Reflections on a Workshop

How Can We Promote Meaningful Collaboration Across Scientific Disciplines?

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REFLECTIONS ON A WORKSHOP

HOW CAN WE PROMOTE MEANINGFUL COLLABORATION ACROSS SCIENTIFIC DISCIPLINES?

Workshop on "The role of social sciences and humanities in addressing societal challenges",
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1 Introduction

On April 4, 2017, Copenhagen Business School (CBS) and the Think Tank DEA held a workshop in Copenhagen on "The role of social sciences and humanities in addressing societal challenges". The aim of the workshop was to revitalize a long-standing question, namely how to stimulate increased research collaboration between the social sciences and the humanities (SSH) on the one hand and science,[1] technology, engineering and mathematics (STEM) on the other.

To solve the complex challenges facing society, we need complex solutions. Scientific disciplines can supply essential building blocks and they have a lot to offer in their own right. But to build effective and sustainable solutions, we often need to integrate building blocks from multiple disciplines. STEM researchers can provide scientific and technological solutions, but SSH have a vital role to play in generating insights into the social, economic, legal and ethical factors that influence the suitability and, ultimately, successful implementation of these solutions.

For societal challenges to be effectively solved, understanding of humans and societies must be integrated into the strategic research projects that are aimed at addressing such challenges. Despite many years of efforts to promote interdisciplinary collaboration, SSH still often end as isolated appendices in interdisciplinary efforts, or as an approach to handling the back-end problems associated with new technologies or policies. Either way, this leads to suboptimal collaborative outcomes.

With this publication, we hope to contribute to the debate on why we need to further step up our efforts to promote problem-oriented collaboration across scientific disciplines and what this will take. The publication presents key takeaways from the workshop held in April 2017, alongside the organizers' reflections on how best to promote increased collaboration between STEM and SSH researchers. Our recommendations are aimed at all parts of the research system, including politicians, research foundations, university managers and researchers.

Discussions at the workshop were fueled by talks by two invited speakers, Paul Nightingale, professor and deputy director of the Science Policy Research Unit (SPRU), University of Sussex, and Tobias Bade Strøm, policy officer, Unit Open and Inclusive Societies – DG Research and Innovation, European Commission. The workshop was moderated by David Budtz Pedersen, professor and co-director of the Humanomics Research Centre, Aalborg University Copenhagen. The workshop gathered almost 80 participants from the policy arena and scholars from the SSH and STEM communities in a constructive discussion of the challenges and opportunities for increased interdisciplinary collaboration. We hope such events can help pave the way for continued dialogue between the SSH and STEM communities, as well as other relevant stakeholders.

The publication also includes examples of recent or ongoing interdisciplinary research collaborations among Danish SSH and STEM researchers that underline that meaningful collaboration is not just possible, but also of great value to science and, ultimately, society. Independent journalist Simon Kratholm Ankjærgaard, Quote Kommunikation, researched and wrote the examples on behalf of CBS and DEA.[2]

[1)] The definition of STEM used in this publication broadly defines "science" to include not just the natural sciences (e.g. the physical and life sciences) but also the health and medical sciences as well as the agricultural and veterinary sciences.
[2)] A total of five cases were developed and can be downloaded in full length from CBS and DEA's websites.

an example *of*
INTERDISCIPLINARY RESEARCH COLLABORATION

INCREASED DIFFUSION OF TECHNOLOGY FOR EARLY DIAGNOSIS OF BLOOD POISONING

A collaboration between the Department of Micro- and Nanotechnology at the Technical University of Denmark (DTU Nanotech) and CBS could potentially save the lives of millions of people. Nine million people die worldwide each year from blood poisoning. This alarmingly high figure can be reduced significantly, if earlier diagnosis and treatment is made possible. This is precisely the aim of an interdisciplinary collaboration spearheaded by DTU Nanotech and CBS. *Smartdiagnosis* is a four-year project aimed at developing a product that allows for a much earlier detection of blood poisoning than is possible today.

Responsibility for the technical part of the project lies primarily with DTU Nanotech, while CBS researchers are responsible for ensuring that the products can be sold in the market, a necessary factor in enabling the wide diffusion and use of the technology. "Essentially, this is about getting the technical side and the commercial side talking very early in the process," explains Associate Professor Jens Geersbro, Department of Marketing, CBS.

Associate Professor Anders Wolff, DTU Nanotech, tells the story of how prior collaboration with the National Food Institute, also located at DTU, led to the development of rapid tests for, among other things, salmonella. The aim of the *Smartdiagnosis* projects is to further a new application of previously developed knowledge and technology, namely to speed up the diagnosis of blood poisoning.

Together with a range of partners in Denmark and abroad, DTU Nanotech is currently developing two products that are expected to revolutionize the diagnosis of blood poisoning on several parameters, including the speed and effectiveness of diagnosis. One of the products under development is intended for use in laboratories in the healthcare industry, while the other is being developed for point-of-care use in, e.g., intensive care units and emergency rooms.

"We're talking about two different markets," Wolff explains, "because who would be performing the diagnosis using our products differs. This is why our ambition is to stand here in four years with two products that can be sold either to the people undertaking diagnostics in the lab or to the people who will perform the diagnosis at the site where the patient arrives."

Finding a partner with research-based expertise in understanding the market was a goal from the start of the project, quickly leading Wolff and his team to CBS.

"At the end of the day, we're responsible for looking at – and ensuring – the business case behind of all this," states Jens Geersbro, CBS. "A key part of our work is to study and create the need necessary to ensure that, in three years' time, we have not just one but two markets for the product DTU is spearheading efforts to create."

"But," he explains, "we're a research institution, so we don't just contribute with commercial insight; in that case, this would just be a consulting project for us. We run a parallel research project and have our notepad in hand. We observe, analyze and conclude based on the entire process. This gives us much greater insight into how universities that span national borders, disciplinary borders and the sciences collaborate."

According to Wolff, the collaboration has, at least so far, been a success. "This is the first time we are collaborating with CBS, and working with them has been a great idea because we think in entirely different ways. We're the technical people; they think about commercialization and communication. This brings out entirely new perspectives and actually ensures that the whole will be greater than the sum of its parts."

2 Why is promoting interdisciplinarity (still) an issue?

INTERDISCIPLINARITY YIELDS MORE EFFECTIVE SOLUTIONS TO SOCIETY'S CHALLENGES

The need to address important and persistent societal challenges related to, e.g., climate change, health, food, energy, water and economic inequality is widely recognized. Solutions to these challenges, and the processes needed to bring about such solutions, however, are less obvious. Many policymakers turn to scientific research and, in particular, interdisciplinary research collaborations, for answers.

Indeed, over the past decade, we have seen a significant shift in international science policy priorities, from boosting the uptake of university research in industry through university-industry interaction to solving important societal challenges through collaboration among academic researchers from a wide range of disciplines, and often also involving users of research and other relevant stakeholders from industry and the wider society.

The European Commission, for instance, has built its eighth Framework Programme up around the need to address a series of Grand Societal Challenges, and the OECD has formulated seventeen Sustainable Development Goals for the world to solve by 2030. In Denmark, addressing societal challenges was the cornerstone of the national innovation strategy published in 2012. Flagship efforts to promote interdisciplinary research collaboration aimed at solving important societal challenges include the establishment of Innovation Fund Denmark and its Grand Solutions instrument, and the recurrent, participatory foresight and prioritization of strategic research and innovation agendas known as FORSK2015, FORSK2025 and INNO+.

Stimulating interdisciplinary research is by no means a new agenda in science policy, but it has received renewed attention, and a greater sense of urgency, as a result of the heightened focus on addressing pressing societal challenges.

> For the purposes of this publication, the term **interdisciplinarity** is defined in the broadest possible sense as any form of academic research collaboration involving two or more scientific disciplines. Drawing on Budtz Pedersen (2016: 1), as "a complex phenomenon that takes place along a continuum extending from short-term collaborations with minimal levels of commitment to large-scale research programmes with significant levels of interaction." **Interdisciplinarity** can thus take many forms, depending on the aims and scale of a given collaboration.

This is because real-world challenges are complex and typically do not fit neatly into existing scientific disciplines; as a result, solving them often requires combining expertise and efforts from several scientific disciplines.

Policymakers have taken a particular interest in stimulating collaboration among SSH and STEM disciplines. This is because addressing societal challenges requires more than finding appropriate scientific and technological solutions; it also calls for an understanding of the social, economic, legal and ethical factors that influence the suitability and, in due course, successful implementation of these solutions. Here, SSH researchers can deliver valuable, and sometimes even necessary, inputs to the development of solutions to societal challenges, for instance, by providing insight into the opportunities and obstacles for societal transformation, or the mechanisms and instruments for bringing about societal transformations (Budtz Pedersen 2016).

As pointed out by participants at the workshop on "The role of social sciences and humanities in addressing societal challenges", SSH can play a role at all stages of the development of a technological solution. They can guide the initial design of STEM or interdisciplinary research projects, e.g., by bringing user or wider societal perspectives into the preliminary identification of research aims and paths. SSH research can also lay the groundwork for the ultimate implementation and diffusion of the technological solution, by identifying key factors in bringing about positive, desired changes and by helping to interpret observations related to the acceptance and use of a scientific or technological solution.

As Lowe et al. (1992: 8) explain, such integration of scientific approaches is crucial to the successful development and implementation of science or technology-based solutions to complex challenges:

> ... technological change is often portrayed as an autonomous process deterministically driven by scientific advance and with social and environmental effects analytically separate from, rather than integral to, the process. The partitioning of scientific research in relation to technological change reproduces and reinforces this artificial separation with engineering and the physical sciences seen as sources of innovation, and social and environmental sciences as furnishing analyses of 'uptake' and 'impacts'. Clearly, this divide needs to be overcome if social and environmental factors are to be incorporated in the design, execution and regulation of ... technology.

SIGNIFICANT BARRIERS TO INTERDISCIPLINARITY PERSIST

Despite many years' focus among policymakers, research funders and university managers on stimulating interdisciplinary research collaboration, important barriers to discipline-spanning collaboration persist. It is widely recognized that the strong disciplinary structure of the sciences can create disincentives and barriers to discipline-spanning research (see, e.g., Rafols et al. 2012; Iorns 2013; Guthrie et al. 2013; Martin 2013; Bollen et al. 2014; Yegros-Yegros et al. 2015). Scientific disciplines play an important role in developing robust knowledge, theoretical frameworks and methodological approaches for studying given phenomena, criteria for assessing the quality of research undertaken, and thus also for making decisions about which research projects or groups to fund, and which research findings to publish. These disciplinary standards and approaches develop in parallel with distinct communities of researchers, specialized journals and conferences, and even researcher training programs. When research projects reach beyond these established disciplines and researcher communities, they are met with many challenges, including, e.g., obtaining research funding, finding publication outlets and getting papers accepted for publication. For instance, research has shown that interdisciplinary research projects consistently experience lower success rates on applications for funding than monodisciplinary research projects (Bromham et al. 2016).

Even if researchers manage to set up interdisciplinary collaborations – and possibly obtain external funding for it – they have yet to make the collaboration work. Among other things, this may require finding a common language and theoretical and methodological foundation that allows for joint interdisciplinary work. Indeed, recent work has argued that there is a tendency to underestimate how difficult it is to successfully integrate otherwise distinct disciplines, and how important this is for whether the involved scientists (and others) will ultimately deem the results of the collaboration to be 'good' or 'bad' (Hvidtfeldt 2016). Even when scientists are successful in building scientifically productive and valuable interdisciplinary collaborations, doing so takes time, both with regard to developing the basis for the collaboration and publishing results. Recent research indicates that researchers who engage in higher degrees of interdisciplinary work tend to be more cited but also less productive than comparable researchers (Leahey et al. 2016), and that novel, interdisciplinary research publications take longer than other types of scientific publications to get cited (Wang et al. 2016).

> "Assessment schemes and performance indicators have over time tended to skew research towards safe, incremental, mono-disciplinary mainstream work guaranteed to produce results publishable in top academic journals, and away from interdisciplinary and more heterodox, risky and long-term research. They have also generated perverse incentives, encouraged cynical gameplaying to beat the system, and resulted in various unintended consequences."
>
> —Martin (2016: 17)

UNFULFILLED POTENTIAL FOR COLLABORATION BETWEEN SSH AND STEM RESEARCHERS

There is a broad consensus that the potential for promoting interdisciplinary collaboration – partic-ularly among the SSH and STEM disciplines – is far from realized (see, e.g., LERU 2013; Budtz Pedersen 2015, 2016; Lawrence 2016). There is even a reasonably general consensus within parts of the policy community that STEM research is more 'useful' to society than SSH research, even though the results of empirical research of the transfer and use of different types of research does not support that view (Olmos-Peñuela et al. 2014).

Projects that involve both STEM and SSH researchers remain relatively rare. Budtz Pedersen (2016) points out that most calls for challenge-driven interdisciplinary research projects still fail to explicitly mention SSH. He also argues that, "While many stakeholders acknowledge the need to integrate SSH research in solving key societal challenges, such as climate change, migration or national security, funding for SSH is limited and tends to focus on strategic interventions and in-strumental solutions" (Budtz Pedersen 2016: 1).

In addition, the wider the gap between approaches and methodological approaches in the disciplines involved, the greater the costs of coordination necessary to enable the development of a "synthetic view" or common ground become (Budtz Pedersen 2016). As such, building relationships and bridges across disciplines can be particularly difficult, time-consuming and uncertain in SSH-STEM collaborations. "Overcoming barriers to interdisciplinary collaboration, such as the cognitive distance between expert fields, or the difficulty of choosing a clear publication strategy," Budtz Pedersen (2016: 4) argues, "requires significant investment of time and resources on the part of the researchers, as well as careful attention to the different incentive structures of the collaborating disciplines."

As such, it is not surprising that even when such collaborations exist, SSH is often treated as an appendix or an end-of-pipe technology, i.e., as an independent subproject within a larger project (DEA 2012; Peter et al. 2012; Lowe et al. 2013; Budtz Pedersen 2016). This may be partly explained by a tendency for SSH researchers not to be involved in the early formulation of research problems in interdisciplinary projects, but instead to be invited in later on to work on specific parts of a project, e.g., on issues related to science communication or ethical perspectives (Rabinow & Bennett 2007, as cited in Budtz Pedersen 2016). This limits the ability of SSH researchers to contribute to the aims and overarching research questions guiding the collaboration. Moreover, as previously mentioned, even when interdisciplinary collaborations are established, successful collaboration is by no means guaranteed (Hvidstedt 2016).

> "[The role of] social sciences as a backend fix to the problems arising from new scientific developments ... can be parodied by 'we have invented this, now find a market for it' or 'we have invented this but it has a few unfortunate side effects. How do we get people to accept it?"
>
> —UK Commission on the Social Sciences (2003, p. 29), cited in Lowe et al. (2013)

We often think of a more effective interplay between STEM and SSH as a modern invention. Yet, history reveals that the value of bridging insights from a wide range of scientific fields has played a key role in enabling technological and societal change in the past. For instance, Lowe et al. (2013: 207-208) pointed out that:

> … social science has not always been cast in such a subsidiary role in relation to science and technology. Indeed, the nineteenth century founders of social science (amongst whom were engineers, social reformers, philanthropists) saw it as an essential counterpart to natural science and engineering, helping to steer the enormous technical possibilities they generated and to guide the potential they unleashed for destabilising change.
> … Although improvements in engineering and manufacturing techniques would drive the industrial revolution, they were dependent on developments in the social sciences, particularly economics and social statistics, for their realisation in an expanding economy and evolving society.

The role of SSH is probably even more important now than it was in the nineteenth century. This underlines the importance of maintaining efforts to promote increased, effective collaboration across scientific disciplines. In the next section, we turn to key takeaways from the workshop, focusing on how meaningful, effective interdisciplinary collaboration can be supported.

an example *of*
INTERDISCIPLINARY RESEARCH COLLABORATION

INTERDISCIPLINARY VENTURE PAVED THE WAY FOR THINK TANK ON THE FUTURE OF FARMING

At the University of Copenhagen, an interdisciplinary think tank called Plants for a Changing World brings researchers from plant biology together with social scientists from disciplines such as law, philosophy and economics. The collaboration came about because advances in plant research had created deep insight into plant genomes, yet the insights needed to apply this knowledge for the benefit of society were lacking.

"We were sitting there with so much knowledge," explains Professor Michael Broberg Palmgren, Department of Plant and Environmental Sciences, University of Copenhagen. "We needed completely new perspectives on our work – and on what our work could be applied to," he continues.

In 2013, the University of Copenhagen launched the UCPH Excellence Programme for Interdisciplinary Research, which was aimed at stimulating collaboration across faculties. One of the projects that received funding was Broberg Palmgren's Plants for a Changing World.

"In the project," he explains, "I brought together researchers in the field of law, philosophers, economists and other social scientists – and plant biologists and botanists – and our first, crucial step was to find a common language that we could all speak. Only then could we begin to focus on the aim of the project: finding new solutions for the future of industrial agriculture." Four years later, the project has materialized into a think tank on the future of agriculture. According to Broberg Palmgren, the convergence of disciplines has been vital in the development of the think tank. "One of the first things that the societal researchers and philosophers said to us biologists and botanists was that we had focused much too narrowly on the technical opportunities. We had not considered what the societal needs were."

"That led to very important and very exciting discussions about sustainability, plant cell cultures and industrialization," he clarifies. "Among other things, we discussed concepts like sustainable intensification, i.e., how we can get more from less. There are several different models for doing this, but in the meeting between different disciplines, faculties and sciences, new opportunities and perspectives emerged." For example, Broberg Palmgren mentions how economists pointed to the importance of understanding the willingness of consumers to pay for agriculture produce grown using new methods, while experts on the law questioned which technical possibilities lay within – and beyond – the law. Meanwhile, philosophers and social scientists shed light on societal needs and on the ethics and implications of new approaches to agricultural farming. Such interdisciplinary contributions challenged the traditional way of thinking and working among the plant biologists and botanists.

According to Broberg Palmgren, "This was the first time we took the needs of others into consideration in our work, before we delivered the final product. It was new for us to ask whether what we were doing truly had a future outside of the walls of the faculty." The interdisciplinary think tank has advocated, for example, for the use of genome editing to induce mutations in wild plants, which are nutritious but not currently suitable for eating or for agricultural production, to make them more farmable. In comparison, the plants currently in use in industrial agriculture have traits that have been developed through thousands of years of selection and crop domestication to make them suitable for farming and consumption. Some of the possible benefits of the approach suggested by the think tank include allowing us to better utilize resources we already have at our disposal, increasing food supply and biodiversity, and decreasing the need for the use of fertilizers and pesticides. Any gene editing of crops may face ethical and legal issues; however, precisely because this approach involves deleting existing genes rather than introducing genes from other organisms, it is likely to be more palatable to consumers, pending effective communication about the underlying methods.

3 Key takeaways from the workshop

Ultimately, successful SSH-STEM collaboration may increase the overall societal relevance and impact of research efforts targeted at addressing complex challenges in industry and society. Therefore, the central aim of the workshop on "The role of social sciences and humanities in addressing societal challenges" was to engage participants in a discussion of how to strengthen the participation of Danish researchers in collaboration across SSH and STEM disciplines. In the following, we present the key themes that emerged from the table discussions at the workshop.

INTERDISCIPLINARY COLLABORATION MUST BE MADE MEANINGFUL

Several participants argued that many interdisciplinary efforts are less value-adding than they could be, or even unsuccessful, because too little attention is paid to ensure that the collaboration is meaningful.

But when is interdisciplinary collaboration "meaningful"? According to workshop participants, there were two key prerequisites for collaboration to be meaningful. First, the collaboration must yield cross-fertilization that creates added value, e.g. scientific approaches, insights and/or results that could not have been created in the absence of disciplinary-spanning collaboration. Second, the perceived benefits of the collaboration (as measured by the outcomes of the collaborative re-search) must outweigh the costs incurred during the course of the collaboration, including the investment of time needed to find a common ground and approach to scientific collaboration among the disciplines involved.

What is the key to meaningful interdisciplinary research? Some of the key steps to promote meaningful interdisciplinary research collaboration identified by workshop participants were:

- *Match the challenge with the team, and the team with the challenge*. Ensuring that the means fit the desired ends is important, i.e., that interdisciplinary research is only pursued when it is crucial to solve a given challenge, and by a team where all participants are expected to play a significant role in addressing the challenge. Assembling an interdisciplinary research team, however, raises a chicken-and-egg dilemma. If the starting point is a challenge defined from outside the team, motivating researchers to get involved can be difficult, but assembling an all-star team to go searching for a problem to solve, there is the risk that the team will be left unguided. There is no golden solution to this challenge, but it is clear that all projects need a relevant group of motivated researchers to drive them.

- *Focus on establishing temporary teams*. Strong professional skills are usually key to good interdisciplinary collaboration, which points to the importance of engaging well-established researchers. It is unlikely, however, for well-established researchers to allocate most of or all their research efforts to a young, uncertain interdisciplinary collaboration with limited funding and publication opportunities. As such, several participants suggested building interdisciplinary networks or collaborative projects of a temporary nature, allowing researchers to simultaneously remain active within their disciplines and engage in interesting, challenge-oriented interdisciplinary collaboration. It must be stressed, however, that such temporary teams must be established in good time, before a relevant funding call is put out, as it takes time to assemble relevant researchers, establish mutual insight, and explore research themes of joint interest to lay the foundation for meaningful collaboration.

- *Find the "right" level of interdisciplinarity for a given collaboration*. Recognizing that interdisciplinary research can take many forms is essential, as is making explicit, informed decisions about the level of interdisciplinarity in any discipline-spanning venture. Indeed, as Budtz Pedersen (2016: 1) argues, interdisciplinary research is "a complex phenomenon that takes place along a continuum extending from short-term collaborations with minimal levels of commitment to large-scale research programmes with significant levels of interaction." It is important to avoid generic or unreflected approaches, which may result in needlessly complex or ineffective collaborations. Is it, for instance, sufficient to ensure that work undertaken within disciplinary settings is informed by insights from other relevant disciplines, or is it crucial to ensure that different disciplinary approaches and findings are truly integrated to reap the desired benefits? The answer to this question should determine the level of interdisciplinarity in a given project and thus influence the ultimate design of the research project and collaborative efforts.

- *Ensure adequate, upfront "de-risking" of interdisciplinary projects*. Discipline-spanning projects are characterized by high levels of uncertainty, which only increases the importance of thoroughly planning the research design and activities. Some workshop participants suggested moving at least part of the peer review upfront, i.e., before even submitting any funding applications. This is in line with the pre-registration of research projects, which is becoming increasingly common as an alternative or supplement to peer review of subsequent publications from research projects, particularly by proponents of open science. Other suggestions for increasing the likelihood of success included mentoring by experienced researchers, particularly from interdisciplinary fields, and the use of pilot projects to test key assumptions, forms of collaboration and research approaches.

- *Build engagement with users and other stakeholders into the collaboration from the beginning*. Effective dialogue and sometimes even direct collaboration with users of research and other relevant stakeholders is important for increasing the ultimate societal value of the research undertaken and its subsequent uptake by users. Participants pointed out that effective research dissemination is not an event but rather an ongoing process, where researchers are engaged in long-term efforts to build strong relationships with key stakeholders. Funding and support for such activities is typically not provided for individual research projects; as such, this may require institutional support to ensure adequate funding and resources for academics to establish and maintain fruitful relationships with selected users.

EFFECTIVE SSH-STEM COLLABORATION REQUIRES UPFRONT ENGAGEMENT

Lowe et al. (2013:211) argue that, for SSH to play a bigger and more strategic role in addressing societal challenges and shaping society, they need to be "contributing to the shaping of technological development, rather than studying the consequences of new technologies on society." This, in turn, requires, they contend, "upfront engagement … in the framing of problems and the strategic direction of research" (ibid: 212). Getting involved in the definition of societal challenges and the early shaping of research efforts entails a much earlier and, frankly, messier form of engagement with researchers from other fields and other stakeholders than many SSH researchers prefer or at least are used to, but is, according to Lowe and his co-authors, absolutely central to increasing the role of SSH in challenge-driven interdisciplinary research collaborations.

Several workshop participants echoed these arguments and stressed the importance of:

- *Ensuring that SSH researchers play an active and significant role in shaping the direction of interdisciplinary, challenge-driven collaborations*. For example, one participant argued that such projects often become focused on the development and demonstration of a particular technological solution; yet, a valuable contribution of SSH research may be to throw that very solution into question at the beginning of the project. Potentially, questions posed at the right time might lead to a project being abandoned or given new objectives, ultimately contributing to a more efficient use of resources.
- *Aligning SSH and STEM aims and activities*. SSH and STEM researchers are likely to pursue different aims, even within the same project, and to engage in at least some degree of independent research activities. When complexity is high, and deadlines for funding applications draw near, it can be tempting to agree on the broader aims of a project and neglect the specifics of the collaboration. However, as in many other aspects of research, the devil lies in the details. Insufficient elaboration on the concrete research questions and activities to be pursued, or on plans for how to ensure interdisciplinary cross-fertilization, can easily lead project partners to pursue divergent paths, thus undermining the overall value of the collaboration.
- *Allocating funding for SSH activities from the outset of the project*. Some interdisciplinary projects have a lamentable tendency to not allocate dedicated funding for SSH activities or to not specify the nature, scope and scale of these activities until late in the project. This is especially likely when SSH researchers are not involved in the initial design and planning of STEM-driven projects and may lead to less than optimal conditions for the SSH research undertaken in the project and for cross-fertilization between the disciplines involved.

"We need to better understand and communicate the value of SSH to STEM researchers, and also to funders and policymakers. Among other things, this requires that we develop models for understanding and communicating the potential contribution of SSH to STEM projects."

—Workshop participant

On a related note, several workshop participants underlined that a precondition for SSH researchers to be included upfront in the planning of STEM-driven projects is that they become better at explaining the value of SSH in addressing societal challenges and supporting the development and implementation of scientific and technological solutions to these challenges.

Several participants pointed out that many SSH researchers have an unfortunate tendency to focus on barriers to interdisciplinarity or place blame on STEM researchers for not involving them. The same participants argued that SSH researchers must become more proactive in seeking out and establishing interdisciplinary collaborations, and more effective in communicating the value of SSH in such collaborations. Some participants mentioned that much of the academic literature on SSH is based on prior insights and concepts derived from research on the STEM disciplines, and that SSH researchers often define their work and its value in relation to that of STEM researchers.

As one participant stated:

> There is a need for the social sciences and humanities to become better at communicating what they can contribute with, as distinct scientific disciplines and in interdisciplinary research projects.

Other participants argued that it is important to increase knowledge of different disciplines within SSH and of their particular contribution to challenge-driven interdisciplinary projects. Similarly, some participants discussed the importance of how the desired impact of, e.g., strategic funding programs, is described for the types of interdisciplinary research projects they can attract applicants for. One participant asked:

> How should the aims [of a strategic research program] be stated in a call? If you want to bring forth optimal interdisciplinary solutions to a problem, it is, for example, not necessarily a good idea to ask for things to be brought closer to the market. There could be much value in, e.g., finding that a project should be killed off or thoroughly rethought, or in doing research on whether users and society are ready for a new technology. Funding bodies need to work with much broader notions of value and impact.

BUILD FERTILE SOIL BEFORE LAUNCHING INTERDISCIPLINARY RESEARCH EFFORTS

Another recurring theme in the workshop discussions was the need to, as one participant phrased it, build fertile soil for interdisciplinary collaboration. Several participants drew attention to difficulties associated with identifying good potential partners for interdisciplinary projects, and in generating initial ideas for such projects. The networks of academic researchers rarely reach far beyond their disciplines. Yet the foundation for good interdisciplinary collaborations may be found in very different and distant parts of the scientific community. As previously mentioned, researchers in interdisciplinary projects do not necessarily have an interdisciplinary profile, but may predominantly come from a single discipline; in this case, they are even more difficult for potential collaborators to identify. For example, a funding application in response to a call for research on genetically modified food may benefit from insight into legal or ethical aspects – but how do you identify a potential collaborator from legal or ethics research among hundreds or thousands of researchers within those topics? As one participant stated:

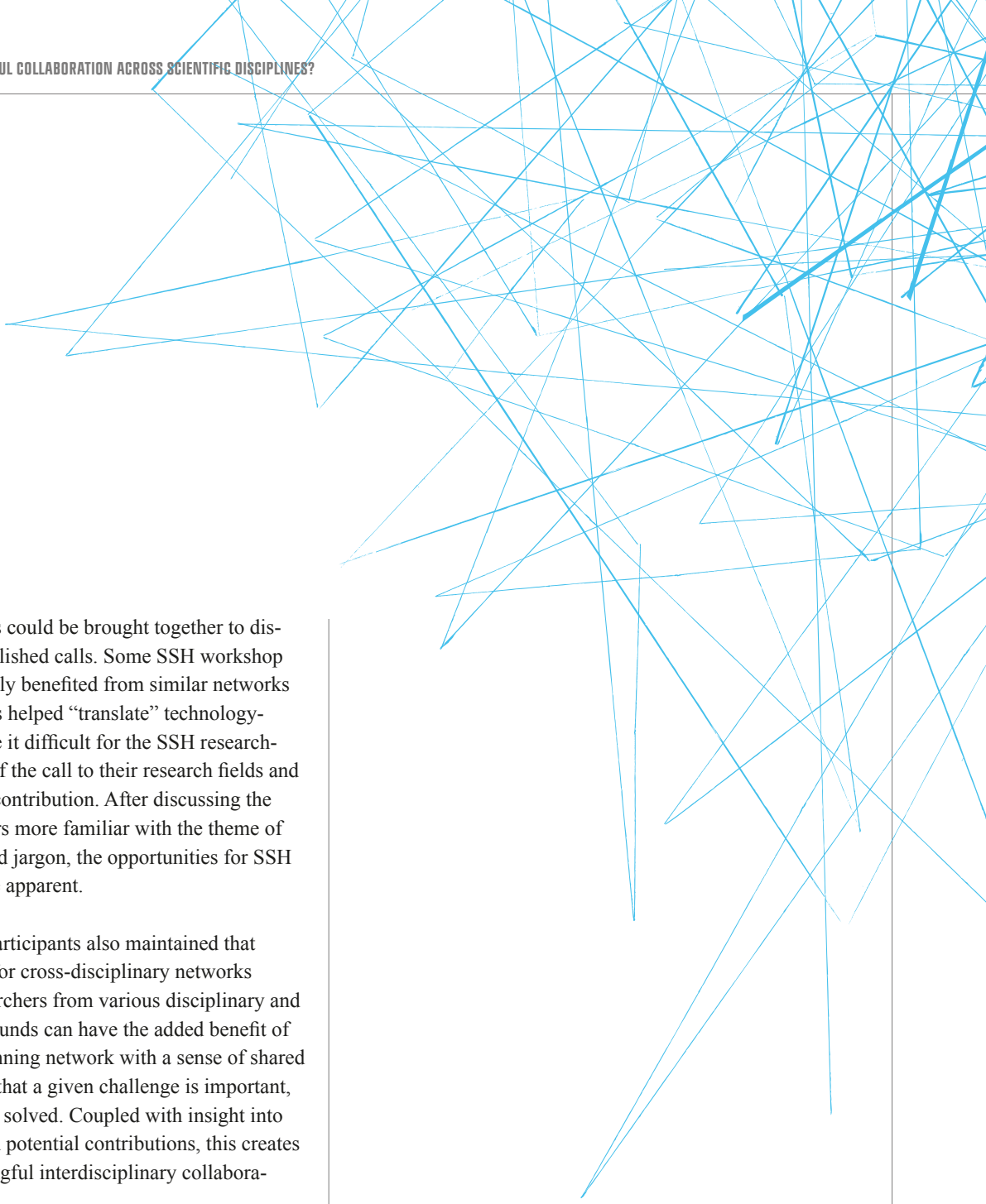
> You can't just turn on a tap and get interdisciplinary research. The networks, the ideas and the supporting infrastructure behind it need to be cultivated gradually.

This means that when calls for interdisciplinary research projects are published, researchers are likely to fall back on established contacts and, perhaps, ad hoc searches for potential partners from other disciplines. In view of one of the earlier takeaways from the workshop, namely that interdisciplinary teams should be assembled to solve specific and appropriately identified challenges, and not vice versa, this is far from ideal and therefore begs the question: how can potential collaborators find each other, e.g., in response to a specific call?

The response from several participants was that personal networks, and even targeted efforts (e.g., by university managers), at matchmaking in response to a call with an upcoming deadline can only bring you so far. Instead, participants suggested laying the groundwork for new collaborative constellations long before calls are even issued. In practice, this could mean that research funders, university managers or even key stakeholders from the wider stakeholder community in a given area (e.g. genetically modified foods, IT-related data security or sustainable energy technologies, to name a few random examples) should take steps to establish long-term ties between potentially relevant researchers from different fields by bringing them together in non-binding meetings with the purpose of promoting knowledge exchange, focused discussions and, potentially, new personal ties and collaborations. As one participant argued:

> You need compost to make the soil more fertile for interdisciplinary research. People need to know each other, understand each other's interests and abilities, to be able to explain what they're looking for, and to be open to different angles and perspectives.

This approach would allow researchers to identify potential collaborators and ideas for collaboration. The resulting networks of researchers could even be drawn upon by research funders in providing feedback on call texts, to help funders ensure that the calls are optimally phrased to stimulate original and meaningful interdisciplinary research projects that invite inputs from a broad range of relevant disciplines.



Moreover, such networks could be brought together to discuss opportunities in published calls. Some SSH workshop participants had previously benefited from similar networks in that STEM researchers helped "translate" technology-inspired jargon that made it difficult for the SSH researchers to see the relevance of the call to their research fields and therefore their potential contribution. After discussing the call with other researchers more familiar with the theme of the call and the associated jargon, the opportunities for SSH researchers became more apparent.

Some of the workshop participants also maintained that building the foundation for cross-disciplinary networks among handpicked researchers from various disciplinary and interdisciplinary backgrounds can have the added benefit of creating a discipline-spanning network with a sense of shared purpose or shared belief that a given challenge is important, needs solving and can be solved. Coupled with insight into each other's interests and potential contributions, this creates fertile ground for meaningful interdisciplinary collaborations.

Finally, these types of networks should ideally also include suitable representatives from potential users or other key stakeholders, who can help define interesting problems, shape nascent ideas for interdisciplinary research projects and, ultimately, help disseminate and implement the results of the projects.

GET REAL: EXPECT PROBLEMS AND DEAL WITH THEM HEAD ON

As previously mentioned, numerous studies show that interdisciplinarity is time and resource-consuming. It takes longer to identify research aims, to discuss the contents and links between work packages within a project, to get funding, to establish a common language and toolbox, to integrate research insights, to get published and to get cited. As a result, several participants underlined the importance of explicitly recognizing this, not just within projects (e.g., by reserving a sufficient portion of the budget for face-to-face meetings, personnel exchanges, coordination and project management), but also in the application and project preparation phase and in the subsequent assessment of publication and citation results from the interdisciplinary project.

On a related note, many workshop participants stressed the importance of creating a greater recognition of the difficulty of interdisciplinary research, which can be frustrating to the point of risking that researchers abandoned it to pursue independent research ventures. As one participant put it:

> Scientists get confused in interdisciplinary research. It makes it difficult for them to get work done.

This implies that research funders, university managers and interdisciplinary project managers have an important role to play in preparing project participants for the hurdles they are likely to meet, and in helping the researchers to overcome them. Workshop participants also discussed that all involved disciplines in an interdisciplinary project may not be equally active, or central, at all times during a project, which further complicated the task of effectively managing the collaboration without sidelining some of the project participants.

Experienced interdisciplinary researchers at the workshop also stressed that:

> Real interdisciplinarity requires a completely different approach to designing and managing research projects. You need to learn it, and that takes time. For example, sometimes you can spend half the budget just getting to know and understanding each other.

One of the most frustrating aspects of interdisciplinary collaborations highlighted by the participants is that discipline-spanning work forces researchers to change the aims they are pursuing, to work with imperfectly developed concepts and eclectic theoretical foundations, and to accept immature and often fuzzy standards for data collection and analyses. According to the participants, the magnitude and implications of these uncertainties and downsides are often underestimated by researchers who enter into interdisciplinary projects. One participant argued that:

> There will be consequences for your publications and your effectiveness. You will have to get your hands dirty. It's important to have realistic expectations, if you want to see the collaboration to an end.

Several workshop participants pointed out that SSH scientists may be particularly in need of a reality check before embarking on an interdisciplinary collaborative venture, as many SSH researchers are accustomed to working individually or in small groups of two or three people. In contrast, STEM researchers are often used to working in large laboratories and teams, and on projects with substantial budgets and multiple partners.

SUPPORT INTERDISCIPLINARY RESEARCH PORTFOLIOS, NOT STAND-ALONE PROJECTS

Some workshop participants were skeptical of what they described as a tendency to pack too much interdisciplinarity into one project, particularly where SSH-STEM collaborations were concerned. Participants reasoned that the goal of interdisciplinary collaboration was not necessarily to involve and integrate participating disciplines at all stages of the research or in all projects, but to stimulate a productive interplay between them. This point has two key implications. First, not all disciplines need to be brought into play at all times; for instance, SSH may be most relevant at the beginning of a research project, e.g., to question the formulation and underlying premises of the research questions, or towards the end, to assess the dissemination, implementation and use of a given technological solution. Second, close integration between disciplines (based on a jointly developed theoretical and methodological foundation) is not necessary at all stages of collaboration, or even in all projects. Thus, some aspects of a project may involve only SSH or STEM research, while others may promote communication and constructive dialogue, or full-on collaboration between disciplines.

One idea discussed at the workshop was to think of interdisciplinary efforts aimed at addressing complex societal challenges not as stand-alone projects that must involve all relevant disciplines in a given, short-term project, but rather as a portfolio of projects, potentially dispersed over many years, where individual projects can have varying degrees of interdisciplinarity but are joined together by a common issue and by formal interaction and informal personal relations that have developed over time.

This suggestion has significant implications for politicians and research funders, who often tend to prefer funding time-limited, flagship projects as opposed to committing to longer-term support for a less well-defined set of activities. However, taking a long-term portfolio approach to support research within a given theme allows for key issues to be addressed from multiple perspectives and at different levels of maturity, while at the same time being conducive to the gradual development of a network of researchers from all relevant branches of science. The key to reaping the potential benefits from such a portfolio approach is to successfully establish connections between key individuals and organizations and to foster opportunities for cross-fertilization between projects. Asking less of the individual project but more of the underlying program may greatly increase the chances of promoting meaningful and effective challenge-driven research collaborations across scientific disciplines.

Finally, a related theme discussed at the workshop was the need to clarify which types of challenges discipline-spanning collaboration can help solve in the effort to ensure that realistic targets are set for interdisciplinary research programs and projects. In order to provide optimal conditions for challenge-driven interdisciplinary collaborations, it is important for policymakers and research funders not to place an unrealistic amount of faith in the ability of science to solve a given challenge. As pointed out during the workshop, complex societal challenges essentially stem from policy failures. As such, science alone cannot solve complex challenges, but it can be used to identify and develop policy options and possible solutions. Other stakeholders, however, must be mobilized to actually implement and diffuse science-based solutions.

As such, the start of interdisciplinary research collaboration must begin by determining which actors will be needed for the eventual results of the project to be validated, further developed and put to effective use to bring about the desired changes and effects. As Paul Nightingale, the keynote speaker at the workshop in April, argued:

> Science policy is often used to solve political failure to deal with failed policies. Instead, we should be addressing the wider issues of how to actually solve these problems, which may or may not include science … Instead of saying fund science, we should ask which problems we want to solve. Then, and only then, should we ask if we are funding research that will help us solve them and consider what needs to happen to actually bring about the desired change. Who are the key actors and are their interests sufficiently aligned? What are the key stepping stones between where we are now, and where we want to be, and are these stepping stones in place?

Foray et al. (2012) discuss how public, mission-oriented (or, as they are known in Denmark, strategic) R&D programs should be designed to allow them to address the types of complex societal challenges we face today. Some of their key arguments underline points made at the workshop in April, for instance, that public programs should focus on long-term support for the development and improvement of possible inputs to solutions to societal challenges rather than seeking one-time breakthroughs; they also call for stable and credible funding for public, mission-oriented programs. This is in line with the suggestion to focus on portfolios of related projects rather than one-off flagship projects that are expected to solve all, or most of, a problem in one fell swoop.

In addition, Foray et al. (2012) focus on the importance of engaging with, and eventually mobilizing, private actors and other stakeholders essential to the further advancement and ultimate use of inventions, technologies and insights developed through academic research. While the authors warn against giving users too dominant a role in the design of research programs (as this, they argue, may lead to the program being "captured" by powerful user groups or to an overemphasis on near-term improvements in existing technologies over long-term, more radical research agendas), they underline the role of good communication with users, sufficient insight into their needs, and the eventual, successful mobilization of these users for increasing the likelihood that research can actually contribute to the desired aims.

an example *of*
INTERDISCIPLINARY RESEARCH COLLABORATION

ECONOMIC INSIGHTS PUT TOOLS FOR DATA SHARING AND ANALYSIS TO EFFECTIVE USE

Data security is a hot topic in the increasingly digital world in which we live. As a result, it was a breakthrough when computer scientists at the University of Aarhus began acquiring the ability to analyze encrypted data. Prior to this, data had to be decrypted before analysis was possible. This leap forward opens up a completely new set of opportunities, which are being identified in collaboration with economists.

Center for Research in the Foundation of Electronic Markets (CFEM) was established as a collaboration between, amongst others, computer scientists and economists at Aarhus University and economists at CBS.

Professor Peter Bogetoft, Department of Economics, CBS, explains that, "At CFEM, computer scientists and economists are working together in an entirely new and very interesting way."

"With the ability to analyze encrypted data," he continues, "it is possible to identify entirely new markets. This is something we economists can help the computer scientists with. At the same time, the computer scientists get an opportunity to develop entirely new algorithms that ensure anonymity and data security while also being used for very specific purposes."

"When you're in the business world," Bogetoft adds, "you're very careful about sharing data – for competitive reasons. You don't want your competitors to gain access to your data – yet the dilemma is that you really want to gain access to theirs."

For instance, in the banking sector, it can make sense for two or more competitors to share vital, but encrypted, data on consumer groups they wish to gain greater insight into. The more data that is available, and the more companies that supply data, the better the decisions that can be made. Another example is from the electricity market, where consumers are no longer bound to one supplier but instead can choose freely between multiple suppliers. The previous companies of consumers, however, are reluctant to share information on individual consumers or their needs with the new supplier. The ability to work with encrypted data, however, provides new opportunities for sharing data among competing companies.

Bogetoft clarifies that economists contribute by developing models for calculating expected profits from sharing and analyzing encrypted data in different sectors, e.g., the banking sector. "How can we ensure that this becomes a winning situation for all parties involved? This is how economists can contribute. The computer scientists come up with concrete solutions, but they must be involved from day one and onwards with the companies and sectors interested in our ability to work with encrypted data."

4 Recommendations from the workshop organizers

In the following, we present 10 recommendations for strengthening interdisciplinary research aimed at addressing societal challenges, particularly with a view to enhancing collaboration between the SSH and STEM disciplines. The recommendations were inspired by discussions at the workshop held in April 2017 but have been formulated by the organizers of the workshop, CBS and DEA.

The recommendations focus on how interdisciplinary collaboration can be promoted within strategic research programs, also known as challenge-driven or mission-oriented programs. The aims, and sometimes also the means, of these programs are defined by politicians and policymakers in an effort to stimulate research addressing challenges deemed important for society to solve. Because of their challenge-oriented nature, strategic research programs often call for some degree of interdisciplinary research. However, many of the recommendations are also relevant for other types of research programs that seek to promote effective, value-adding collaboration across disciplines.

Many actors play a role in realizing the aims of strategic research programs, which is why the recommendations target four groups of key stakeholders: politicians and policymakers, research foundations, university management, and researchers.

RECOMMENDATIONS FOR POLITICIANS AND POLICYMAKERS

1. ESTABLISH LONG-TERM STRATEGIC RESEARCH PROGRAMS WITH BROAD POLITICAL SUPPORT

All too often, funding for strategic research is given to short-term programs lasting three to five years, or even one-time calls. This severely limits public research councils in their ability to involve relevant researchers and users in preparing for and delivering proposals to strategic research programs. It also limits the opportunities and incentives for researchers and other relevant stakeholders (e.g., private or public users of research) to build networks from which ideas, collaborations and follow-on projects can emerge. We therefore recommend a political commitment to long-term strategic research programs to promote the development of lasting interdisciplinary networks, "portfolio thinking" among foundations, and strengthened incentives for institutions and researchers to engage in such programs.

2. FOCUS ON THE CHALLENGES – NOT ON PRE-IDENTIFIED SOLUTIONS

An open-ended, challenge-based call for strategic research grant proposals is more likely to stimulate original ideas and to promote meaningful interdisciplinary collaboration than a close-ended call that identifies possible solutions that proposals should or could address. Thus, politicians must take care not to define the themes for strategic research programs too narrowly, instead giving research funding foundations more leeway in designing concrete calls. In addition, politicians and policymakers should send a clear message to foundations, institutions and individual researchers to seek out meaningful interdisciplinary projects, particularly ones that involve both SSH and STEM.

RECOMMENDATIONS FOR PUBLIC RESEARCH FOUNDATIONS

The next three recommendations focus on public research foundations that administer strategic research programs, for example, the Danish Innovation Foundation and the EU's Horizon 2020. Many of the recommendations also hold relevance for other public research foundations and programs, as well as for private research foundations seeking to promote interdisciplinary, challenge-driven research.

3. PURSUE AN INTERDISCIPLINARY APPROACH TO THE DEVELOPMENT OF CALLS AND EVALUATION OF APPLICATIONS

Calls should be developed and applications evaluated on the basis of inputs from advisory boards or panels consisting of esteemed researchers from a broad range of potential disciplines (including both STEM and SSH). In order to reflect the needs of individual, long-term programs, panels can be ad hoc or permanent, but their composition must reflect the scope of the societal challenge to be addressed.

4. BUILD FERTILE SOIL FOR CHALLENGE-DRIVEN COLLABORATION ACROSS SCIENTIFIC DISCIPLINES

Foundations should – ideally in collaboration with research institutions and other key stakeholders – take the initiative to build fertile soil for cross-disciplinary collaboration. In practice, this could mean identifying leading-edge researchers across all relevant disciplines, e.g., in interdisciplinary fora that allow researchers to build mutual insight, establish personal connections and develop ideas for collaboration within a given strategic research program or a set of related programs. This would help facilitate the development of joint project applications, particularly among researchers who are new to the subject of a given challenge (and therefore do not have contact to relevant researchers from other fields).

Ideally, the foundations could even provide seed funding for early-stage ideas to be explored, or for initial collaborations to be developed, before participants apply for larger-scale projects. Seed funding may promote the establishment of more balanced partnerships and early definition of joint aims and methods.

5. PROMOTE THE DEVELOPMENT OF A COMMON LANGUAGE AND SHARED DEFINITIONS

Interdisciplinary work is often hindered by differences in "language", methods and standards for good research across different disciplines. For example, disciplines differ greatly in their under-standing of the wider societal value or impact of a research project. Foundations can help promote the development of a common language and shared definitions among an interdisciplinary group of researchers with joint interests. By doing so, foundations can, for instance, increase the likelihood that researchers from all relevant disciplines can see their potential contribution and facilitate collaboration across disciplines. Efforts by the EU and Innovation Fund Denmark to establish a concept of Societal Readiness Level give hope that a common language and shared definitions with relevance across disciplines can be established.

RECOMMENDATIONS FOR UNIVERSITY MANAGEMENT

The following recommendations are aimed at managers in universities, primarily at university and faculty level, but, where relevant, also at the departmental level. As a general comment, it is necessary for management at universities to clearly communicate – internally as well as to external stakeholders – a wish to see and support interdisciplinary collaboration. For instance, CBS and the Faculty of Science at the University of Copenhagen are working to strengthen their collaboration, but external stakeholders have yet to be told about the initiative.

6. IDENTIFY AND INVOLVE KEY PEOPLE

All research projects start with people – researchers who produce research of high quality. In the case of strategic research, the researchers who define and lead projects must also have a keen interest in cross-disciplinary collaboration and in solution-driven research. In academic research environments, collaboration cannot be effectively propelled from the top down. Instead, management should identify and support relevant researchers with an existing or potential interest in key societal challenges, and with the potential to drive interdisciplinary collaborations aimed at addressing these challenges. These researchers can act as role models and, over time, help develop a culture that supports interdisciplinarity at departments and institutions.

7. FOSTER RELATIONS AND RESPECT ACROSS DISCIPLINES AND INSTITUTIONS

Management at universities has a key role to play in promoting interdisciplinary respect and insight, not only to promote the development of science, but also to encourage the application of science in the service of society. This kind of collaboration can take many forms and involve, e.g., inviting external stakeholders to discuss societal challenges widely, promoting interest in research from other fields, offering master classes on how to make interdisciplinary collaboration work, and inviting selected researchers to discuss specific topics or societal challenges relevant to a broad range of disciplines. Fostering respect and insight based on joint interests is vital. The connections that develop may later lead to novel, cross-disciplinary project and applications.

8. SET UP THE NECESSARY ORGANIZATIONAL FRAMEWORK FOR INTERDISCIPLINARY RESEARCH

Developing and undertaking interdisciplinary collaboration requires additional time and resources, e.g., to build interpersonal networks that involve new disciplines, to define new types of research questions and to build a common “language” and methodological toolbox for research. Research shows that interdisciplinary projects face more difficulties than other types of research in attracting funding and getting published, and that getting cited in academic journals takes longer. As such, university managers who wish to encourage cross-disciplinary collaboration must provide resources and time for the involved researchers and facilitate networking.

RECOMMENDATIONS FOR RESEARCHERS

The final two recommendations are intended for academic researchers responsible for developing ideas for interdisciplinary collaborations and for carrying out these collaborations.

9. RESEARCHERS SHOULD EMBRACE STRATEGIC RESEARCH PROGRAMS AND INTERDISCIPLINARY COLLABORATION

Creating interdisciplinary research programs requires motivated researchers who are willing to take the initiative, just as achieving the full effect of research projects entails interdisciplinary collaboration. For this reason, researchers must reach out to other disciplines – and to foundations which offer strategic research programs. In particular, SSH researchers should invest time and effort in presenting the contribution, impact and value of their research projects to stakeholders in other disciplines, policymakers, industry and society at large.

10. ESTABLISHED RESEARCHERS SHOULD BE EXPECTED TO TAKE THE LEAD IN SETTING UP AND MAINTAINING CROSS-DISCIPLINARY COLLABORATIONS

Academic citizenship is key to developing the culture in universities and, in this case, to promoting interdisciplinary research and participation in strategic research projects. Senior staff, which plays a major role in this respect, can be an important role model. Not just by showing the importance of participating in interdisciplinary research and challenge-driven projects – but also in redefining, for example, the role of SSH researchers. Thus, established SSH researchers can pave the way for greater inclusion of SSH in strategic research projects by taking the lead on interdisciplinary applications that involve STEM researchers.

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