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ORIGINAL ARTICLE

The Grand Concepts of Environmental Studies Boundary objects between disciplines and policymakers

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Abstract

Inter- and transdisciplinary collaboration is necessary in order to take on the environmental challenges facing humanity. Different disciplines, stakeholders, and policymakers need to work together to produce the knowledge necessary to create effective and just courses of action to counteract environmental problems. Recently, the notion of 'boundary objects' has been increasingly used within environmental studies to explain how some objects facilitate communication across the boundaries between different groups of actors. Due to their vague use in common contexts and specific use in each group, these objects let groups retain their own understanding while still communicating successfully with others. Novel concepts like 'resilience', 'ecosystem services', and 'sustainability' are due to their interpretive flexibility commonly described as boundary objects. However, in order to implement these concepts in concrete policy, some amount of standardization is needed. This presents a tension with the vagueness required for the facilitation of communication. This paper explicates whether and how novel concepts in environmental studies can be usefully understood as boundary objects. I review how boundary objects have been applied in the literature surrounding inter- and transdisciplinary collaborations, focusing especially on instances where concepts were considered to be boundary objects. I suggest that novel concepts in environmental studies can be understood as both 'grand concepts' in their most widespread use and as 'hubs and spokes' in local contexts. This allows for both vagueness at the macro level and standardization at the local level. I also explore how models, frameworks, and data have been successfully used as boundary objects.

Keywords Boundary objects · Interdisciplinarity · Transdisciplinarity · Resilience · Ecosystem services

Introduction

It has long been recognized that the challenges facing humanity in regard to our environment transcend the boundaries of traditional academic disciplines. Researchers need to reach across those same boundaries in order to produce knowledge on how to face these environmental challenges. Inter- and transdisciplinarity has therefore become central to the fields of environmental studies and sciences. However, these are notoriously difficult concepts to grasp, and there has been much discussion about what interdisciplinarity and transdisciplinarity is and how to successfully conduct such research (Klein 2008, 2017; Sciences, National Academy of, National Academy of Engineering, and and Institute of Medicine 2004). Recently, much attention has been directed at the notion of 'boundary objects' as a theoretical perspective explaining the role of objects in inter- and transdisciplinary research (Levesque et al. 2019; Pennington et al. 2016). Boundary objects are situated between social groups and are relevant to each group, and therefore enable communication, mutual learning, and negotiation. They are especially relevant when research is co-produced with stakeholders and policymakers (Bergmann and Jahn 2008; van Bruggen et al. 2019; Hauck et al. 2014). Boundary objects are thus involved in the production of interdisciplinary knowledge both between academic disciplines and with actors outside of academia.

Within environmental studies, a number of concepts have been either invented or revived in order to facilitate collaboration between disciplines and with stakeholders. Such concepts include the famous 'resilience', 'ecosystem services', and, of course, 'sustainability', as well as less widespread concepts like 'urban ecology', 'blue-green networks', or 'landscape quality'. These concepts are often described as boundary objects due to their interpretive flexibility.

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However, for the most widespread ones, this status is controversial (Ainscough et al. 2019; Brand and Jax 2007). This is typically due to tensions between the concepts' inherent vagueness and the need for standardization in policymaking. Facilitating communication is weighed against concrete policy implementation. Is 'boundary objects' an appropriate way of understanding these concepts, considering this tension? The matter is complicated further by the fact that not only concepts but also frameworks, models, data, and physical objects have been considered to be boundary objects.

The aim of this paper is to explicate in what ways novel concepts, as well as other objects in environmental studies, can be understood as boundary objects. In order to do this, I investigate how the concept of boundary objects has been used in the literature surrounding inter- and transdisciplinary projects. This analysis shows how 'boundary objects' can be applied in various situations stressing different aspects of the concept. I also suggest understanding conceptual boundary objects in environmental studies as 'grand concepts' and 'hub-and-spoke concepts' depending on the scope in and purpose for which the concept is applied.

Background

In their 1989 paper, Star and Griesemer coined the term 'boundary object' to describe "objects which both inhabit several intersecting social worlds […] *and* satisfy the informational requirements of each of them" (Star and Griesemer 1989:393). A boundary object must be meaningful to all relevant social worlds, although the meaning of that object will be somewhat different to every world it inhabits. Nevertheless, there is sufficient overlap of meaning that the object is clearly identifiable as *the same* object by all relevant social worlds. When these objects are employed in common, inter-world use, they have a weak structure, and when they are used within a single social world, they have a stronger structure. The paradigm example of a boundary object is *the state of California* in the context of the establishment of the Berkeley Museum of Vertebrate Zoology. California was a boundary object for a number of reasons. Firstly, there was an overarching goal of preserving the Californian nature in most of the interacting social worlds. Secondly, while the geographical area of California constituted a common understanding among all social worlds, the maps utilized by actors from different worlds demonstrate how the significance of the elements of that area differed between them. The state of California was described by Star and Griesemer as a boundary object with *coincident borders* but different *internal configuration*.

A second example representing a different kind of boundary object offered by Star and Griesemer is the notion of 'species'. This concept served as a means of communicating between scientists and trappers (who were amateur) by incorporating both theoretical and concrete data. It thus had meaning for trappers as a way of labelling specimen, and for scientists as a means of translating specimen into ecological data. However, the concept itself does not accurately describe either specimen or ecological data. Star and Griesemer label such abstract descriptions *ideal types*. They also identify *repositories* and *standardized forms* as boundary objects.[1]

Carlile (2004) further develops the theoretical dimension of boundary objects in his study of communication across departments in industrial product development. He identifies three crucial roles that boundary objects play. Firstly, they constitute a shared *syntax*. A shared syntax allows actors to express knowledge and concerns across the border between social worlds. Secondly, boundary objects bridge *semantic* boundaries by allowing actors to learn about the perspective of the other. The object allows actors to specify details of their concerns and knowledge, so that the other side can gain a deeper understanding of them, as opposed to the mere syntactic acknowledging of their existence. Finally, boundary objects overcome *pragmatic* boundaries by allowing for the transformation of knowledge. If a problem has occurred at an intersection of social worlds, individual actors need to be able to alter their understanding of the situation in order to come up with a solution that is acceptable for both. This can be done by altering the contents (either practically or conceptually) of a boundary object. Ideal types and objects with coincident borders are the only types of boundary objects that readily allow individuals to alter their contents.

In her 2003 paper on the transformation of knowledge on a production floor, Bechky invokes the notion of 'work context' to explain why some boundary objects are successful in one context, yet fail in another. According to her, a boundary object can only create common ground between two social worlds if it is used in the day-to-day practice of both worlds. Thus, engineering drawings failed to convey engineers' concerns to manufacturers because they did not reflect the physical conception of the product from the daily work of the manufacturers (Bechky 2003).

In addition to theorizing about the internal properties of boundary objects, there have also been discussions about the limits of the concept. Lee (2007) argues that the term has become a catch-all term for any (material) artefacts inhabiting boundaries in collaborative projects. She notes that the concept was in its inception exclusively related to standardization and well-functioning routines, whereas later uses sees the concept applied to more chaotic, non-routine projects. Lee instead coins the term 'boundary negotiating artefacts' to describe such artefacts as take part in the redrawing of boundaries and the redistribution of labour. These are not merely subject

[1] It was later stressed by Star (2010) that these four categories of boundary objects were not meant to be exclusive, but few have added to that list.

to standards, and do not simply move passively across boundaries, but are actively involved in the negotiation of both. Lee argues that there are instances where boundary negotiating artefacts are mistakenly labelled as boundary objects, inadvertently contributing to the dilution of that term. Pennington (2010), on the other hand, recognizes the more narrow original definition of boundary objects as pointed out by Lee but argues that the use of the concept has since evolved, and that any boundary-crossing object could be referred to as a boundary object.

Star attempts to provide somewhat of an answer to the question "what is NOT a boundary object?" in her posthumous 2010 paper. She puts forward three aspects of boundary objects that need to be taken into consideration: (1) interpretive flexibility, (2) material/organizational structure of different boundary objects, and (3) the dynamic of ill-structured use at the common scale and well-structured use at the local scale. A boundary object need not be a physical object, or "thing", it is sufficient that the object is acted towards and with. However, the usefulness of the concept of boundary objects is dependent on the scope and scale of the investigation that it is part of. As for scale, boundary object is a particularly useful concept when studying an object at an organizational level. That is to say, even such a thing as a word can be a boundary object if it is central to some organized work effort, such as the interpretation of the Rosetta stone. Regarding scope, Star insists that the concept is at its most applicable when investigating a clearly delineated enterprise. The American flag can be considered a boundary object in the context of its manufacture, marketing, and distribution, but for the analysis of the American flag as such other frameworks will prove more useful (Star 2010).

Materials and methods

The materials for this literature survey were collected by performing two searches in the database Scopus. The first was constructed to find articles that refer to boundary objects and explicitly to either transdisciplinarity or interdisciplinarity.[2] The second was constructed to find articles that refer to boundary objects and any form of cross-disciplinarity, excluding articles from the first search.[3] I conducted similar searches in Web of Science, but found that the results were entirely contained within those from Scopus, except those instances where the terms had been indexed by the database itself, not used by the authors. The searches returned a total of 247 documents, 119 from the first search and 128 from the second. The documents included articles, conference papers, book chapters, and retractions. Publication years ranged from 1995 to 2020 articles in press, although the majority were from 2014 and later. Out of the 247 documents, 57 were judged upon reading of abstracts as not relating to cross-disciplinarity or not actually applying the concept of boundary objects. Of the remaining articles, 18 were inaccessible in such a way that no usable information could be extracted from them. From each of the resulting 172 articles, excerpts relating explicitly to boundary objects, along with one or two paragraphs of case description, were extracted. The excerpts relating to boundary objects were found by using a word search for the term 'boundary object', and including the paragraphs (or a few sentences from the paragraphs) in which the term figured. Case descriptions were generally extracted from the introductory parts of articles, unless a separate section for the introduction of cases was present.

The collected material was coded according to a grounded theory framework (Charmaz 2014). Thus, categories were derived from the material itself and were continuously re-evaluated in light of that material. Codes from the first round included different kinds of objects, as well as the various fields being described. As these codes were not used for any rigorous quantitative analysis, I did not judge it useful to formalize them further. Having done a first round of coding, I performed a close reading of articles according to codes, focusing in particular on instances where concepts were labelled as boundary objects.

Variety

As noted by Lee (2007) and Star (2010), the concept of boundary objects has seen widespread and varied use across a multitude of disciplines. This variety of contexts has given rise to a variation in the way that the concept is used. In this section I explore some of the variation that can be seen in the studied material.

Variety of contexts

Most of the papers surveyed concern cross-disciplinary collaborations that incorporate one or more of five common 'themes'.[4] These five themes are *(environmental) sustainability, technology, education, art,* and *healthcare*. The themes often overlap, such that some papers deal with technological education (Fominykh et al. 2016; Reddy et al. 2019), healthcare education (Timmis and Williams 2017), or technology in art (Norman 2014). Not all papers touch on any of these five themes, but no other theme occurred more than once or

[2] Search string: TITLE-ABS-KEY("boundary object" AND (interdisciplin* OR transdisciplin*)), conducted on 2019-07-16

[3] Search string: TITLE-ABS-KEY("boundary object" AND *disciplin* AND NOT (interdisciplin* OR transdisciplin*)), conducted on 2019-07-29

[4] These do not represent disciplinary belonging. They characterize the projects, not the participants or the authors.

twice (except in cases where the same authors published multiple articles based on the same case). Articles touching on sustainability concern descriptive or normative discussions of environmental issues or societal issues arise on the basis of these. Articles having technology as a theme concern the production, development, or implementation of some technological novelty. Education involves either a case study of some actual educational context or theoretical discussion pertaining to education. Articles involving art describe projects that were referred to as artistic or involving artefacts referred to as art. Healthcare involved both medical research and practice as well as discussions of healthcare policy. Sustainability was the single most common theme, also being the one that most often appeared alone.

Variety of objects

Throughout the material, I observed a number of categories of objects, some of which sometimes overlapped. These include *events, places, software, models or frameworks, concepts, concrete objects, visualizations, information, standards,* elements of *language,* and *activities.*[5] While it is possible to show that instances of each of these categories have at some point been described as boundary objects, it is not always clear in each individual case precisely what it is that is being described as the boundary object. In articles investigating theoretical frameworks, for instance, it is sometimes unclear whether the boundary objects are the words used in the framework, the concepts they represent, the framework itself, the practice of constructing the framework, or everything at once.

In articles dealing with sustainability, most objects were either concepts or models/frameworks. Models and frameworks consist of concepts in a particular interrelation, often with an accompanying visualization, and are used in order to represent ways of thinking about problems or phenomena.[6] Some articles also viewed research data, catastrophic events, or places as boundary objects (Lillo-Ortega et al. 2019; Opdam et al. 2013; Venable 2017). Thus, within environmental science, boundary objects are not usually material or concrete objects.

Conceptual variety

Clarke and Star (2007) emphasize in their introduction to the social worlds framework that its concepts are not to be seen as definitive, i.e., with rigid definitions, but rather as sensitizing: giving researchers an indication of where to look, rather than necessary and sufficient criteria of application. Boundary object is one of the concepts included in this framework. Accordingly, the concept has been interrelated with a number of other terms dealing with boundary phenomena, some of which were developed from the notion of boundary objects itself. These include 'boundary work', 'boundary organizations', 'boundary negotiation', and many others (Trompette and Vinck 2009).

This tendency of exploring and coining related concepts can also be observed in the articles surveyed. Some of the terms used include 'research object' (Bergmann and Jahn 2008; Hermelingmeier and Nicholas 2017), 'boundary device' (MacGillivray and Franklin 2015), 'fetish object' (Hirschhorn 2018), and 'epistemic object' (McGreavy et al. 2013; Nicolini et al. 2012) among others. Here, the concept 'boundary objects' is used by researchers to attune to the particularities of their situation of study. More than its ability to describe the phenomena at hand, the strength of the concept 'boundary objects' in these instances is its use in re-examining and developing theories and categories. This is true to the concept's origin in grounded theory, which is at its core about theory-development (Charmaz 2014; Clarke and Star 2007).

Work-context and constructed objects

As pointed out by Bechky (2003), failure of objects to function as boundary objects can (sometimes) be explained by their absence from the work context of collaborating participants. This insight was mirrored by many of the surveyed articles. In particular, when information in the form of data or maps was recognized as boundary objects, the ability of all participants to utilize (and not only understand) that information was highlighted (Risner et al. 2019; Venable 2017). However, in some instances, particularly involving 'grand concepts' (see below), boundary objects were not noted as figuring in the day-to-day work of participants. Instead, these objects served a more over-arching function in facilitating collaboration.

Of the articles focusing on work context, some employ the notion of co-production to emphasize the mutual participation of various groups in creating a boundary object (Levesque et al. 2019; Roux et al. 2017). This illustrates a further aspect of boundary objects common in some interdisciplinary contexts. Here, artefacts are actively constructed specifically to function as boundary objects and are designed to exhibit the characteristics described in the theoretical literature. This is particularly common when the objects are models and frameworks (van Bruggen et al. 2019; Mattor et al. 2014). The notion of 'negotiation' figures strongly in these contexts, and focus is on active exploration of differences in meaning among participants.

The idea of constructing boundary objects is not present in the early theoretical explorations of the concept. There,

[5] These categories are not meant to be theoretically meaningful in the way that those of Star and Griesemer (1989), Wenger (2008), or Carlile (2004) are. examples from each of the categories above could possibly be subsumed under any of these higher-level classifications.

[6] Simulations and data models were considered to be software in this analysis.

objects assumed the role of boundary objects as a consequence of the organizational properties of the collaboration in which they figured and were identified as such only after they had already assumed the role. The move towards actively seeking boundary objects in order to facilitate collaboration was undertaken when the concept was imported into organizational studies (Zeiss and Groenewegen 2009). In environmental studies, co-production of boundary objects is regularly discussed as an effective means of incorporating stakeholders' and policymakers' perspectives into research. However, care must be taken that participation does not become token, but that stakeholders are empowered and their views accurately represented (Elzinga 2008).

Concepts as boundary objects

In interdisciplinary collaborations, central concepts are often considered to be boundary objects. Although boundary objects are more intuitively thought of as concrete things, they need not necessarily be so (Star 2010). In Star and Griesemer 1989, the notion of species is considered to be a boundary object of the 'ideal type' variety. If concepts are to function as boundary objects, they will need to exhibit the dynamics of ill-structured use in the common context and well-structured use in each social world. Thus, it is important that such a concept does not have a precise definition in its common use. At the same time, however, the concept needs to be recognized as being *the same* throughout all relevant social worlds. Thus, these concepts cannot be entirely without definition either.

I would like to posit the notion of 'thin definitions' to suggest an explanation of how concepts can be both vague and maintain a rigid identity. A thin definition (from Geertz and Darnton (2017) distinction between thick and thin descriptions) is a definition where social context is stripped away, and the culture-specific meaning of a thing is lost. Star and Griesemer argue that the strength of the ideal type as a boundary object resides in precisely this deletion of local contingencies (1989:410). Thickness and thinness are or course relative notions: a (very) thin description of the sentence "It was the best of times, it was the worst of times" as written on a page would consist of a description of the spatial relations of lines to each other, whereas a (very) thick description would contain an account of both Dickensian writing and Victorian England, and all intermediate levels of description would be either thick or thin depending on which they are compared to. If multiple social worlds can agree on a thin definition of a concept, then its identity can be maintained without loss of context-specific meaning. For the concept of species, a thin definition like 'sorts of living things' leaves a host of questions to be answered in each social world (e.g. about what constitutes a 'sort', what things are to be considered 'living', etc.). Of course, these thin definitions need not to be explicit, but should always be possible to find.

From the collected materials, two archetypes of conceptual boundary objects could be discerned.

- *Grand Concepts* are concepts that are policy-oriented, see widespread use, are in tension with standardization, and maintain ambivalence.
- *Hub-and-Spoke Concepts* are local to single contexts, are objectives or approaches, and strive to stabilize the interfaces of exchange, while moving towards greater standardization.

In the remainder of this section, I describe these two archetypes as they are characterized in the surveyed articles.

Grand concepts

These are common in (though not exclusive to) environmental studies. Concepts such as 'resilience', 'ecosystem services', 'stewardship', and 'sustainability' are often discussed as boundary objects between science and policy. I choose to name them 'grand concepts' because of their connection to the 'grand challenges' of society they are often employed in describing. Central aspects of grand concepts are as follows:

1. Widespread use:
   "[T]he concept is used by various scientific disciplines as an approach to analyze ecological as well as social-ecological systems…" (Brand and Jax 2007:1).
   "[T]he popularity of 'resilience' has exploded in both academic and policy discourse…" (Meerow et al. 2016:39).
   "With this wide and diverse use across research, policy and practice…" (Peçanha Enqvist et al. 2018:18)
2. Orientation towards policy:
   "[T]he ES paradigm features prominently in policy, theoretical and activist discussions…" (Jadhav et al. 2017:2).
   "…promotes research efforts across disciplines and between science and policy…" (Brand and Jax 2007:1)
3. Tension with standardization:
   "[T]o impose a universal definition can obstruct One Health's function as a boundary object…" (van Herten et al. 2019:27).
   "Standardization facilitates implementation, yet efforts to standardize both the concept and practice of the ES may diminish its ability to function as a communication device…" (Steger et al. 2018:154)
4. Ambivalence:
   "[T]he catchword sustainable development enables different scientific disciplines or social groups to justify their particular interest with respect to an accepted and

ethically legitimated, societal goal […] It may thus even hide conflicts and power relations when different persons agree on the need for sustainability when in fact meaning different things by it" (Brand and Jax 2007:9).

"[T]here is a danger of overlooking the ways resilience discourses legitimize certain practices and nullify alternatives, thereby leading to undesirable outcomes and hindering transformational change" (Gillard 2016:16).

Research involving these grand concepts is normally intended to influence policy. Such research is usually not focused on exploring the concepts themselves—it is rather conducted under the umbrella of these concepts. For example, research employing the concept 'ecosystem services' most often amounts to concrete ecosystem service valuations and suggestions for (and evaluations of) policy implementations. The conceptual discussions cited above thus constitute the minority of grand concept research.

Because they are vague, yet highly politicized, grand concepts are ambivalent as to whose interests they further. Those advocating their application thus run the risk of reinforcing existing power structures. However, these same concepts also carry transformational potential. It is therefore important to be reflexive when using them (Gillard 2016).

Grand concepts constitute an overarching frame, a rallying point for researchers from a variety of disciplines. The concepts help researchers demarcate a unified front of interdisciplinary research, and make that front politically relevant. From the other direction, activists and advocates can utilize these concepts in order to make their policy suggestions scientifically relevant.

Hub-and-spoke concepts

Concepts of this kind are common in smaller projects with specific aims, or in new interdisciplines. Smaller projects might include local implementation of policy, or interdisciplinary workshops. I name these concepts 'hub-and-spoke concepts' because of their role in stabilizing interdisciplinary interfaces. Central aspects of hub-and-spoke concepts are the following:

1. Locality:
   "This paper presents an analysis of a research project conducted by a network of environmental research institutes called Partnership for European Environmental Research (PEER)" (Hauck et al. 2014:376).
   "In this context of resistance, it was the task of the project 'Integrated Assessment of the river Meuse' (IVM) to propose a selection of politically acceptable flood management measures that would ensure the legal level of flood protection in future…" (Wesselink 2009:407).
2. Being either a goal or an approach:
   "Landscape quality is thereby both the objective and the result of land use planning for water management" (Wesselink 2009:409).
   "Although not planned to be such, the vague idea of mapping, assessing, and valuing served as a boundary object that proved capable of engaging different interests." (Hauck et al. 2014:382)
3. Stabilizing interfaces:
   "The more promising approach is to establish ongoing cooperative structures […] aligned by and centered around shared research questions and tasks […] Establishing and maintaining such 'discipline-linking' cooperation is essential if DAI and sociology are to come closer together" (Strübing 1998:442).
   "Epistemically, the main challenge to interdisciplinary game research is the lack of cross-disciplinarily 'robust' research questions, constructs, and paradigms […] instead of trying to first establish consensus about shared questions and ways of answering them, game scholars might look for shared *boundary objects*…" (Deterding 2017:535), italics in original.
4. Moving towards more structure:
   "As the researchers advance towards a concrete result, they are engaged in the process of making the boundary object strongly structured, as they specify its parameters for the concrete case they are working on" (Wesselink 2009:410).

Hub-and-spoke concepts have a more instrumental role in facilitating collaboration in particular projects than grand concepts do. These concepts unite the collaborating parties in interest (Nicolini et al. 2012) and communication (Carlile 2004). They also typically exhibit the development towards infrastructure pointed out by Star (2010) as characteristic of boundary objects, which grand concepts generally do not.

There is no exact boundary between hub-and-spoke concepts and grand concepts. Concepts that are not quite as widespread as the paradigm grand concepts do not necessarily exhibit all of the characteristics above, and some of the grand concepts might function as hubs or spokes at local levels. In environmental studies, hub-and-spoke concepts can help stabilize collaborations between disciplines and with stakeholders. If concepts are understood as both grand concepts at the macro scale and hubs-and-spokes at the local scale, then the vagueness needed for communication can be maintained despite standardization at local levels.

Conclusion

Boundary objects can be made to facilitate interdisciplinary research in environmental studies in a number of ways. By

making data and information understandable and usable across disciplinary borders, the day-to-day work of participants contributes meaningfully to the interdisciplinary exchange. Co-production of models and frameworks with stakeholders can let their perspectives in, and allow for the production of knowledge that is better suited to deal with concrete societal problems.

Novel concepts in environmental studies can be understood as 'grand concepts' when they are applied in a broad-scoped context. Here, their use is to create bridges between disciplines and policy in a more general sense. In such contexts, maintaining vagueness despite pushes for standardization is crucial in order for the concept to facilitate communication. It is also important to reflect on aspects of power when using concepts on this level due to their vagueness allowing them to be used in any actor's interest. When concepts are applied at the local level, they are better understood as 'hubs and spokes'. In this role, concepts serve to stabilize collaboration, being approaches or goals that start out vague, but become more structured as collaboration goes on. Having the same concept can be understood as both a grand concept and a hub or spoke in different contexts alleviates the tension between the vagueness needed for communication and the standardization needed for policymaking.

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