A Framework for Analyzing Broadly Engaged Philosophy of Science

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Philosophers of science are increasingly interested in engaging with scientific communities, policy makers, and members of the public; however, the nature of this engagement has not been systematically examined. Instead of delineating a specific kind of engaged philosophy of science, as previous accounts have done, this article draws on literature from outside the discipline to develop a framework for analyzing different forms of broadly engaged philosophy of science according to two key dimensions: social interaction and epistemic integration. Clarifying the many forms of engagement available to philosophers of science can advance future scholarship on engagement and promote more strategic engagement efforts.

1. Introduction. Recent years have witnessed a surge of interest in broadly engaged philosophy of science. This interest has come primarily in two forms. First, many philosophers of science are *doing* broadly engaged work; this is evidenced by a wide range of collaborations between philosophers of science and other stakeholders, such as scientists, policy makers, community groups, government agencies, and nongovernmental organizations. Indeed, in a recent survey of philosophers of science, the majority of participants reported that they had engaged with one or more of these groups as part of their work (Plaisance, Graham, et al. 2021). Second, many philosophers have been *advocating for* more engaged approaches, frequently out of a motivation to improve social and environmental welfare (Fehr and Plaisance 2010; Cartieri and Potochnik 2014; Frodeman and Briggle 2016). Some even argue that the discipline has an obligation to enhance public welfare (e.g., Cartieri and Potochnik 2014), and there is empirical evidence suggesting

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that these arguments have broad support among members of the discipline (Plaisance, Graham, et al. 2021). To meet this obligation, several national and international organizations have been founded, including the International Consortium for Socially Relevant Philosophy of/in Science and Engineering (SRPoiSE), the Joint Caucus for Socially Engaged Philosophy and History of Science (JCSEPHS), and the Society for Philosophy of Science in Practice (SPSP).[1]

Despite what seems to be a growing interest in broadly engaged work, we currently lack a framework for analyzing the variety of forms that engaged philosophy of science can take. Instead, previous accounts of engaged philosophy have focused on delineating particular approaches to engagement. These efforts serve a valuable purpose in encouraging philosophers to participate in more engaged scholarship. Nevertheless, as more philosophers of science seek to study and participate in engaged activities, it is important to develop a nuanced analysis of the range of engaged approaches and the similarities and differences among them, which is precisely what this article aims to do. Notably, our analysis focuses on the nature of engagement itself, regardless of why or with whom one might engage.

In developing such a framework, our goal is not to argue that some approaches are more valuable than others. Rather, we adopt a pluralist stance, highlighting how different forms of engagement can play important roles in various contexts. Moreover, philosophical work that is not as broadly engaged (i.e., that is focused on issues internal to the discipline) is also essential, both for its own sake and because of the ways it can inform scholarship that engages with those outside the discipline. We also resist restrictive definitions of what counts as "engaged" or even "philosophy of science," as one of the strengths of this area of inquiry is how its practitioners have creatively transcended typical disciplinary and scholarly boundaries.

In keeping with this broad approach to engaged philosophy of science, we include engagement with scientists and other scholars within academic settings, as well as engagement with stakeholders outside the academy and institutions like nongovernmental organizations, government agencies, and companies. In addition, we include activities associated not only with scholarship but also with teaching and service; this is especially appropriate given that these three categories often blur together when philosophers are doing engaged work. Some may prefer to focus only on particular forms of engagement that have historically been neglected by philosophers of science, such as collaborations with nonacademic stakeholders geared toward improving

1. For more information, see http://www.srpoise.org, https://jointcaucus.philsci.org/, and https://www.philosophy-science-practice.org/. Unfortunately, JCSEPHS was disbanded in June 2020 because the History of Science Society (HSS) and Philosophy of Science Association (PSA) no longer have plans for colocated meetings. Nevertheless, the leadership of both societies has expressed ongoing commitment to social engagement.

social welfare. However, we think it is valuable to develop a more comprehensive analysis of engagement that includes a wide spectrum of partners, goals, and activities. This enables us to analyze different approaches to engagement without presupposing which ones are most helpful for achieving particular goals. For example, even if one's goal is to improve social welfare, engagement with other academics can be an effective strategy for benefiting nonacademic stakeholders. Furthermore, distinguishing between different kinds of partners is not always clear-cut (as with the case of citizen scientists), and the partners and goals involved in a particular engagement effort often develop and change over time. Therefore, it is useful to consider different approaches to engagement together rather than in isolation.

There are several benefits of developing a framework for analyzing different forms of engagement. First, providing a more comprehensive account of the wide range of engaged activities that philosophers of science can undertake will help orient those who are interested in doing or supporting this kind of work. Second, representing and differentiating various forms of engagement is important as different forms likely come with different challenges and strategies for overcoming them, as well as different outcomes. By thinking more intentionally and critically about one's approach, it may be possible to better anticipate potential challenges or impacts, thus increasing the likelihood of achieving one's goals. Third, analyzing different forms of engaged scholarship can help foster greater institutional support and recognition for this work. Having a broad but systematic account of engaged philosophy of science gives philosophers something they can point to when others question whether such work counts as "philosophical." Finally, many philosophers of science fear that engaged approaches are not respected in the discipline, which may discourage some from pursuing this type of work (Fehr and Plaisance 2010; Frodeman and Briggle 2016; Plaisance, Graham, et al. 2021). By developing a more nuanced account of different forms of engaged philosophy of science (and engaged philosophy, more generally), we can better understand and alleviate the barriers to pursuing engaged work.

We begin in section 2 by providing some historical perspective. As we note, previous accounts of engaged scholarship excel at articulating the value of having philosophers of science reach out beyond their discipline, but they tend to focus on particular ways of being engaged rather than providing a comprehensive account of different approaches to engagement. Building on these accounts, as well as on literature from other disciplines on the topic of engagement, section 3 provides a general framework for characterizing different forms of engaged philosophy of science. Our framework focuses on two key dimensions of engagement: social interaction and epistemic integration. Both of these dimensions lie on a spectrum, meaning that engagement itself can come in a matter of degrees. In section 4, we instantiate the framework using several exemplars of engaged philosophy of science.

Finally, section 5 shows how those interested in engagement can use our framework to pursue approaches that are best suited to their particular goals and contexts.

2. Overview of Engaged Philosophy of Science. Recent scholarship on the history of philosophy of science has examined the extent to which the field has been broadly engaged over time (Howard 2009; Douglas 2016). When reflecting on this work, it is helpful to distinguish between "scientifically engaged" and "socially engaged" philosophy of science. Roughly speaking, scientifically engaged work connects philosophers of science with practicing scientists and scientific research, while socially engaged work connects philosophers of science with nonacademic stakeholders and social issues. Although we later challenge the cogency of this distinction, it helps to clarify recent discussions about the history of engaged philosophy of science. Throughout the twentieth century, a great deal of philosophy of science has been at least minimally scientifically engaged, in the sense that it has grappled with contemporary scientific concepts and theories. Moreover, many philosophers of science have collaborated with scientists, attended scientific conferences, and published in scientific journals (Plaisance, Graham, et al. 2021). Despite the prevalence of scientifically engaged scholarship, recent work in the history of philosophy of science has demonstrated that while philosophy of science was once highly committed to social engagement, it moved away from this commitment in the late 1950s (Howard 2009). Douglas (2016) illustrates this change through an analysis of the mission statements and bylaws of the PSA. As she points out, early bylaws noted the PSA's dedication to "the encouragement of practical consequences which may flow therefrom of benefit to scientists and philosophers in particular and to men of good will in general." However, in the late 1950s, those bylaws were changed and no longer mentioned any connection to or engagement with science or society (Douglas 2016). Vaesen and Katzav (2019) attribute this change in part to the National Science Foundation's funding policies, which favored value-free philosophy of science.

This situation seems to be changing. Over the past decade, there has been a resurgence of work advocating for and demonstrating socially engaged approaches (e.g., Plaisance and Fehr 2010; Cartieri and Potochnik 2014; Katikireddi and Valles 2015; Frodeman and Briggle 2016). Feminist scholarship played an important early role in this development, pushing philosophers to think about how science and the philosophy of science were embedded in their social context and could be used to change that context for the better (e.g., Longino 1990; see Kourany [2010] and Richardson [2010] for historical overviews). This contributed to a large body of work on the roles that values play in scientific research (e.g., Longino 1990; Douglas 2009; Elliott 2017) and on ways of making scientific practices more socially

responsible (e.g., Kourany 2010; Schienke et al. 2011; Biddle 2013; Elliott and Resnik 2019; Fernández Pinto and Hicks 2019; Brown 2020).

Moreover, it is not just philosophers of science who are advocating for more engaged approaches. In 2017, Valerie Tiberius conducted a survey of philosophers on the "well-being" of philosophy, seeking their views on the value of different approaches to philosophical work. Tiberius found that, overall, philosophers "value interdisciplinarity, relevance, engagement, and diversity," while they "do not value 'sticking to tradition' in a way that excludes new methodologies" (2017, 68). As with philosophy of science, new networks and organizations have emerged to support engaged philosophy, such as the Public Philosophy Network (http://www.publicphilosophynetwork.net) and Engaged Philosophy: Civic Engagement in Philosophy Classes (https://www.engagedphilosophy.com/). These initiatives demonstrate that philosophers are taking seriously the importance not only of engaged scholarship but of engaged teaching and service as well (e.g., Shrader-Frechette 2010; Dotson 2015).

As attention to the importance of engaged approaches has reemerged, philosophers have developed accounts of socially and scientifically engaged philosophy of science. Below, we provide brief overviews of three major accounts that serve as an important starting point for our framework: socially relevant philosophy of science, socially engaged philosophy of science, and field philosophy. As we argue below, while all of these accounts have a good deal of merit—and have played a key role in articulating the benefits of and need for more engaged approaches—they do not analyze the nature of engagement itself in detail. This is precisely what we seek to do in section 3.

In 2010, Carla Fehr and Kathryn Plaisance proposed a pluralistic endeavor called Socially Relevant Philosophy of Science (SRPOS). As they explain, the project "arose out of a keen sense of lost opportunities for philosophy of science to effectively contribute to public welfare" (Fehr and Plaisance 2010, 302). On their account, SRPOS includes philosophical work that (1) relates to scientific research and topics that are "directly relevant to public welfare," (2) "focuses on or engages various *stakeholder groups*," or (3) aims for a broader set of practices and venues in which philosophers engage (302–3). The name of this account—socially *relevant* philosophy of science—may make it seem as though Fehr and Plaisance are advocating for work that is merely relevant to society without being explicitly engaged. However, each of these three facets can involve broadly engaged approaches (in fact, the second facet they list explicitly points out that SRPOS includes work that engages stakeholders directly). Fehr and Plaisance offer four examples of SRPOS that illustrate the breadth of this type of work: collaborating with scientists; addressing policy, regulation, and institutional structures; investigating relationships between scientific communities and lay publics; and changing philosophical practice.

Shortly thereafter, in 2014, Francis Cartieri and Angela Potochnik advanced a more restrictive account, which they call Socially Engaged Philosophy of Science (SEPOS). SEPOS is intended to be "a program of research, education, and advocacy, undertaken by philosophers of science *qua* philosophers of science, with the aim of improving human welfare" (Cartieri and Potochnik 2014, 909). Notably, the general aims of SEPOS and SRPOS are quite similar; where they differ is in the range of more specific goals and approaches that fall under one or the other account. Cartieri and Potochnik lay out three desiderata of SEPOS: public motive (to improve public welfare), specificity (both in terms of the socioscientific issue and the stakeholders involved), and accessibility (to the relevant stakeholders). This last criterion captures the 'engaged' part of SEPOS, as it necessitates that "work is published in ways that reach relevant communities and is presented in terms that they will engage with" (910). This requirement is key, as Cartieri and Potochnik want to "move beyond producing socially relevant work, to actually effecting social change" (912).

The concept of field philosophy was first introduced in Frodeman (2008) and developed in detail in Frodeman and Briggle (2016). Frodeman and Briggle lay out several characteristics of field philosophy (FP), where its goal is to address "philosophical dimensions of real-world policy problems," its approach is to start with problems "as defined and contested by the stakeholders involved," and its audience is "non-disciplinary stakeholders" (124). Frodeman and Briggle stipulate that success is based on "how effective the field philosopher is in achieving non-disciplinary goals" (126). In other words, it is the goals of the nondisciplinary stakeholders with whom one is engaging that motivate and drive the work, rather than those of the philosophers themselves. More recently, in an edited volume on FP, Brister and Frodeman also emphasize that FP is necessarily collaborative in nature and that it "aims to make something other than a research article; its primary goal is to work with others to craft a new policy, practice, community, or object" (2020, 5). Thus, FP is focused on particular types of outcomes that align with its broad goals.

Overall, these three accounts share an overarching aim of improving public welfare. Where they differ is on the particular aspects of the aim that they emphasize. SRPOS is a broad account that articulates the benefits of examining socially relevant topics and issues, which may or may not include broader engagement as part of one's approach. SEPOS requires that work be made accessible to relevant stakeholders and that it be driven by the aim of effecting social change. Cartieri and Potochnik emphasize that, "under SEPOS, this effect is intentional and primary rather than incidental and secondary" (2014, 912). FP takes this a step further by requiring collaboration with nondisciplinary stakeholders, where the philosophical work itself is driven by problems as defined by the stakeholders themselves.

These efforts to articulate particular approaches to engaged philosophy of science can be extremely helpful, especially when trying to reenergize particular forms of engaged scholarship. However, they can also put too much focus on what 'counts' as doing (or not doing) SRPOS, SEPOS, or FP, rather than emphasizing the wide range of approaches that are available. Furthermore, difficulties may arise when trying to apply the specific criteria used to differentiate these approaches from more traditional philosophical work (or from one another). For example, while reflecting on one's aims and intentions can be useful for considering what approaches are most promising, requiring that philosophers' aims be "intentional and primary" is challenging in practice. Philosophers often do not have straightforward aims when they begin collaborative activities; they may be motivated initially by curiosity or personal relationships, but upon discovering what their collaborations can achieve, their aims may shift and evolve (Kennedy 2019). Similarly, it is often difficult to divide research topics neatly into those that advance public welfare and those that do not, especially since it is often difficult to know in advance what the social effects of particular scientific research programs might be.

Instead of focusing on what criteria should be used to determine whether something counts as engaged, or advocating for a particular approach, we seek to analyze the nature of engagement itself. In doing so, we argue that engagement is best seen as a two-dimensional spectrum, with different approaches falling in different regions of the spectrum. This allows for a broad and inclusive framework for analyzing engagement in a manner that can help articulate key differences among different approaches, such as those discussed in SRPOS, SEPOS, and FP.

3. A Framework for Analyzing Engagement. At its core, we view engagement as *connecting with someone or something*. Thus, broadly engaged philosophy of science involves the formation of connections with people, institutions, or ideas from outside the discipline. These connections can be classified according to two key dimensions: social interaction and epistemic integration. We represent these dimensions as axes that structure a two-dimensional spectrum of approaches to doing philosophy of science (fig. 1). The dimension of social interaction represents approaches that range from being highly individual to those that involve extensive collaboration with others outside the discipline (e.g., scientists, policy makers, or community stakeholders). The dimension of epistemic integration captures the extent to which one's work integrates epistemic elements from the philosophy of science with epistemic elements from outside the discipline, with intradisciplinary approaches at one end and transdisciplinary approaches at the other.[2]

2. Others have discussed both epistemic and social dimensions of cross-disciplinary integration in ways that are compatible with our framework (e.g., Klein 1990; Bergmann,

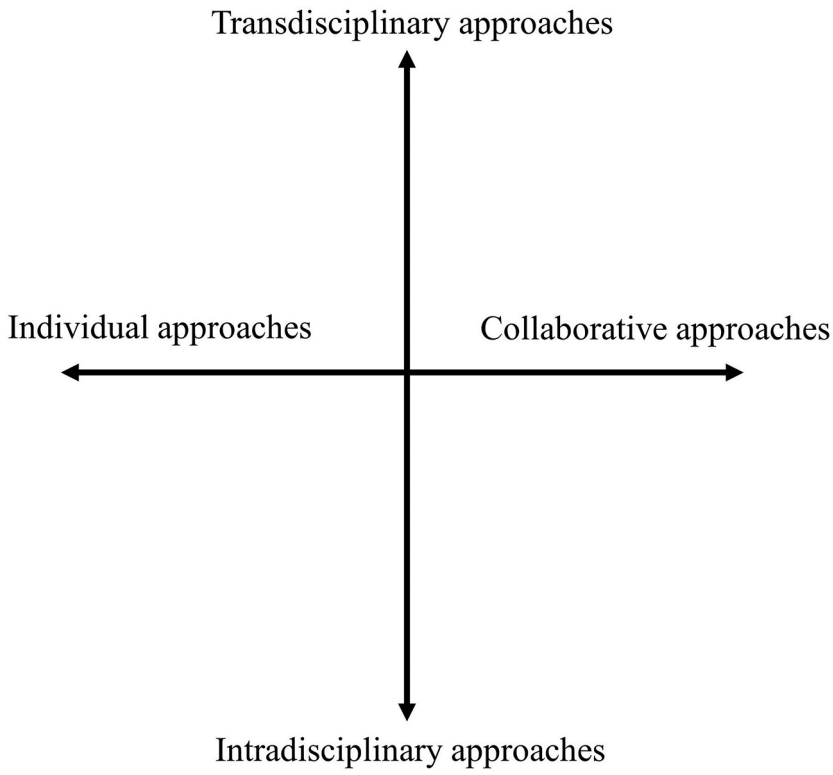

Figure 1. Approaches to the philosophy of science, organized according to two dimensions of engagement: social interaction and epistemic integration.

In sections 3.1 and 3.2, we explicate these two dimensions. In the course of doing so, we draw on and cross-pollinate different bodies of literature, demonstrating how more general work on engaged scholarship and cross-disciplinary integration can help clarify the types of engaged activities available to philosophers of science.

Ultimately, a complete account of broadly engaged philosophy of science would need to describe other aspects of engagement, such as its aims or goals, partners, impacts or outcomes, and the barriers one might encounter. In order to approach this complex topic in a manageable way, we focus here on providing an account of the different forms that engagement can take (i.e., its social and epistemic features), regardless of other aspects such as the specific aims or partners. In section 5, we revisit these other aspects,

Klein, and Faust 2012; O'Rourke, Crowley, and Gonnerman 2016; O'Rourke et al. 2019).

showing how this framework can lead to more thoughtful decisions about which forms of engagement are most appropriate for achieving particular aims, working with particular partners, avoiding particular barriers, and so on.

3.1. Social Interaction. The *X*-axis of figure 1 represents the dimension of social interaction between philosophers and others outside the discipline. Forms of engagement toward the left end of the figure involve work done primarily as an individual, whereas activities toward the right involve more collaboration between philosophers of science and other individuals, communities, or organizations outside the discipline. Several articles in the broader literature on engaged scholarship have characterized degrees of engagement from a social perspective, focusing on the level of reciprocity or mutuality between the engaged parties (e.g., Stanton 2008; Saltmarsh, Hartley, and Clayton 2009; Doberneck, Glass, and Schweitzer 2011). Doberneck et al. (2011) characterize engagement in terms of two constructs: *intensity* and *degree*. They analyze intensity as a function of the "frequency, duration, and complexity of faculty members' interactions with community partners" (19). Degree of engagement is characterized by "the extent to which faculty members collaborated with their community partners in reciprocal, mutually beneficial ways" (19). To assess the reciprocity, Doberneck et al. (2011) examined factors such as the extent of shared decision making and the bidirectional flow of information between the partners.

Drawing on this literature, we classify philosophers of science as taking a more collaborative approach with those outside the discipline to the extent that they display (*a*) longer or more frequent interactions, (*b*) more bidirectional flow of information, and (*c*) more joint control over decision making (e.g., shared control over the choice and development of projects rather than decisions made by one partner). This is not an exhaustive list of the factors one could use to assess degrees of social interaction, but it provides a promising starting point. One could treat these factors as distinct dimensions, rather than components of a single dimension, to develop a particularly fine-grained taxonomy of different varieties of engagement. Nevertheless, we chose to group these different elements together in a single category for the sake of creating a more economical framework. Furthermore, although these different elements are not perfectly correlated, they are often related (e.g., longer term interactions provide more opportunities to build trust, which is often required for genuinely shared control over decision making).

When philosophers of science engage with people outside the discipline in ways that meet all three criteria, we would classify such work as highly collaborative. An example of this is Adam Briggle's long-term partnership with community members to develop policy recommendations for hydraulic fracturing (see sec. 4 for an extended analysis of this example). Yet, when

one or more criteria are met (e.g., frequent meetings over an extended period of time) but others are not (e.g., an absence of shared decision making), the social interaction would be placed toward the middle of the *X*-axis. Ken Waters's approach to immersing himself in a relevant scientific community to develop his account of the gene concept is a good example of this (see sec. 4).

We acknowledge that some readers might prefer to reserve the term "engagement" to describe highly collaborative activities that involve bidirectional information flow and joint decision making with stakeholders outside the academy. Similarly, one might apply the label of "public philosophy" to work that disseminates scholarship outside the academy and the term "interdisciplinary" to collaborative work within the academy. We would like to resist the temptation to carve up broadly engaged philosophy of science into these separate categories. For one thing, some philosophers of science are already including "public" activities like the production of blog posts and op-eds under the umbrella of "socially engaged" work (e.g., Cartieri and Potochnik 2014). Even more importantly, we think there is value in providing a unifying framework that can consider these activities together, especially since they frequently share common goals of benefiting public welfare and face many of the same barriers. Thus, it is helpful to have a framework that can capture both the similarities and the differences among them. We use the term "broadly engaged philosophy of science" to clarify that we are capturing a broader range of activities than would be considered in the literature on engaged scholarship more generally (e.g., Doberneck et al. 2011).

3.2. Epistemic Integration. The second dimension of engaged activity, represented by the *Y*-axis in figure 1, is epistemic integration. Here, we draw on an extensive literature that discusses integration of knowledge claims (e.g., Bergmann et al. 2012; O'Malley and Soyer 2012; O'Rourke et al. 2016). At a general level, integration can be described as a process through which inputs are combined (fused, knit, mixed, etc.) to generate outputs (O'Rourke et al. 2016). Different forms of integration can be distinguished on the basis of the sources of the inputs, the ways in which inputs are combined, and the outputs that result (O'Rourke et al. 2016). On our framework, inputs involve epistemic elements from other fields or domains (e.g., theories, concepts, models, methods, data) that are integrated with epistemic elements from philosophy of science. To understand the various ways inputs can be combined, we turn to literature on multi-, inter-, and transdisciplinary research (e.g., Klein 1990; Eigenbrode et al. 2007; Lotrecchiano 2013).[3]

3. Although we use literature on cross-disciplinary research to characterize the nature of epistemic integration, we find the terminology employed in this literature to be limiting insofar as it specifically refers to disciplines (rather than, say, epistemic communities). Philosophers of science can engage with epistemic communities and ways of knowing

According to Lotrecchiano and Misra (2020), unidisciplinary research (also called mono- or intradisciplinary research) involves relatively narrow forms of epistemic integration, as epistemic elements are not shared or altered across disciplines. In multidisciplinary research, knowledge claims are *shared* between two or more disciplines, making these approaches somewhat more integrated. However, in multidisciplinary research, the epistemological framework of one discipline also tends to take priority, and the methodological approaches of the disciplines involved typically remain unchanged. This form of research brings together epistemic insights after they have been generated, with the added step of amalgamating those insights to produce a broader or more complex picture. In the case of interdisciplinary research, epistemic elements (e.g., methods, models, and theories) are *adjusted* through interactions between disciplines, thus leading to higher levels of epistemic integration. Finally, transdisciplinary research includes the highest levels of integration, involving deeper *transformations* that break down traditional disciplinary approaches and generate long-term changes in research practices.[4]

Drawing on this literature, the degree of epistemic integration between the philosophy of science and another field or domain can be described as greater (and thus further up the *Y*-axis) to the extent that (*a*) epistemic elements are altered or transformed (as opposed to merely being shared or critiqued), (*b*) the integration generates changes to large-scale theoretical frameworks or epistemic practices rather than just specific epistemic elements, and (*c*) the integration affects both philosophy and the partner domain. Again, we do not claim that this is an exhaustive list of the factors that characterize epistemic integration. Moreover, we acknowledge that these factors could be treated as separate dimensions rather than as elements of a single dimension. For the sake of economy, however, these elements provide a helpful starting point for analyzing degrees of epistemic integration.

Returning to figure 1, when philosophers of science do work that is completely intradisciplinary, it would be at the bottom of the *Y*-axis. When they and their partners share information with each other but do not otherwise significantly change their ideas or practices, we would place such approaches somewhat higher on the *Y*-axis. When philosophers use their conceptual

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that are not structured in terms of disciplines. Thus, even though we use this terminology to describe the extent to which epistemic integration occurs, the epistemic components being integrated on our framework are not always associated with academic disciplines.

4. We follow O'Rourke et al. (2019) in our use of the term 'transdisciplinarity', which captures higher levels of integration. Others use the term to refer to approaches that necessarily involve nonacademic stakeholders, but we prefer to separate the epistemic aspects of integration from the particular partners with whom one is working. For a detailed discussion on the philosophy of interdisciplinarity, see Frodeman, Klein, and Pacheco (2017).

skills to critique or clarify ideas for their partners, or when the partners successfully challenge philosophical ideas, this would count as a more extensive form of epistemic integration insofar as it involves changes to initial ideas and thus would be placed even higher on the *Y*-axis. Many blog posts and op-eds would likely appear in the middle of the figure, given that they are typically written in ways that integrate philosophical concepts or insights with examples or problems from outside the discipline. Even deeper forms of epistemic integration occur when philosophers or their partners substantively change their epistemic practices. This might occur, for example, if scientists alter not only a specific concept but a theoretical framework or a methodological approach in response to input from philosophers of science. Nancy Tuana's work with climate scientists on coupled ethical-epistemic issues is a good example of this, which we discuss in section 4. Finally, a particularly deep form of integration would occur if both philosophers and their partners changed their epistemic practices in response to their interaction.

It is important to emphasize that our description of epistemic integration is not limited to interaction between philosophers of science and other scholars who work within academic disciplines. Philosophers of science and stakeholders outside the academy can share ideas and perspectives, as well as sharpen and alter each other's views and approaches, as we demonstrate in section 4. Philosophers of science are also uniquely situated to help facilitate interactions between other academic and nonacademic stakeholders (Whyte and Crease 2010). In doing so, they often use their philosophical skills to clarify the views of different stakeholders and the relationships between them.[5] This facilitative form of epistemic integration can be extremely valuable.

4. Engagement in Action. To illustrate how this framework can illuminate our understanding of the differences among engaged approaches, we provide examples of engaged philosophy of science from different areas of figure 1. Notably, we focus on specific philosophical projects, as any one individual can take vastly different approaches over the life of a career.

We start with the upper-right quadrant, which involves relatively high levels of social interaction and epistemic integration. An example of this type of engagement can be seen in Nancy Tuana's work with climate scientists. For many years, Tuana has collaborated with climate scientists at Penn State University to help them identify assumptions and values embedded in the decisions they make when constructing climate models. To achieve this, Tuana identified scientists interested in working together, spent a significant amount of time improving her own understanding of climate science, and

5. The Toolbox Dialogue Initiative, which uses philosophy as a tool for enhancing interdisciplinary collaboration, is a perfect example of this (see O'Rourke and Crowley 2013).

met on a regular basis with her interdisciplinary research team. These meetings involved two-way communication to ensure Tuana understood the decisions climate modelers have to make and to enable her to help identify the values that might be driving particular decisions. Furthermore, it resulted in the formation of a National Science Foundation sustainable research network on Sustainable Climate Risk Management (SCRiM). This work is high in every aspect of social interaction: it is long term and frequent; involves bidirectional flow of information, ideas, and analysis; and includes joint control over decision making (e.g., regarding the content of coauthored publications). It is also high on epistemic integration: by working with Tuana, her scientist collaborators were better able to uncover and scrutinize particular values and assumptions that led to changes in their modeling techniques. Tuana has integrated the results of these collaborations in her own work, advancing her framework of 'coupled ethical-epistemic' analyses (Tuana 2017). Tuana's team has gone beyond sharing to altering one another's models and theories and generating new scientific and philosophical insights. What's more, SCRiM provides a persistent context through which future interdisciplinary integration can occur. Notably, Tuana has also leveraged insights from this work to identify gaps in policy makers' understandings of climate models and risks, making her work all the more socially relevant and engaged. Thus, it also illustrates how philosophical engagement with other academics can lead to broader social impacts.

Before moving on to other quadrants, we discuss a second example of high social interaction and epistemic integration to illustrate the ways engagement can vary even within a particular quadrant. To do so, we look at Kyle Whyte's work with Indigenous communities to develop adaptation plans for responding to climate change. Whyte's scholarship highlights the fact that engaged philosophy of science is not limited to direct interactions between a philosopher and another individual or small group of people; it can also include engagement with broader communities and organizations. Moreover, engagement can include the efforts of a philosopher to facilitate knowledge exchange among other individuals and communities.

As a member of the Citizen Potawatomi Nation, Whyte has collaborated a great deal with Indigenous groups in the United States and around the world. His work involves developing future scenarios that characterize the potential effects of climate change on tribal communities and partnering with those communities to develop plans for scientific research and to create policies that address the scenarios they have developed (Whyte et al. 2014). The planning process typically involves workshops that incorporate scientists, policy makers, tribal leaders, and community members. Importantly, Whyte often uses a theoretical model—the Menominee Theoretical Model of Sustainability (MTMS)—to emphasize important issues that need to be considered during the planning process (Dockry et al. 2016). Whyte's

work displays an extremely high level of social interaction. In order to organize workshops for scenario planning, he meets in advance with a variety of stakeholders to identify priorities and develop scenarios.[6] Thus, he engages with communities over extended periods of time in ways that involve a great deal of bidirectional communication. His work also displays a high level of epistemic integration. In this respect, Whyte's efforts have much in common with the work Tuana has done to help climate scientists recognize the social and ethical ramifications of their research choices. The MTMS calls for scientists and policy makers to consider an array of issues related to economics, culture, and Indigenous sovereignty as part of their planning. By bringing together community members with scientists and policy makers and using the MTMS framework, Whyte fosters new approaches to applied science and policy making that take the knowledge and concerns of Indigenous communities into account.

Next, we consider engagement activities that fall in the upper-left quadrant of figure 1, which involve lower amounts of social interaction but medium-to-high levels of epistemic integration. Many philosophers of science have done research that fits in this quadrant. Waters's (1994) work on the gene concept is a particularly good example. To develop his account, Waters spent several months immersed in a community of molecular biologists, listening to how they used the term 'gene' and aiming to understand the reasoning they used in their arguments about genetic causation. His approach involved some social interaction, given that he spent significant amounts of time in the presence of scientists. However, Waters's approach was not bidirectional, nor did it involve shared decision making; in fact, he intentionally refrained from trying to influence scientists.[7] Thus, Waters's form of engagement in this project was not as collaborative as Tuana's or Whyte's approaches. In terms of epistemic integration, however, Waters's approach was relatively high, as the development of his account relied heavily on what he learned from listening to scientists.[8]

To illustrate what scholarship in the lower-right quadrant of figure 1 might look like, consider Adam Briggle's work on fracking. Briggle is a proponent of FP, which he put into practice as a participant in citizen efforts to ban hydraulic fracturing (fracking) in his hometown of Denton, Texas. His efforts began when a city council member asked him to help form the Denton Stakeholder Drilling Advisory Group (DAG) to advise the city on policies related to fracking. His subsequent activities were extremely high on the spectrum of social interaction. He engaged in meetings with the citizens

6. Whyte, pers. comm., 2019.

7. Waters, pers. comm., 2019.

8. For a more detailed analysis of this case, see Plaisance (2020).

on the DAG for years, met with numerous community members to discuss the issues, and when the DAG concluded that a ban on fracking was the best course of action, he engaged in political campaigning on behalf of the ban. His efforts were extremely influential insofar as a ban was ultimately passed, but his work did not involve a great deal of epistemic integration. He used his philosophical skills primarily to help clarify the issues at stake, both in community meetings and in online blogs and popular essays (e.g., Briggle 2012a, 2012b). His subsequent book (Briggle 2015) provides an excellent introduction to ethical principles and scientific issues related to fracking debates, but for the most part he applied these ideas to the fracking debate rather than generating radically new philosophical ideas. This is not to take away from the value of his efforts; his book and popular essays are perfect examples of doing clear and engaging philosophical work for broader publics that has led to significant impacts.

Kristin Shrader-Frechette is another philosopher of science who has done a great deal of engaged work. Although her activities have spanned multiple quadrants, some of her projects illustrate that one can do highly impactful work that falls in the lower-left quadrant of figure 1, which involves relatively low social interaction and epistemic integration with other fields. In much of her work, she takes an area of research, a risk assessment, or an environmental impact statement and highlights its flaws so that it does not contribute to problematic public policies. An example is her critical analysis of scientific research on hormesis, a phenomenon involving alleged beneficial effects associated with exposure to low levels of pollutants that are toxic at higher dose levels (Shrader-Frechette 2010). Government agencies like the US Environmental Protection Agency use default models to extrapolate from the toxic effects of chemicals and radiation observed in high-dose animal studies to the effects that would likely occur in humans at lower doses. Edward Calabrese, a prominent hormesis researcher, argued that government agencies should change their default models to assume that low-dose exposures to toxic chemicals are not harmful (Calabrese and Baldwin 2001). Shrader-Frechette critically evaluated Calabrese's research, focusing on the concept of hormesis. She argued that he unjustifiably shifted between the concept of hormesis as a phenomenon that only occurs occasionally to the concept of hormesis as a phenomenon that is generalizable across different species, chemicals, and biological endpoints (Shrader-Frechette 2010, 2014, chap. 3). On the basis of her analysis, she argued that his policy recommendations were not justified.

Shrader-Frechette's work in this example is engaged to at least some extent given that it involves connections with people, institutions, and ideas from outside philosophy. Thus, in contrast to philosophical work that would be placed at the far bottom left of figure 1 (i.e., work that involves no collaboration or epistemic integration with people or ideas from outside philosophy

of science), Shrader-Frechette's work would be placed closer to the middle of the *X*- and *Y*-axes. Nevertheless, we would still place it in the lower-left quadrant because the connections in this particular project (as opposed to many of her other projects) involve relatively low levels of social interaction and epistemic integration. In this case, Shrader-Frechette did not meet personally with Calabrese or engage in extended conversations with him about his research; instead, she focused on reading his published work. Her social interaction with the scientific community was limited and indirect, although she did publish some of her work in a scientific journal, thereby increasing its likelihood of being taken up by the scientific community (Shrader-Frechette 2008).[9] Her work displayed some epistemic integration insofar as she used philosophical tools of conceptual analysis to challenge elements of Calabrese's research, but this was a relatively limited form of integration. Shrader-Frechette was not seeking to integrate philosophical insights with hormesis research to develop a more fruitful or sophisticated research program; rather, her focus was almost entirely critical. At the same time, Shrader-Frechette's work has had significant influence on science policy, illustrating that broadly engaged work does not need to be high on either dimension in figure 1 to have important impacts outside the discipline.

5. Planning Engaged Approaches. Our framework distinguishes different forms of engagement, highlighting how philosophers of science can forge connections that vary along both social and epistemic dimensions. We take these dimensions to be fundamental to describing the form of engagement activities; however, there are other important aspects of engagement to consider, including goals, outcomes, partners, and barriers. In table 1, we provide a list of questions that philosophers of science can consider in order to promote more thoughtful engagement efforts. As the last question in the table highlights, the framework we have provided in this article can help those interested in engaged scholarship pursue forms of engagement that make the most sense for their projects. In this section, we briefly illustrate the kind of reflection that our framework can help facilitate.

5.1. Goals and Outcomes. Different forms of engagement are likely to lead to different outcomes and can help achieve different goals. For example, engagement activities that incorporate extensive social interaction with local communities are ideal for enhancing one's knowledge about those

9. McLevey et al. (2018) examined citation patterns of peer-reviewed journal articles written by philosophers of science and found that scientists were much more likely to cite philosophers' papers that were published in science journals than those published in philosophy journals.

TABLE 1. Questions for Reflecting on Broadly Engaged Approaches in Philosophy of Science

What are your goals or aims?
What outcomes will help you achieve your goals?
With whom do you need to engage in order to achieve these goals and outcomes?
What barriers might you face as you pursue your engagement efforts?
What steps could you or the broader philosophical community take to address those barriers?
What forms of engagement are most appropriate for achieving your goals and outcomes, working successfully with your partners, and overcoming potential barriers?

communities and their interests. However, given the commitment of time and energy that might be needed for engaging effectively and ethically with some communities, it might not be advisable to pursue such activities without evaluating whether they are truly essential for achieving particular outcomes. In other cases, philosophers of science might underestimate the degree to which social interaction is needed to achieve their goals. For instance, many philosophers of science would like to integrate insights from philosophy of science into scientific work. However, these contributions might not be taken up by the scientific community if philosophers do not spend enough time talking with members of the relevant scientific community, attending their conferences, writing joint papers, and publishing in their journals (Plaisance 2020; Plaisance, Michaud, and McLevey 2021). Careful attention to how particular forms of social interaction facilitate various forms of epistemic integration could help philosophers of science achieve the outcomes and impacts they seek.

5.2. Partners. Different forms of engagement are also more or less advisable depending on one's partners. For example, working with local communities often requires high levels of social interaction in order to build relationships and cultivate trust, especially when those communities have been marginalized or mistreated. In contrast, when philosophers of science are engaging primarily with ideas from outside philosophy, as we see in Shrader-Frechette's work, it may not be necessary to foster extensive social interaction. It is also important to consider the institutional contexts in which one's partners work. Depending on whether a scientist is at one's university, in a government agency, or in a private company, different forms of engagement may be more or less feasible or appropriate. For example, scientists in private companies may be working with confidential business information that makes information sharing, and thus epistemic integration, more difficult. Citizen scientists, however, are often members of the community who do not have such constraints (Cavalier and Kennedy 2016; Elliott and Rosenberg 2019), yet they may not share the same types of institutional

support that other scientists enjoy. This blurring of the line between scientists and publics may require or encourage different forms of engagement between philosophers of science and these partners.

5.3. Barriers. Different forms of engagement are also likely to face different barriers, regardless of the partners or stakeholders. Typically, forms that involve only one-way epistemic integration (in which a philosopher incorporates others' perspectives or ideas) and are relatively low on social interaction will be less time consuming. Such approaches may also be less likely to depart from the typical incentive structure of philosophy and academia more generally. If the goal of the engagement is to inform one's philosophical view, and the main outcome consists of peer-reviewed publications in philosophical venues, then engagement is unlikely to threaten one's career trajectory. Ken Waters's work on the gene concept is a good example of this. As Waters himself notes, despite the amount of time he spends in scientists' labs, other philosophers do not seem to question whether he is "really" a philosopher, which he attributes to the fact that his primary goal is to enhance his philosophical accounts and that his outcomes fit within the discipline's typical reward structure.[10] In contrast, approaches to engagement that involve high levels of reciprocal social interaction are likely to be much more time consuming and less likely to generate publications that facilitate one's career advancement. In some cases, such as Whyte's engagement with Indigenous groups, one might be working with sensitive information that partners would prefer not to be published. In other cases, such as Briggle's work with local communities, academic publications might be less likely to further the goals of one's engagement activities than dissemination activities geared toward broader publics. Recent philosophical scholarship on the barriers to engaged philosophy has illustrated a lack of alignment between such activities and the discipline's typical reward structure (e.g., Tiberius 2017; Plaisance, Graham, et al. 2021). Our framework can be used to develop a more nuanced understanding of the barriers to engaged work and the strategies for resolving them by attending to the unique characteristics of different forms of engagement. It is possible that it is not engagement itself but rather the time commitments and the outcomes associated with particular forms of engagement (e.g., writing white papers or blog posts as opposed to academic papers) that have the greatest ramifications for career advancement.

5.4. Engagement as an Iterative Process. Of course, not all philosophers of science interested in broadly engaged work will systematically work through all of the issues from table 1 in advance. Engaged projects are likely to develop in an iterative and piecemeal fashion. Just as it has proved fruitful

10. Waters, pers. comm., 2019.

to study the iterative process of scientific progress (Chang 2007; Elliott 2012), it may be fruitful to study the iterative development of engagement activities as well. A philosopher of science might begin with one form of engagement (e.g., having conversations with an academic scientist), which can open doors for other forms of engagement (e.g., attending lab meetings).[11] Such social interactions can lead to new opportunities for epistemic integration. However, achieving these deeper levels of epistemic integration might require more extensive forms of social interaction that could slow down a philosopher's career trajectory. We think the questions in table 1 can prove fruitful as philosophers of science reflect on the course of their engagement efforts and consider ways to advance them while navigating tensions with disciplinary incentives.

6. Conclusion. The time is ripe for philosophers of science to develop a more systematic understanding of the range of ways they can engage outside the discipline. Building on previous accounts of engaged work, we have proposed a framework for analyzing broadly engaged philosophy of science, focusing on the different types of connections philosophers of science can form with people and ideas outside the discipline. Drawing on the broader literature related to engaged scholarship and cross-disciplinary research, we have characterized these connections in terms of the degrees to which they exhibit social interaction and epistemic integration. Furthermore, we have illustrated how this framework can highlight important differences among various forms of engagement, which will be useful for advancing future scholarship on engaged philosophy of science. As we illustrate, different approaches have varying advantages and disadvantages, so rather than regarding particular approaches as more valuable than others, we suggest philosophers of science explore how different forms of engagement can prove most helpful for accomplishing particular goals in particular contexts.

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11. See Plaisance, Michaud, and McLevey (2021) for an empirical analysis of the relationship between these activities and the broader uptake of philosophical work.

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