5,8,11,14]. Crucially, underrepresentation of the social sciences in sustainability research risks missing out on opportunities and perspectives to re-frame how the problem space is envisioned – likely to prove particularly key for navigating the Anthropocene, amidst the ubiquitous need for a constant, deliberative rethinking of societal values, goals, problems and solutions [16]. In fact, without collaboration between and beyond disciplines, the relevance and epistemic quality of the attained knowledge and insights has the potential to be endangered and impoverished. It is especially within the spaces of inter- and transdisciplinary collaboration where innovative ways of thinking about the aims and approach of sustainability research emerge, along with new ways to formulate problems not specific to any discipline (but highly relevant for society as a result).

[1] We follow the definitions provided by Stock and Burton [12], who define interdisciplinarity as "studies [that] focus on addressing specific 'real world' system problems and, as a result, the research process forces participants (from a variety of unrelated disciplines) to cross boundaries to create new knowledge". Transdisciplinarity goes even further, by "maintain[ing] a clear emphasis on developing a holistic approach to problem solving involving stakeholders and scientists in a joint project". The discussion of Wickson et al. [13] is also recommendable here.

Even if often falling short in practice, the above-mentioned ideal has undergirded the efforts of sustainability research – as a beacon that lights the way forward, notably, whenever day-to-day realities and (im)practicalities of implementation, adaptation, policymaking, and research may intervene and complicate things. It is in this spirit that we were interested in the recent article by Overland and Sovacool [17], highlighting the significant imbalance in how resources are allocated (by funding agencies) between natural and social sciences in the context of climate-related research. Analyzing a new global dataset of research grants, the authors find that the natural sciences received around 770% more funding over the last three decades and, in terms of overall funding, the social scientific share for researching sustainability is a microscopic 0.12%. Irrespective of flowery exhortations to take greater responsibility for sustainability and climate change, these hard statistics conjure a distinct reality, one where sustainability remains under-appreciated – and the social sciences even more so. Both facts stand in stark contrast to an increasing presumption in sustainability research that social and natural sciences are equal partners, or at least are becoming so over time. Looking at the funding data in Overland and Sovacool, there is little in the way of improvement to be discerned though. Indeed, the funding imbalance between the sciences seems to increase after 2007 – unless, that is, we are comforted by sharp declines in funding for the natural (and social) sciences over the last four years, which brings the two closer together. While Overland and Sovacool's analysis was broadly restricted to climate-related research, there is ample evidence suggesting that imbalances in this domain are symptomatic of a more general malaise throughout sustainability research [18].

In this Perspective, we aim to complement the funding-oriented perspective of Overland and Sovacool by embedding it in a broader view of structural and cultural hindrances to the fuller integration of the social sciences in interdisciplinary sustainability research (going beyond only climate-related research). We thus utilize the findings of Overland and Sovacool to help explore what is required for social science to assume its (presumed) significance, and for sustainability research to take another step towards being "a field defined by the problems it addresses, rather than by the disciplines it employs" [3]. Writing from the perspective of social scientists who are involved in sustainability-related research projects driven by those in the natural sciences, and where we are the clear minority, we specifically contend with those kinds of organizational and institutional factors that limit project colleagues to working in their disciplinary silos and prevent deeper collaboration toward developing robust and constructive answers to societally pressing questions. We focus on the European context, where we are both currently active and which is often considered to be 'avant-garde' in terms of facilitating interdisciplinarity [18,19].

In spite of the many ways that the institutional and organizational environment is formative for sustainability research, it is perhaps its inherently contextual nature which causes it often to go overlooked in favor of more cross-cutting, top-down features such as the framework conditions set by funding agencies, national authorities, and intergovernmental agencies. Accordingly, our bottom-up perspective sheds light on: the imbalance between the social and natural sciences, how and why the status quo is reproduced for both structural (funding) and cultural (norms and rules which guide everyday research) reasons, and how transformation along these dimensions can be achieved. We develop our argument by posing two interrelated questions: first, why the focus on funding alone is insufficient and should (at least) be complemented by questions about the research environment into which funding flows. Second, given the structural and cultural incentives working against interdisciplinarity, what changes must accompany and complement the rechanneling of more funding to the social sciences? Our arguments draw as much on the relevant literature as our own experiences, and we further consider such insights to be relevant for not only – or even primarily – other social scientists, but natural scientists, engineers, policy makers, and representatives of funding bodies who aim to promote deeper engagement among natural and social sciences (and society at large) in tackling the sustainability crises we face.

Is it all about funding?

The availability of funding for sustainability research has long been a point of contention, both as an opportunity for willing researchers to commit their expertise and talents to this important field and as an expression of the relative importance, in the eyes of policy-makers and society at large, of their role. The latter has received particular attention from social scientists, seeking to establish equal footing between ‘hard’ and ‘soft’ sciences. Despite ostensible improvement in the stated recognition of the social sciences, however, it is not at all clear that much progress has been made– as ably demonstrated by Overland and Sovacool’s [17] analysis of funding patterns in climate research. However, for all its importance both to the day-to-day functioning of research and the fulfillment of its overall aims (i.e. to incentivize the generation of actionable and socially robust knowledge for sustainability and promote collaborations between natural and social sciences), it is increasingly clear that the framing of respect and recognition in terms of funding alone is at best misleading, and at worst acts to (unintentionally) reproduce the exact imbalances that it seeks to address. In order to demonstrate why a focus on funding is important but by no means sufficient for the practice and success of sustainability research, we explicitly

consider how it can foster the neglect of the many other kinds of support that are required for the social sciences to play its active and unique role for sustainability.

With regards to the recipient of such funding, it definitely appears that certain disciplines are (implicitly) deemed less relevant for sustainability research, or less deserving of funding. Take the emblematic case of the Horizon 2020 framework in the European Union and, in particular, its aim of leveraging social science and humanities to tackle the "grand challenges" confronting society, humanity, and nature [8,18–20]. Indeed, following the Vilnius Declaration and sizable pressure from governments, Challenge 6: "Europe in a changing world—Inclusive, innovative and reflective societies" was added, and with it core funding to social science and humanities [21]. Nonetheless, Budtz Pedersen [18] observed that only 27% of EU funding schemes invite contributions from social science, with the humanities represented even less. Driving this fact home, a report by Science Europe [22] finds about 75% of ostensibly interdisciplinary projects could not find any place for the social sciences and humanities. In other words, there is deep recognition that society requires the approaches and insights of the social sciences but the same is not true for research undertaken in the world's largest funding program for interdisciplinary research – a fact which complements the insights from Overland and Sovacool [17].

The fundamental point is that there is a tendency to promote, and pursue collaboration with, a certain version of social science – a kind of collaboration where researchers in the humanities, for instance, are viewed as surplus to requirements. One plausible explanation is the prevalence of research-funding formulations aimed more at the natural and technical sciences or what they can offer: e.g. new technological devices or fixes and ways to assess and monitor the potential for risks and hazards. However, if funding is developed with the typical focus and interests of natural sciences in mind, this prejudices the course and structure of sustainability research and, by encouraging the natural sciences to take the lead, modes of engagement afforded to social scientists [7,20]. It has thereby been remarked that social science is asked to "support a research agenda framed by others" [23,24] and with their role "consigned to cleaning up the mess that technology design has created, or […] to develop marketing to promote technical innovations" [24].

As a result, it is the case that some fields of social science better lend themselves to assuming such tasks, resulting in a funding imbalance not only between the social and natural sciences, but among the social sciences themselves. In our experiences, there are two stylized strategies that natural scientists follow in seeking social science partners for project proposals, especially

in ‘technical’, quantitatively oriented contexts like climate and energy or agricultural research. These strategies entail, first, where close collaboration is envisioned, preference for economists who, possibly due to their history as the “social physics” [25], are more suited to the language and approaches that prevail in the natural sciences, and moreover implicitly advantaged by the tendency to assess research impact in economic terms: focusing on “short-term technological or economic gains [or] private gains over public benefits of the sort that sustainability provides” [26, see also 27]. And secondly, where social science is viewed as an ‘outreach add-on’, there is greater interest in a qualitative approach and engaging sociologists and social geographers, or partners with specific expertise in (science) communication. This situation is aggravated by a frequent perception of ‘social science’ as a monolith. However, it is worth highlighting *there is not one social science* and the *social science disciplines are not interchangeable*. The matter of which social science disciplines should be part of the project must not thus be based on how easily they can be cooperated with, but on the novel perspectives they can bring to bear [28].

In any case, one implication here is that the nature of these collaborations tends to be more of the transactional rather than transdisciplinary variety, lasting for as long as the duration of the project or however long is required to fulfill such ‘on-demand’ research [18]. There is limited opportunity, as a result, for more sustained discussion, exploration, and reflection on differing assumptions and beliefs, let alone to jointly cultivate a ‘fusion’ of these different approaches [5,10,13,26,29]. In consequence, while interdisciplinary projects on climate mitigation plainly need atmospheric physicists, geoscientists, glaciologists, meteorologists, oceanographers, and so on, when it comes to social scientists, there seems to be the assumption that only one – often any one – will do. However, especially in sustainability contexts, distinct perspectives from the social sciences are required, with representatives of various disciplines needing to be integrated in a more structured fashion. An economist has different insights to provide than a sociologist, anthropologist, or political scientist – more often than not, all of these insights are valuable in tackling societally relevant and epistemically intriguing sustainability problems.

The fact that the social sciences are asked to “support a research agenda framed by others” [24] moreover limits the nature and depth of its engagement to acting as spokesperson or uncritical collaborator with the natural sciences [5]. There is justified concern regarding whether and how social scientific insights can ultimately be integrated and taken on board – notably, for policy and decision making. This entails, first of all, deeper understanding of success versus failure in relation to collaborative knowledge production – that is, not just attempts to work together but whether this is reflected in actual policy and able to deliver real-world benefits for stakeholders

[26,27,30]. Far too often however, not only do decision makers draw insufficiently on available scientific knowledge, instead preferring internal sources of information, but researchers tend not to plan their research with the ultimate usefulness of the results in mind [27,31]. Parallel to this, it was quickly realized in the sustainability literature that it was necessary to engage with practitioners and stakeholders in society who had direct contextual knowledge of the problems, and would eventually be asked to adapt to and implement the solutions being proposed [27,30]. Discussions around co-production of knowledge and the "need for socially robust knowledge" thus came to the fore [14,23,32–35], especially as a feature of critical approaches such as post-normal science.

Previous discussions of these issues have thereby presented a variety of novel tasks needing to be accomplished by sustainability research, including reducing the gap between knowledge and action, developing deliberative approaches to governance, and facilitating deeper engagement with the public [7,14,16,20,36]. Maybe due to the many hats that social scientists have tended to wear within interdisciplinary research projects [5,7], these distinct roles typically fall to them – with the upshot being that, often, the function of the social sciences is defined by the specific needs of the project, whether emergent or defined from the outset. Conversely, except in rather rare instances [26], the responsibilities assigned to researchers from the natural and technical sciences are established much more clearly, especially where projects call for new applications to predetermined problems. Indeed, the principal lesson of such exceptional cases, explored in depth below, is that it is the extent to which the commitment to transforming the 'science of sustainability' is held by all partners that is the sole guarantor of success [26,29]. It is doubtful as a result whether this can be attained by funding alone.

What is needed to empower social scientists and strengthen sustainability research?

Having examined why funding is important but insufficient on its own, we examine and discuss other changes that are necessary to empower the social sciences and social scientists to assume a long-term role as effective collaboration partners in sustainability research. Here, our guiding assertion is that the context and practice of research cannot be overlooked. Although funding offers incentives for engaging in sustainability research, it can neither automatically institute nor compensate for the absence of the culture, institutions, and disciplinary recognition that is often lacking for such research. Furthermore, insofar as any funding must inevitably be filtered through and become enmeshed within this overarching context, if these other issues are not

resolved, funding alone cannot be expected to achieve the hoped-for increase in the engagement of social scientists nor the necessary impact and societal relevance of sustainability research.

Here, we provide suggestions of how and where additional support is needed in order to address the underrepresentation of the social sciences in sustainability research and thereby improve the societal relevance and epistemic quality of such research. Importantly, just as rechanneling funds towards social sciences will not solve the problem, the solution also does not lie in simply empowering social sciences – this empowerment is also necessary but not sufficient to produce truly relevant research. Rather, what is required is an open and transdisciplinary approach that requires a realignment of the normative and incentive systems that are in place [18,29,37]. Both funding and the culture of research crucially generate and reproduce imbalances between the natural and social sciences, and among the social sciences as well. However, since the former is somewhat easier to address, especially by means of top-down initiatives, changes to culture tend to be either overlooked completely or assumed to follow from changes to funding policies. The previous section has already detailed why this is not the case and, accordingly, why there is greater need for further changes to the context of research – and context in which researchers in the social sciences work and strive to carve out a career.

Support for research and researchers in social sciences via funding

In the most general sense, there is a need for stronger and more coherent incentives for inter- and transdisciplinary collaboration at different levels: including the organization and degree of exchange afforded between the disciplines at institutes, universities, and research centres. Here we observe that interdisciplinary work tends to function best wherever it has been instituted in the guiding vision and fundamental mission of a place, rather than only via temporary funding programs. Weichselgartner and Kasperson [27] underscore how the gap between the producers and users of knowledge could be reduced, and mutual understanding promoted between them, by "increas[ing] the amount and intensity of face-to face interactions by creating institutional contexts where both are encouraged to interact". Looking at those methods and strategies that have been developed to advance stakeholder engagement, one finds a toolbox including collage processes, citizen interaction with computer models, participatory scenario development, and science fiction prototyping [35,38,39] that enables sketching out desirable or possible futures, or helps to identify and engage institutions, technologies, behavioral patterns, and knowledge gaps of specific importance for sustainability. Moreover, O'Brien et al. [29] illustrate with their method of "futures literacy" how collaboration among an approximately equal number of social

and natural scientists, working across disciplinary divides, proves to be directly necessary for interdisciplinary research – thereby supplying a useful tool and highlighting the importance of the composition of research teams.

In a similar respect, Müller and Kaltenbrunner [37] observe the importance of a physical locus, or even conversational culture, characterized by mutual trust and "intellectual musing" around topics in a non-targeted way. Various authors have thus highlighted the necessity of long-term environments and cultural settings that facilitate "open cooperation between different science communities and all others with relevant knowledge for contributing to solutions for the complex problems of sustainability" [26]. Whether denoted, alternately, as "knowledge arenas" [26] or "integrative environments" [18], the crucial feature is how deeply the emphasis on such collaboration resides in the 'structural DNA' of an organization, as well as its likelihood of enduring over time. Indeed, it is much more difficult to 'retrofit' interdisciplinarity-promoting structures, or for that matter to get buy-in from all researchers, than if founding structures have been shaped with the mission of sustainability and interdisciplinarity in mind. As a specific positive example, take the Helmholtz Centre for Environmental Research (UFZ) in Leipzig, Germany, which was created with a specifically interdisciplinary focus. During the funding period 2013–2020, there existed two distinct, interacting layers of organizational structure: on the one hand, disciplinary departments in the traditional sense; on the other, a further layer, orthogonal to the departmental one, in which scientists from distinct disciplines working on similar topics (e.g. energy, land use, bioeconomy, and agricultural landscapes) are expected to collaborate (so-called 'integrated projects'). Each scientist at the Centre was assigned to organizational units that encompassed both layers, and since allocation of funds to and within UFZ strongly depends on the quality and societal relevance of research – where quality is defined in part by degree of interdisciplinarity – strong incentives exist for engaging in collaborations across disciplinary boundaries. While such a structure is far from bulletproof[2] and only works if involved scientists are sufficiently open-minded and inclined to invest time and (cognitive) resources to constantly update their joint understanding of research questions (see below), we find it to be broadly conducive for interdisciplinary work. Among other things, the greater intimacy of having natural and social scientists engaged daily in interdisciplinary

[2] In fact, this structure has now been reformed in the course of the initiation of the new funding period (starting in 2021), resulting in the loss of some of the explicitly interdisciplinary structure (with the caveat of this being a still ongoing process at time of writing). Furthermore, even with the IPs, the social sciences remained underrepresented – of the ca. 40 departments of the UFZ, only four are devoted to social sciences, two of them also being relatively small.

work, and co-located in a shared space, opens up rich opportunities for the kind of serendipitous encounters that occur less often from interactions taking place at sporadic project meetings.[3]

In contrast, at the level of funding bodies, the main desideratum for funding decisions tends to be coherence – i.e., if societally relevant sustainability research is the goal, the incentives are to make this generally feasible. Accordingly, in many of the major funding initiatives, notably Horizon 2020, there does emerge an emphasis on interdisciplinary research as a "key to future scientific breakthroughs" [41]. And yet, exactly because such top-down pressure does not seek to engage with the context and practice of research or because the "incentives... for academic engagement in sustainability-oriented science are weak and generally transient" [26], it tends to neither effect wholesale changes in everyday practices nor consider those kinds of potential changes to institutions that would outlive the framework of a particular project. In this regard, possible opportunities include: making social science (and humanities) the target audience, e.g. in terms of topics, in funding calls, possibly including preferential treatment of social science-led projects; finding creative ways to grant funding to the kinds of bottom-up interdisciplinary collaborations that have tended to represent the natural outlet for humanities scholars to engage in sustainability research [42], thereby avoiding the tendency for 'sustainability' to be used as a buzzword to sell research which is otherwise only loosely interdisciplinary in nature [43,44]; and the requirement of stakeholder engagement over the whole project lifetime, instead of just at the end. Indeed, some programs do stress the latter [45], with Cornell et al. [26] identifying it as one of the essential elements of successful collaborations – notably, "stakeholders can contribute to the design of the arena (including agreeing on priorities for funding decisions), rather than being brought in as participants once goals have been set". To our mind, these three actions would do much to tackle the frequent perception of social science as an 'add-on' to the 'real science' core of the project by committing all partners more deeply to the overall aims of sustainability research.

Another, deeper-going suggestion here may be two-step funding calls, where at the first step, funds would be allocated to activities tied to problem formulation, thus emphasizing a strong transdisciplinary focus, opening up a space for "intellectual musing", and driving an early focus on the societal relevance of the research and stakeholder integration. Only at the second step

[3] Here we discern clear parallels to the innovation management literature, specifically for the establishment of cross-cutting teams to manage the interface between, e.g., R&D, marketing, and external partners and thus ensure that more relevant capabilities are brought to bear on a problem [40]. This literature thus offers new perspectives and insights on how interdisciplinary research might be organized.

would project proposals (iteratively) engage in problem-solving activities. At present, both of these project types (and calls) exist, including projects that disentangle the stages. However, to the best of our knowledge, no structured and systematic strategy for structuring the funding of sustainability research has been formulated. In fact, such are the problems of extant approaches that apparently radical solutions are starting to gain attention, notably, randomized research funding [46]. While we do appreciate the merits of such proposals for addressing widespread biases and inequality of access to necessary funds, the notion of randomization (un)necessarily obviates the principle of merit-based funding. We suggest, instead, to focus on more 'mundane' changes like ensuring reviewers have interdisciplinary competence or including stakeholders from the general public, in order to increase the societal relevance and epistemic quality of sustainability research, and to thus better engage with the knowledge that is already there.

Support for research and researchers in social sciences via cultural change

The 'science of sustainability' has been the subject of much attention and transformation, of changes both incremental and far-reaching, and exemplified by the launch of various inter- and transdisciplinary initiatives and sustainability-oriented research programs the world over [26]. Given the notable tendency however for each one to "set out as if they were the first one ever devised" [26], the resulting literature, and all its accumulated insights, tend not to be translated into practice – each undertaking just representing another round of re-inventing the wheel. In what follows, we thus explore those 'cultural' implications for the situation in academia that emerge due to both the prevalence of such a piecemeal approach and the quite narrow focus on funding. For this discussion, we draw heavily on first-person observations gleaned from our everyday work, though also, where available, relating these to threads and insights within the literature. In specific, we focus on the incentive system that confronts early, not-yet-established scientists who are participating in sustainability research, and which can frequently contradict the more nascent incentives set forth by funding agencies and national and international policy agendas. In this way, we aim to add depth and another perspective to the burgeoning knowledge of the "core elements of success" of interdisciplinary research on sustainability [26].

From our perspective, the most important cultural change revolves around a fuller awareness and appreciation of the epistemic value[4] of the social sciences and their theoretical, conceptual, methodological diversity – much in line with the ideals of 'sustainability science' [1,3]. Indeed,

[4] We define epistemic value as a positive contribution to the stock of knowledge (overall and in relation to a specific topic).

sizable attention has been given to the potential for transformation in education, to endow the next generation of researchers with the skills and capabilities required to drive interdisciplinary research [29]. Facilitating exchange between natural and social scientists is crucial as a result – within programs oriented toward applied research, and as part of an overhaul in the graduate and postgraduate curriculum. In specific, education in sustainability-related disciplines should be used to incentivize familiarity with the existing diversity across the social science disciplines and gain a better grasp of the potential to make contributions (with this true not only for natural scientists, given that social scientists can also have a distressingly superficial understanding of their fellows' work). Here we pinpoint the necessity of opportunities for proto-interdisciplinary collaboration (between students) across the assorted disciplines. So that this assumes a more practical bent, such an initiative could be undertaken under the aegis of contests such as the International Genetically Engineered Machine (iGEM) Competition,[5] an annual and global competition in synthetic biology in which teams of students, from high school up to graduate studies, use synthetic biology approaches to solve everyday problems. iGEM offers to many a fundamental introduction to the aims and practice of science, most notably in relation to open, interdisciplinary, and challenge-focused research. Indeed, the ethos of "building solutions to local and global challenges", e.g. in the domains of energy and the environment (https://igem.org/Impact/Global-Challenges), is rightly central to iGEM – with teams invited to explore and employ synthetic biology as they see fit. At the same time, it is emblematic that the promotion of an open community through interdisciplinary groups of students assigns limited importance to social scientists, with only philosophy merited for inclusion alongside, e.g. biology, chemistry, industrial design, and mechanical engineering.

In this regard, the case of iGEM is broadly illustrative of how wide-eyed efforts to inculcate a new approach and values in the coming generation of scientists can run against the rocks of received wisdom. Here, it must be stressed that any exclusion of social science is in a sense 'two-sided', as would-be teams have noted the difficulty of attracting social scientist partners and maintaining their interest throughout the process. Despite how much participation in such competitions could breed familiarity between social and natural sciences, the fact remains that, in academic contexts, the stronger focus on inter- and transdisciplinarity can come at a cost – as a large part of the system remains discipline-oriented (often for good reason). It is thus the case that inter- and transdisciplinary research, and even publications and funding, often fail to attain the same peer recognition, nor are similarly rewarded when it comes to opportunities for

[5] Detailed information about the iGEM competition can be found here: https://igem.org/Competition.

professional advancement [37]. And though to this point in our somewhat young academic careers, we have been fortunate enough to see things slowly change, with for instance the ability to work across disciplines an increasing feature of calls for positions and funding, such change is much harder to discern as one moves up the hierarchy. Both of us have received the cautionary advice that, sure, interdisciplinary research is valuable and critical, but succeeding in getting professorial appointments still depends on criteria defined by particular disciplines (number of publications in journals with the imprimatur of a relevant association, etc.), and is determined by gatekeepers often firmly embedded in the accustomed way of doing things. Too often, the choice is thus between the research needed to tackle the grand challenges that confront society and the disciplinary research rewarded with professional advancement, and that enables early-stage researchers to 'remain in the game' and have long-term impact.

In this context, we highlight the particular and emerging role of administration in university contexts, whether by establishing cross-disciplinary faculties, promoting spaces for the deeper discussion and engagement across fields, or taking steps to ensure success in interdisciplinary research is a 'hard' criterion for professional appointments. Indeed, we are personally aware and appreciative of efforts that already move in this direction. For example, Cornell et al. [26] highlight the establishment of a novel academic structure at Lund University (external to the main faculties) serving as a platform for bridging the social and natural sciences – with an explicit focus on sustainability and real-world action. The fact that in the meantime, this case of positive innovation has been partly reversed by being integrated in the social science faculty, shows however that any overall positive trend is neither stable nor to be taken for granted. Still, this and other instances (such as the UFZ, discussed above) speak to the need for changes in organizational structure, specifically as a way to transform the culture and practice of research. At the same time, it is notable that the single example in the list compiled by Cornell et al. [26] that aims to heighten the visibility and recognition of "outstanding transdisciplinary research" is a biennial grant (in Switzerland) of around €60,000 (whose continued existence we were not able to confirm). On the one hand, more such awards are urgently needed, and yet it bears asking to what extent such a grant, both in size and reputation, would tip the scales in favor of a potential applicant if, for instance, his or her publications were fewer than another candidate.

It's not all about the funding. In fact, while fixing funding imbalances is definitely important, other institutional and cultural factors also have a detrimental effect on the potential for social scientists to fully participate in sustainability research – there can also, admittedly, emerge limits to their motivation and willingness to do so [37,43,44]. Transaction costs of participation

in inter- and transdisciplinary are high – participants need to develop a common understanding and engage in lengthy (though rewarding) interactive and deliberative processes, not to mention acquaint themselves with a new literature or, depending on the kind of collaboration, literatures. This tends to slow down the frequency, and thus quantity, of publications, which remain a key factor for professional advancement within established academic cultures – and what is more the outlets best suited to interdisciplinary research often do not fulfill the requirements preferred by disciplinarily oriented promotion committees and their reliance on disciplinary criteria [47]. In other words, both the quality and quantity of research is adjudged, by formalized evaluation systems of research, to be lower when it comes to inter- and transdisciplinary research – setting these incentives at odds to those prescribed by and embedded within national and regional science policy [26,37].

This problem setting is far from specific to the social sciences – though it is aggravated by their being marginal(ized) in supposedly interdisciplinary sustainability-related research projects. As such, the (implicit) incentive structure presented to social scientists favors the adoption of one of two strategies: either invest large amounts of resources, i.e. time and energy, to cultivate frequent interactions with natural science partners, working hard to ensure knowledge flows (if unevenly) in both directions – with a risk that the costs of these investments become 'sunk'; or seek to make the best of the situation by working 'on their own' in and around the topic, maybe by 'freelancing' beyond the outline of the actual research project and, eventually, losing touch with the ongoing work of their partners (and vice versa). Notably, such a decision may be taken out of a belief that other types of research are needed to deliver sustainable solutions for society, solutions which are beyond the bounds of interdisciplinary research as currently constituted.

Such insights open up further avenues for the administration to drive changes within the culture and practice of research. We thus call attention to the potential, and indeed the need, to commit to and appoint positions such as 'gatekeeper' and 'sponsor' – presenting an agent and individual to complement the broad structural changes needed to facilitate interdisciplinary collaboration. In this regard, a gatekeeper represents someone who keeps informed of relevant developments for interdisciplinary research, whether inside or outside the research institution, and passes on this information to colleagues via established channels [43]. A sponsor (or 'interdisciplinary research sponsor'), meanwhile, could help to sell novel ideas or relevant initiatives across the research ecosystem by keeping constant contact to professors, administration, or even funding agencies. Too often in our opinion, such key tasks are, of necessity, assigned to different actors. As a result, individuals with the necessary capabilities to, for instance, manage interfaces of

disciplines or act as linkage points, including with external collaboration partners, are missing. Similarly, Weichselgartner and Kasperson [27], in their analysis of the gap between knowledge and action, highlight an increasing need for "knowledge integrators" – the intermediary actors or organizations with a wider perspective on the research that exists and, as such, the ability to merge and synthesize it. We thus stress that the absence of exactly those actors tasked with the consolidated responsibility for managing overlooked elements of inter- and transdisciplinary collaborations renders the structure less robust and culture lacking in those 'supra-disciplinary' perspectives that are most urgently needed. Such additions can enable a smoother functioning of *integrative* research environments by, *inter alia*, retaining a long-term focus on sustainability while also empowering researchers to concentrate more on research, and less on administration. Indeed, given the tendency to reinvent the wheel of interdisciplinary research over and over, it is maybe precisely the neglect of and failure to discharge such a scoping role within emerging interdisciplinary ecosystems that prevents us from consolidating the knowledge that has been gained - and not repeating past mistakes.

More than 'just' fixing funding imbalances is required, as a result, to empower social scientists in sustainability research – or to safeguard those gains that have already been attained. Indeed, the case within Müller and Kaltenbrunner [37], of the institutional decay of a once-pioneering interdisciplinary research center in Sweden – plausibly that of Lund University discussed above – underlines how the extant structure and strictures of funding may even 'disempower' certain kinds of research and certain forms of collaboration. Notably, in the attempt to navigate "an academic landscape characterized by strong disciplinary conventions" (p. 490), and regarding the strategies employed by researchers to position themselves as "reliable academics" (p. 493–494) able to attract the right kinds of funding and be deserving of promotion, we highlight how just the fear of having their voices marginalized can cause otherwise well-intentioned actors to turn their backs on inter- and transdisciplinary collaborations – to the detriment of sustainability research and the needs of society in general.

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