Learning Through Contestation: When are boundary objects productive for sustainability?

ABSTRACT

This paper explores how contestation of knowledge interfaces between diverse disciplinary approaches can prepare students to address complex, multifaceted sustainability issues. As future managers, they will be required to coordinate knowledge sharing between departments and diverse stakeholders concerning these issues. University educators, with their focus on single discipline teaching, are not preparing managers for this task. Interactions across disciplinary silos have been conceptualized occurring through collaborative arrangements, whether they be via inter-, multi or transdisciplinary. Our research involving sustainability-focused academics across disciplines, demonstrates that interactions involving concept contestation are productive for learning about the multiple facets of sustainability knowledge. We find certain types of boundary objects reveal differences in disciplinary interpretations such that individual disciplines are stimulated to re-frame their disciplinary conception of the object. Contestation can also lead to creation of new knowledge through a transdisciplinary approach to abstract meaning of the boundary object beyond disciplinary boundaries. Identifying such boundary objects and the process of contestation they invoke can be used to inform curriculum design. Productive boundary objects can be introduced so that students are stimulated to understand the diverse disciplinary interpretations of the concept. Such learning processes may equip graduates to address complex sustainability issues.

Keywords: Sustainability and Sustainable Development, Interdisciplinary Approaches, Qualitative Methodologies, Boundary objects, learning

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INTRODUCTION

Business is being blamed for a number of social, environmental and economic ills (Kramer and Porter, 2011; Wright and Nyberg 2015), Such issues are typically related to sustainability and can be addressed by businesses creating value across the Triple Bottom Line of economic prosperity, environmental quality and social justice (Elkington, 1997). Continued prominence of sustainability is signified by the United Nations 2030 Agenda for Sustainable Development (UN, 2016), featuring a role for business to address wide-ranging Sustainable Development Goals (SDGs) to end poverty, fight inequality and injustice, and tackle climate change (Sachs, 2012).

Managers are faced with implementing new business approaches to address such sustainability-related issues (Kramer and Porter, 2011; Mackey and Sisodia, 2014) that require collaboration with diverse stakeholders, many with different knowledge backgrounds. Making sense of sustainability issues is a complex task as sustainability is a highly contested (Kelly, 2009; Zaman and Goschin, 2010), values-based concept, with tensions arising between different stakeholder interpretations, approaches and priorities (Angus-Leppan, Benn and Young 2010). Managers may be unprepared for this task on the main having been exposed to narrow, single-discipline-focused education whether it be through a business school or other disciplines (Doh and Tashman, 2014; Navarro, 2008; Ashford, 2004).

Given the renewed need to implement solutions to achieve the 2030 SDGs, it is increasingly important for universities across all areas of teaching and research to develop and implement more holistic and integrative approaches to embedding sustainability concepts in learning (Painter-Morland et. al., 2016; Muff et. al., 2013). Sustainability is not alone in the challenges it poses for developing holistic and integrative learning approaches while ensuring disciplinary rigour. Innovation is another, for example (Thomas, et. al., 2015). Sustainability is taken, for further development in this paper, as a paradigmatic example of a concept unbound from specific disciplines (Shrivastava, 2010) that requires disciplines to work together.

Given these challenges, this research explores how interactions between diverse disciplinary approaches can be productively brought together so that students are prepared to address complex, multifaceted sustainability issues. How can complex issues be understood by drawing on diverse interpretations across disciplines? To explore this question, we sought to identify concepts that enabled productive interactions between academics of diverse disciplinary backgrounds. Such concepts are considered productive as they are characterised as being boundary objects that exist despite consensus between disciplines and this attracts contested dialogue which may stimulate transformative learning and re-framing of extant knowledge. These concepts and the process of dialogue they engender may be most useful for curriculum design to enable students to understand how to engage with complex and contested knowledge domains. Identifying what sorts of concepts act as productive objects between knowledge boundaries can enhance curriculum development such that students can better approach complex sustainability issues in their workplaces and manage and coordinate learning across organizational silos. The findings of

this study contribute to a more nuanced understanding of how boundary objects can be productive instigators of contestation.

Learning for Sustainability

Learning for sustainability is a holistic body of knowledge and understanding for practice that meets the needs of current and future generations (World Commission on Environment and Development, 1987). The rhetoric of education for sustainable development or learning for sustainability has been embraced widely by governments and intergovernmental bodies (UNESCO 2005, 2013). As an educational philosophy, education for sustainability has been proclaimed as a means of raising awareness and developing capacity around sustainability through teaching, training, or other curricula that are locally relevant in cultural, environmental, economic, and societal terms (Bradbury, 2003; Mc Keown, 2002; Springett, 2005). In other words, it is a methodology that relies on highly integrative and holistic approaches to learning. However, in practice, learning for sustainability is hampered by disciplinary silos (Evans 2015) as it is interpreted in the knowledge domains of teaching and research.

In curriculum design, too often sustainability is relegated to stand-alone subjects or boutique programs whereby sustainability principles are not integrated within foundation knowledge (Rusinko, 2010). Integration is problematic because disciplines interpret the purpose and significance of sustainability within their disciplines in vastly different ways, ranging from those who see it as separate to others who understand it as being an integral component (Reid and Petocz 2006; Benn, Edwards and Angus-Leppan, 2013). Hence, within disciplines themselves there is not universal support for working across disciplines to teach and conduct research in sustainability. Indeed, the institutional incentives for working across disciplinary

boundaries are few, doing so challenges the status quo and requires a commitment to new styles of operating in the current education paradigm (Evans 2015).

Approaches to working across disciplines

There is considerable literature on approaches to working across disciplines. The literature outlines three modes of working across disciplines: multidisciplinary, interdisciplinary and trans disciplinary. Although these three terms are sometimes used interchangeably, there is also an established literature that recognises transdisciplinarity as the ideal process for addressing the complexity of sustainability domains (Lang et. al. 2012; Brandt, et al. 2014; Mitchell et al. 2015; Evans 2015; Bernstein 2015). In a multidisciplinary approach sustainability could be an umbrella theme embedded within and across existing disciplines (Tress, Tress and Fry 2005). Inputs are collected from different disciplines but not synthesized (Bernstein 2015). An interdisciplinary approach is integrative and the interaction between disciplines varies in purpose from being epistemologically pluralistic, whereby disciplines are maintained, and/or unitary, where new disciplines are sought through disciplinary integration (Turner et al., 2015). In these approaches, knowledge is shared across disciplinary boundaries in relation to the umbrella theme. Disciplines may draw on knowledge and understanding from other disciplines with the aim of enriching their own disciplinary understanding of the theme.

Transdisciplinarity, on the other hand, presents a challenge to the organisation of knowledge production within disciplines (Choi and Pak, 2006; Bernstein, 2015). A universally accepted definition for transdisciplinarity remains elusive (Jahn et al 2012), however some authors

(Lang et al 2012; Jahn et al 2012) have attempted to define it as having these main requirements: participation from and mutual learning among academics and practitioners from different disciplines; focus on a common, socially relevant goal; and the aim to create solutions that are relevant in both scientific and practical terms. Choi and Pak (2006) add that a certain process of juxtaposition, recombination and recodification is essential for creation of 'new knowledge', which characterises trandisciplinarity. In regards to sustainability education, transdisciplinary approaches have been cited particularly in relation to problem based learning approaches, as a framework (Sipos et al. 2008), for transformative learning (Moore, 2005; Wals and Blweitt, 2010) or for the project-based learning approaches that use 'real-world' transdisciplinary case studies as the basis for learning applied within a disciplinary context (Steiner & Posch 2006; Scholtz, et al. 2006). Fewer studies have examined the transdisciplinary processes of curriculum design where multiple disciplines converge (Clark and Button 2011; Onuki & Mino 2009).

We follow the literature that posits different levels of transcendence through varying complexity of interactions between and within disciplines, with multidisciplinary approaches being the most simple and transdisciplinary the most complex (Bernstein 2015; Zaman and Goschin, 2010). In this sense, multidisciplinary approaches can be seen as the weakest form of interaction between disciplines and transdisciplinarity can be seen as an ideal approach. Both inter- and trans- disciplinary approaches require interaction across disciplines. While a transdisciplinary approach is conceptually appealing as a means of addressing complex issues or problems, it requires novel forms of interaction, connection and cooperative approaches (Jahn et. al., 2012). Common to all three forms of interaction is the role of knowledge objects, such as boundary objects, as points to attract and focus interactions.

Boundary Objects

Boundary objects have gained wide acceptance as a key part of the infrastructure when people from different disciplines interact and collaborate. Boundary objects are artefacts, documents, terms, concepts and other forms of reification around which Communities of Practice (CoP) organize their interconnections (Wenger 1998, 2000) that allow coordination without consensus (Bechky, 2003; Star 2010), such as that required for different actors or groups or stakeholders to interact across disciplinary boundaries. They exist in different forms: the repository, such as a website or a library or a collection or a database where heterogeneity is modularised; the ideal type or general model and standardised methods, protocols and forms, including training materials which facilitate communication and the grouping of diverse content (Star & Griesemer, 1989).

Boundary objects can be conceptual or material. They can be: repositories containing classification schemes; artefacts or 'road maps' in the form of made things such as visual representations or diagrams; standardized forms devised as forms of common communication across work groups; or coincident boundaries, being common objects that have different internal contents in different contexts (Star and Griesemer, 1989; Wenger 2000). Briers and Chua (2001) found evidence for ideal type boundary objects to provide a visionary function. Niccolini et al (2012) found evidence for an epistemic boundary object, a "source of attraction" where people are driven to work together to discover what they don't know. Despite being a powerful concept, Nicolini et al (2012) note that increasingly it is used as a sort of 'deus ex machina'.

What is often overlooked is how boundary objects enable people to interact without consensus and even when the point of their interaction is contestation (Star 2010). When people interact what they want to talk about is what matters to them, they negotiate, they fight, they translate in their own way. What really makes something a boundary object is that people keep "tacking back and forth" and renegotiating meaning (Star 2010). Boundary objects attract people to one another, despite their differences, because it is disruptive (Hawkins 2016) and they continue to renegotiate their own diverse translations of the object and they contest and negotiate their differences. As soon as they come into alignment it ceases to become a boundary object (Hawkins 2016).

Star (2010) highlighted that boundary objects are misconceived when the focus is placed on what they are, in the material sense, rather than the process they imply. The processes implied by the boundary object has three key features (Star and Griesemer (1989), in Star 2010, p.604): (i) the object is a set of work arrangements that are at once material and processual, residing between social worlds (or communities of practice) where it is ill structured. □(ii) When necessary, the object is worked on by local groups who maintain its vaguer identity as a common object, while making it more specific, □more tailored to local use within a social world, and therefore useful for work that is not interdisciplinary; (iii) Groups that are cooperating without consensus tack back-and-forth between both forms of the object. It is in this space where the object can be both locally defined and ill-structured at the same time that the boundary object is productive in enabling contestation.

A good example of how the presence of boundary objects is determined by the level of contestation they provoke (Star 2010) is in a case study presented by Hawkins et.al (2016). They discuss a dairy where management initially had no interest in sustainability, as doing so would just be playing into a "fad," and would distract them from other business imperatives. Through the mediation of a group of sustainability academics, the concept of carbon footprint was introduced to the dairy and it became a highly contested topic, resulting in a period of mutual learning. This is the definition of a boundary object with a set of affordances that maximize interaction as people grapple with it. Over time, the dairy ended up winning some business because of initial efforts it took in reducing its carbon footprint. This culminated in a change in the Dairy's culture and approach to carbon such that everyone was "on board." In Hawkins' terminology, the affordances of carbon reduction were reconfigured and rendered consistent. This normalization of opinions toward carbon had the effect that the imperative of reducing its carbon footprint became embedded in the Dairy's culture, while at the same time it ceased to function effectively as a boundary object between the Dairy and the offsite academics.

Star (2010) claims that, since their original conceptualization (Star and Greisemer 1989), boundary objects have been interpreted by others as anything that inspires different translations. However, that in itself doesne their original conceptualization (Star and Greisemer 1989), boundary objects have been interpreted by others as anything that inspires sustainability education.

METHODOLOGY

This study was undertaken within a metropolitan based university where the seven faculty groupings were taken to be bounded knowledge domains[1]. Within these domains we sampled 20 researchers from 10 different disciplines who have been identified as having a 'sustainability' teaching or research interest. This sample pool was compiled by the university office for sustainability with the intention of obtaining equal representation among disciplines. In total, twelve interviews and two focus groups were conducted across six of the seven faculties[2]. Interviews lasted thirty minutes on average. Focus groups were designed to draw together 'sustainability academics' from each of the knowledge domains.

As the sample was collected through a centralized university process, it is possible that it is not entirely representative of all 'sustainability academics' within the university. Given the high possibility for social-desirability bias in sustainability research, as well as the potential for bias from power asymmetries (Oswick and Robertson 2010) the sample is also weighted to avoid power differentials between informants (academics at a similar level at the university were placed together in focus groups) and no administrators were included in focus groups.

The researchers explicitly called on academics from different discipline areas to discuss their work and frame their responses in terms of "concepts" that serve them in their efforts to teach and research sustainability. As a result, discussion was guided into abstraction rather than toward specific material artefacts such as specific reports into climate change or historical events such as environmental disasters, or certifications such as B-Corps. Interviewers did not guide participants toward concepts that embrace holistic and academically rigorous expressions of sustainability, but rather allowed participants to raise whatever abstractions

[1] The seven faculties are Design Architecture and Building, Arts and Social Sciences, Engineering and Information Technology, Science, Health, Business and Law)
[2] A suitable interview candidate from the health faculty was not obtained.

they found relevant, even those concepts that the participant raised without the expectation of it resonating within other disciplines. Discussion also ranged across those concepts that participants find useless or even counterproductive to the teaching or research of sustainability within their discipline. A sample interview guide is contained in Table 1 (below).

Insert Table 1 about here

Interviews and focus groups were recorded and transcribed verbatim, allowing the interviewer to concentrate on questioning and listening, to provide an accurate record, to enable the use of direct quotes in subsequent analysis (as suggested by Saunders, Lewis and Thornhill, 2003). The transcripts were analyzed using conceptual and relational content analysis. Content analysis is a research technique for breaking down text into categories based on explicit rules of coding (Krippendorf, 2004). Conceptual analysis, the most common form of content analysis, involves the detection of explicit and implicit concepts in the text. Relational analysis considers the relationships between concepts. In line with the recommendations of Gephart (2004), computer-aided textual analysis was used as it allows for systematic and comprehensive analysis. The analysis software used for the analysis, Leximancer, adds reliability by using machine learning to automatically and entirely code the text rather than using the researcher's interpretations to do so. In other words, the computer analysis provides an objective, quantitatively derived framework in which qualitative interpretation analysis is more effectively facilitated (Smith and Humphries, 2006).

The recommended Leximancer analysis procedure was followed (Leximancer, 2005), initially using 'discovery' mode to see what concepts were automatically generated by Leximancer

without intervention, followed by a process of seeding the analysis with user defined concepts based on the research constructs. In this case, we were looking for concepts that may be perceived as boundary objects. A 'concept' is a set of words that are used in conjunction with each other by informants. The components of each 'concept' are placed in a 'thesaurus' that contains the set of associated words and weightings, which indicate the words' relative importance in the concept generation. Each three-sentence block of text is then assessed to ascertain whether it contains sufficient evidence of the concept and if so is so coded. Each block of text was also 'tagged' to indicate which interview group the informant belongs to. Leximancer applies a Bayesian learning algorithm to identify: (1) the most frequently used concepts within a body of text and, more importantly, (2) the relationships between these concepts. The distance between concepts on the "maps of meaning" show how closely the concepts are related. Accordingly, concepts that are strongly related semantically will be mapped closely together (Campbell et al., 2011; Rooney, 2005).

ANALYSIS AND FINDINGS

General conceptual overview

In Leximancer, the frequency of co-occurring concepts is measured, weighted and clustered to produce a two-dimensional map of "concepts" and "speaker tags" (for further details of this process see www.leximancer.com.) The Leximancer map is an overview of the cognitive structure and content of the data. Figure 1 (below) shows the Leximancer map for the transcripts categorized by the ten discipline groups. The size of the dot and its centrality on the map corresponds with the frequency of the concept. Adjacent concepts and speaker tags on the map indicate that they were associated in the transcripts. For example, the concepts "Donald Trump", "indigenous", "cost" and "climate change" are adjacent on the map and sit between "SPEAKER_accounting" and "SPEAKER_engineering" indicating that these

concepts were most likely discussed together by the interviewees from the accounting and engineering disciplines.

Insert Figure 1 about here

Figure 1 is one way of mining our data for concepts mentioned with the greatest frequency, mapped according to relationships with speakers and other concepts. Before getting into a detailed conceptual analysis, it is relevant to note here that most of the participants identify themselves with a particular discipline primarily for organizational purposes, but profess to think and work across a number of disciplines in practice. It is, therefore, incumbent upon us not to artificially pigeonhole speakers according to discipline. In the analysis that follows we apply disciplinary labels only with caution. Another caveat is that this automatically generated map shows the strength of relationships between concepts, but it cannot show negative sentiments. A concept that appears in the map as central to all parties may have just been raised, as a concept everyone agrees is useless. These sentiment lenses are apparent only upon close inspection of the transcripts, which is outlined in the next section.

We may observe at the outset how neoclassical economic terminology prevails and evenly distributes across the map. We note that terms such as “value”, “profit”, “business case”, “cost”, and “market” were not just clustered around the management or accounting speakers, and instead represent shared concerns addressed by participants from all disciplines. It seems ingrained and natural to all participants to foreground the business cases and economic justification of any non-economic aspect of sustainability.

The prevalence of economic terminology in our discussions may, on the one hand, serve as evidence for the multi-disciplinarity of the subject of sustainability. Speakers involved in this

and other projects tend to feel confident to talk about markets and business, regardless of their formal training. At the same time, our experience with this group of participants was in line with common sense that a management lecturer will be less confident to engage with systems engineering than will an engineer, and an engineer will likewise be less prepared to go into great detail about environmental law, as these are subjects that require years of formal training to master. Part of the motivation to frame or justify sustainability in economic terms may arise from educators in our sample trying to train students to compete for jobs outside of academia. Adequate preparation for the job market requires an understanding of the profit motives that drive the hiring behaviors of current and future employers.

We may note also that the more explicitly human aspects of sustainability such as women's issues or diversity or any general Corporate Social Responsibility issues could certainly be learned and mastered by non-social scientists, and yet human focused sustainability did not and does not feature prominently across all disciplines. Words like "society", "social" and "indigenous" do appear centrally in the map, but were generally discussed in the negative, with participants professing their inexperience and confessing a lack of focus on social sustainability.

Productive boundary objects

Next we probed the data for concepts that stimulate debate, iterative reframing, and potential work arrangements such as the coauthoring of papers or joint approaches to pressing social issues.

Notably we observed there appeared to be two categories of concepts:

1. Those concepts that inspired the most discussion (including disagreement and/or proposition for potential collaboration) between disciplines
2. Those concepts that were raised (and often championed) but did not generate much discussion

For simplicity the concepts are classified by this binary categorization in Table 2 (see below). Although this is an oversimplification of the complex and subjective views expressed by our participants, it highlights concepts that were discussed with far greater enthusiasm than the others. Listing a concept such as climate change on the right side of this chart is in no way a claim that our participants do not universally consider it vital to their work. Quite the contrary. Rather, we are simply making the observation that climate change did not inspire much discussion.

Insert Table 2 about here

Next we analyzed why concepts like "ecosystem services" generated discussion and debate while those like "climate change" did not. Identification of a productive boundary object is not only a matter of finding concepts that were discussed by all participants. Concepts were further analyzed to explore if they may act as productive boundary objects. Text related to each concept was extracted and examined to answer the following questions: Is the concept being translated across disciplinary boundaries? Are disciplinary perspectives being negotiated and/or contested? How are differences between disciplines being discussed? Does the discussion of the concept offer possibilities for action (engender work arrangements) and iterative debate (tacking between generic and local translation)?

To aide this analysis, we used Leximancer to generate a relational map for each concept. Figure 2 (below) is an example of a relational map for climate change. While the map itself does not indicate if and how the concept may be considered a boundary object, it allows us to visualize the proximity of the concepts to other concepts and speakers and to extract text across our sample that related to each concept. We then further probed into the text for each concept to understand what was being discussed in relation to these concepts between various different disciplines.

Insert Figure 2 about here

Concepts connected to many speakers and that generated discussion and contestation were categorized as 'productive' boundary objects. Next we outline 'productive' boundary objects by first highlighting examples of concepts that did not create contestation, and then those which did. For each we highlight sections of text that illustrate the discussions surrounding the concepts.

'*Climate change'* as a pressing problem does not by itself seem to inspire much debate within our sample group. We observe its omnipresence in discussions but only as an issue upon which everyone (in our sample) already agrees. Climate change may be a visible emblem in the mainstream debate about sustainability, but it is a topic upon which sustainability-focused academics concurred as a standard, and therefore does not stimulate debate. Standardization in this case, limits the productivity of climate change as a productive boundary object. Evidence for this argument may be found in the marked absence of any controversy among our participants concerning climate change or of its most basic terms of reference. As we shall demonstrate, this comes in contrast to the debate created by other concepts.

The same logic of diminishing ambiguity and increasing standardization applies to many other concepts raised by our participants, such as energy efficiency and biodiversity. Energy efficiency would seem to qualify as a boundary object, owing to its broad linkages with speakers and other concepts on the map. We observe, however, that energy efficiency was only discussed in broadly consensual terms. This is in spite of it being specifically offered by a participant as a concept that is useful to him because it engenders different translations across disciplinary boundaries. "Accounting," explained how the concept "energy efficiency" helps him educate students how to appreciate sustainability problems from different points of view.

> *The concept of Energy Efficiency has multiple meanings. In each of the spheres the same term is accepted and understood in a different way. Through our project, each of the disciplines who accessed the core concept were able to build on it and built their own, more complex mental model. We've integrated energy efficiency across a whole bunch of different subjects, where we would not have been able to integrate 'climate change adaptation techniques', because that overall term would have been outright rejected (Accounting).*

What "Accounting" appears to be describing is energy efficiency as a way of translating sustainability into various subjects that had been resistant to that introduction. Within the accounting discipline, energy efficiency concepts are introduced via an emphasis on capital budgeting and student teams work on campus energy projects, thus introducing students to the interdisciplinary aspects of energy and resource use. The concept of energy efficiency brings together different sub-disciplinary areas to a focus on an aspect of sustainability. Energy

efficiency is also a way of working across disciplines outside of accounting.

While other participants also refer to energy efficiency in their own work, in one case seconding its use as a "taster" and a way of winning over climate change deniers, the concept did not inspire any kind of controversy between participants, nor did it spark in other disciplines the kind of enthusiasm shown within accounting. Once again, energy efficiency appears to be a concept that has been standardized for multi-disciplinary use, so it fails to attract the struggle to iteratively re-frame and negotiate between translations that productive boundary objects do.

Like climate change and energy efficiency, biodiversity was discussed as a topic that translates differently across disciplines, but does not attract debate or iterative re-framing. Discussion focused on its capacity to be translated beyond biology into economic terms, i.e. the valuing the diversity of trees in a forest as opposed to the relatively fewer economic benefits of a single species grown in plantations.

In our sample, biodiversity did, however, serve participants as a launching point into discussing another concept that generated much more enthusiastic debate. Several participants raised ecosystem services as a framework for teaching and researching biodiversity. But ensuing discussion reframed ecosystem services in its broader sense as a concept that marries all sorts of environmental sustainability with economic concerns and valuation (i.e. in line with a more textbook definition of the concept). Interestingly, it was invariably raised as a "contested" and "controversial" area. In the words of one participant:

> *There's quite a dichotomy amongst environmental scientists as to whether [ecosystem services] is a framework or a concept we should be using. I'm not sure because it's very human centric. I really struggle with the economic evaluation. It seems to me each year there are new ways of doing this sort of thing (Biology).*

Although participants acknowledge its contestability, they also gravitate toward ecosystem services as an object because of the way it lends itself to being adapted. Box 1 contains the text of a discussion which illustrates how the concept is applied differently within disciplines, yet how the framing of the concepts is introduced to students as being contested.

Insert Box 1 about here

The contested status of terms underlying the concept of ecosystem services even leads to passionate argument. One of our focus groups discussed the nested systems model as a way of re-framing ecosystems services where the model places *"the economic system inside the social system and both inside the ecological system" (Mgmt).* In this discussion that followed an environmental scientist struggled with business' "appropriation" of the term "ecology." He stated "*that challenges me…having ecology there, it should be environment on the outside circle" (Biology).* Management qualified that the use of that term was necessary as "*Environment in business can sometimes just mean the operating environment…" (Mgmt).* To which 'Biology' reinforced this to be a *"misuse of the word 'ecology'"* and that this was something he had *" really struggled with".* He then sought to define the term:

> *"In my first lecture in Ecology, I teach students what the word ecology actually means. The word ecology has been appropriated by technology; we talk about "Apple Ecosystems". That's not what it is. Ecology is the study of interrelationships between organisms with their environment and each other, simple as that" (Biology).*

What followed was a heated discussion regarding words used to signify "ecology" and "ecologically sustainable development" within various different disciplines. Later in the discussion, all parties came to acknowledge the different ways signifiers of ecology have evolved (particularly in its adjectival, mainstream usage) and this understanding fed back into an adjusted and more nuanced view of how the participants intended to speak about ecosystem services. Elsewhere in the conversation and in one-on-one interviews, ecosystems services appears as a kind of newly emergent area of attraction and debate across disciplines.

Another productively contested concept that came up was "environmental ethics". In one instance, accounting and biology frame "ethics" along a kind of spectrum inhabited on one side by people who are deeply and ethically opposed to the concept of sustainability to those on the other side who are just as deeply invested in the project of sustainability. An indicative exchange is outlined in Box 2 (below).

Insert Box 2 about here

The speakers make the point that ethics are both problematic and underappreciated among students in their respective disciplines. The concept of an ethics spectrum achieves mutual agreement across the board as a useful learning device. Furthermore, it inspires an additional layer of reframing to occur around the role of the individual in an organization, which leads one educator to change how they understand the translation of the concept in their discipline:

> *Just talking about it then I've realized that maybe I'm introducing the whole concept in the wrong order. And that's saying here's a negative example rather than putting it*

> *on a spectrum and saying there are some negative examples and there are lots of positive examples and some in the middle that aren't doing much (Biology).*

Like ecosystems services, environmental ethics is considered one that has productive pedagogic potential. It doesn't inspire passionate debate but it does inspire tacking back and forth to clarify what it is that participants are talking about and how to understand it in terms of their own discipline. In the last quote above from "biology", a new understanding emerges, indicating that the negotiation of the concept "environmental ethics" between these participants resulted in a new translation, the process implied by a boundary object.

Another example of such discussion and iterative reframing across disciplines emerged around the "Phase model". The discussion emerged when participants from science and engineering discussed borrowing a pedagogic device from another discipline (business) with positive results because it enabled them to highlight the significance of human sustainability. The phase model itself explicitly involves both the social and environmental frames. Whereas, predominantly scientists had focused the positioning of sustainability within their discipline through a dominant environmental sustainability perspective, they discussed how the model made sense to their students when they *"talked about social capital, in the way of citizen science as an example of social capital" (Biology)*. Despite this, the scientist appropriated the model in curriculum development within the dominant environmental framing of sustainability.

This dialogue reinforced one of our minor findings—that sustainability concepts are often tagged and referenced with regard to economic terminology ("human sustainability" becomes "social capital"), we also observed the tacking back and forth between interpretations of the

model as the business and science participants discussed how the model was interpreted in their disciplines. The science appropriation of the environmental over the human inspires the business academic, to rethink her own framing of it to extend the human dimension beyond a Human Resources perspective. This discussion attracts other participants to consider the different dimensions of sustainability and how they are contextualized within their disciplines and this evolves into one of the central topics continuing throughout the focus group discussion.

This discussion highlights how the 'phase model' is a productive boundary object, a model that is flexible enough to be adapted for use in different disciplines but also inspires iterative reframing. "Biology" has found a way to adapt the boundary object to meet their specific disciplinary needs, and there is no dispute from "Mgmt" concerning the adaptation, which in fact causes "Mgmt" to rethink their own native adaptation of the model.

DISCUSSION

The finding that concepts like climate change do not always act as productive boundary objects among academics researching and teaching sustainability, while concepts like ecosytems services can fill that role, is perhaps counterintuitive, given the urgency with which climate change is usually discussed and debated elsewhere. The relatively productive agency of ecosystems services and simple two dimensional organizational change models and ethical frameworks relies on a number of common factors. Firstly, the manner in which our speakers engaged with each other on these concepts revealed gaps in consensus toward them. Participants engaged in open dialogue with one another in an attempt to make sense of their differences. This process of 'crossing boundaries' has been found to occur when boundary objects act as mediating artifacts that enable 'coordinated' dialogic learning processes

(Akkerman and Bakker, 2011).

In some instances, participants sought to contest their own interpretations and those of the other disciplines, which is they sought to move beyond their own discipline to understand the concept. This productive contestation has been signified as a critical prerequisite for instances of 'transformation', that is where boundary practices are most likely to generate profound changes in current work practices (Akkerman and Bakker, 2011). We found that these gaps in consensus between disciplines did inspire the participants to reconsider how they approached the concepts (and, in some cases, the way they contextualized sustainability within their disciplinary curriculum design and research). Significantly, it appears that this reframing was iterative and occurred in contested dialogues between participants, through which the concepts themselves morphed and adapted to individual agendas, and adapted again in reaction to other adaptations across disciplines. Finally, the iterative adaptation of these concepts created a sense of novelty that in some instances generated the potential for future multi or transdisciplinary work arrangements.

The capacity of certain concepts to function as productive boundary objects is reliant on those factors identified by Star (2010) as common to all boundary objects. As such, we would expect that the productivity of the concepts we identified in this study to wane and other concepts to take their place over time. Thereby, it is likely that the capacity for boundary objects to be productive in terms of catalyzing contestations that may enable transformation are temporarily bounded. It was beyond the scope of this project to formally pursue follow up interviews, but informal interaction with the participants has suggested that a new series of focus groups would most likely already (one year later) turn up a different set of concepts that may exert the agency of productive boundary objects.

We note also that we have made no assertions about the capacity of the boundary objects we

identified to generate "successful" work arrangements and research collaboration. That boundary objects can cause tensions that may block collaboration has been known (Niccolini et al 2012; Oswick and Robertson 2009), yet it is the dialogic interaction around such tensions that characterizes boundary objects (Star, 2010). Such tensions can be likened to those identified by Turner et. al. (2015) as being 'essential tensions', that typically pervade interdisciplinary interactions but can be productively managed through process-oriented and self-reflective practices.

Differences in approach to a problem may of course sometimes prove large enough to create disincentives to mutual understanding and collaboration. One of our interview subjects ("Biology") warned of one such case, a study on the implementation of a wall of plants as a means of reducing reliance on air conditioning. Differences in disciplinary methodology between "Biology" and collaborators from the social sciences caused the project to be abandoned, rather than generating new layers of reframed meaning. As a result of the breakdown, "Biology" is now interacting with the social sciences discipline at a distance. Not only that, but also the concept of "green wall" has for "Biology" become a generalized trope that he groups together previous examples of failed collaborative projects, rather than a forward-looking object of inquiry and source of attraction between the researchers.

Knorr Cetina (1997; 1999) assert that the capacity of an object to motivate collaboration derives from the view of objects as "epistemic things": objects that embody what one does not yet know and the drive to find out motivates interactions and creates a strong bond between researchers. Similarly, Nicolini et al (2012, p.42) found that "people participated more when they were exposed to objects that presented a puzzle, required investigation, and visibly posed a challenge". In the transdisciplinary setting, the epistemic thing is the solution, albeit it temporary and changing, to a common complex problem. In contrast, interdisciplinary interactions pursue a theme of investigation and the goals are different for researchers from

different disciplines. The fact that the academics in this study do claim to collaborate with peers in other disciplines, despite the institutional disincentives to do so, suggests that they are very self-motivated to pursue working with knowledge from other disciplines and would be highly motivated by an object that drives a transdisciplinary sustainability approach. Indeed, "transdisciplinarity requires an uncommon willingness of individual scientists to learn and to think outside the disciplinary box" (Jahn et. al., 2012, p8).

CONCLUSION AND IMPLICATIONS FOR MANAGEMENT

We began by asserting that business managers are increasingly called upon to include a diverse set of stakeholders and use holistic approaches to business sustainability, and yet their single discipline university educations have on the whole not prepared them for this. There appears to be a pressing need for universities to produce graduates who can play a role in organizational approaches requiring employees and particularly managers to work across boundaries and in transdisciplinary settings that connect the science and practice of sustainability.

This study demonstrates how the dominant economic paradigm in mainstream society influences the work of academics across all disciplines, and hence provides the basic context for the education of our management workforce. Organizational change for sustainability requires a paradigm shift, particularly if organizations are to become part of the solution to "grand challenges" such as climate change, rather than the main cause (Wright and Nyberg 2015). This research suggests the efficacy of teaching future managers in all disciplines how to identify and foreground boundary objects in their sustainability initiatives, and why it is useful to allow diverse groups to tack back and forth as they negotiate meaning.

It is perhaps counter-intuitive to think that gaps in consensus toward sustainability concepts serve to motivate collaboration between diverse stakeholders, rather than emphasizing silo thinking. Instead of pursuing shared meaning and group harmony; or the rhetoric of corporate sustainability as a 'shared value' driven by consensus in organizations (cf. Waddock and Bodwell, 2007); managers could be taught to allow concepts to be disputed as a means of achieving progress. Exclusively pursuing or even mandating the "normalization" of grand challenges like climate change could be less significant than developing learning processes which purposively focus on productive sustainability-related boundary objects.

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TABLE 1

Interview Guide

a) What models and concepts do you find useful in facilitating knowledge sharing around sustainability?

b) How do you justify to students the introduction of models of sustainability into your subjects?

   i) What teaching materials do you use to do this and why?

   ii) How do students respond?

c) What are the barriers to you introducing models of sustainability into your subjects?

d) How do you frame sustainability in research? What key concepts and models do you use?

e) Do you communicate and collaborate with researchers from different disciplinary backgrounds in relation to sustainability?

   i) What is the main focus of this research? What are your research question/s?

   ii) What concepts and models do you use?

   iii) What are the barriers to collaborating across disciplines?

TABLE 2

Concepts According to Discussion Generated

Concepts that inspired more discussion	**Concepts that inspired less discussion**
Ecosystem services Environmental ethics "phase model"- sustainability phase model for organizational development	Circular Economy Climate change Triple bottom line Ecological Footprint Precautionary principle Conservation Indigenous people as a stakeholder Stakeholder theory Nested systems model Biodiversity, especially as it relates to economic sustainability Energy efficiency

FIGURE 1

Leximancer Map of Transcripts Showing Associations between Concepts, Names and Speakers

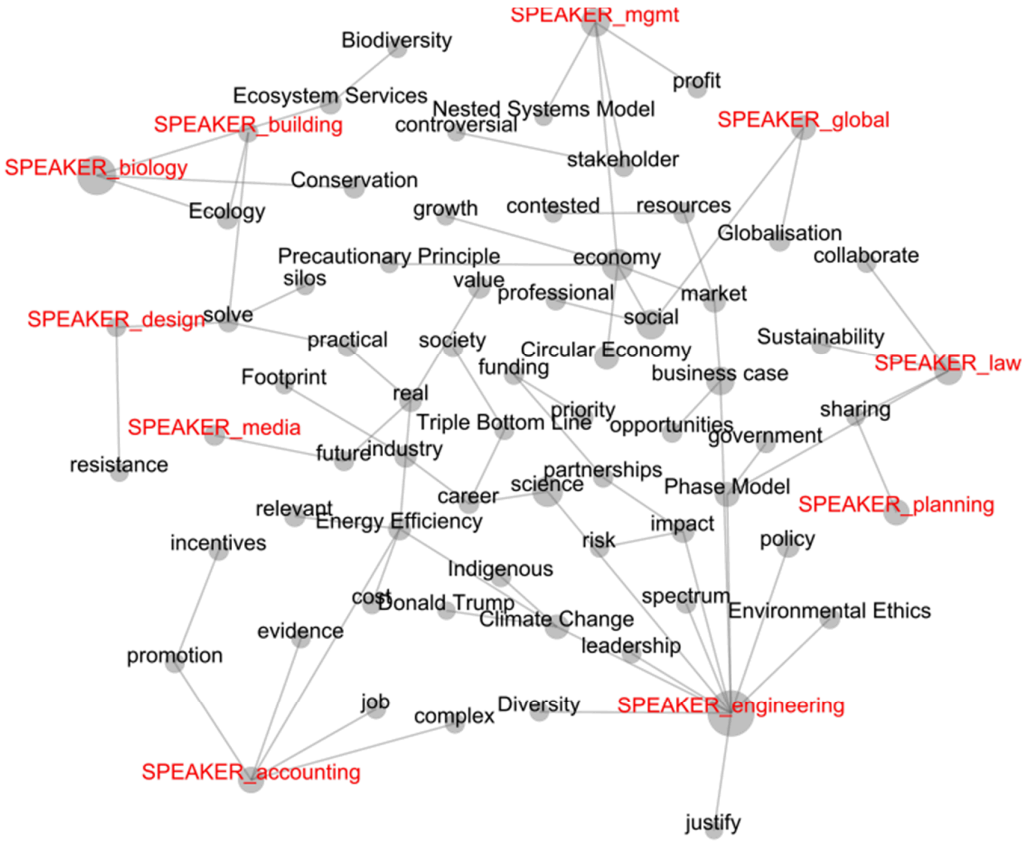
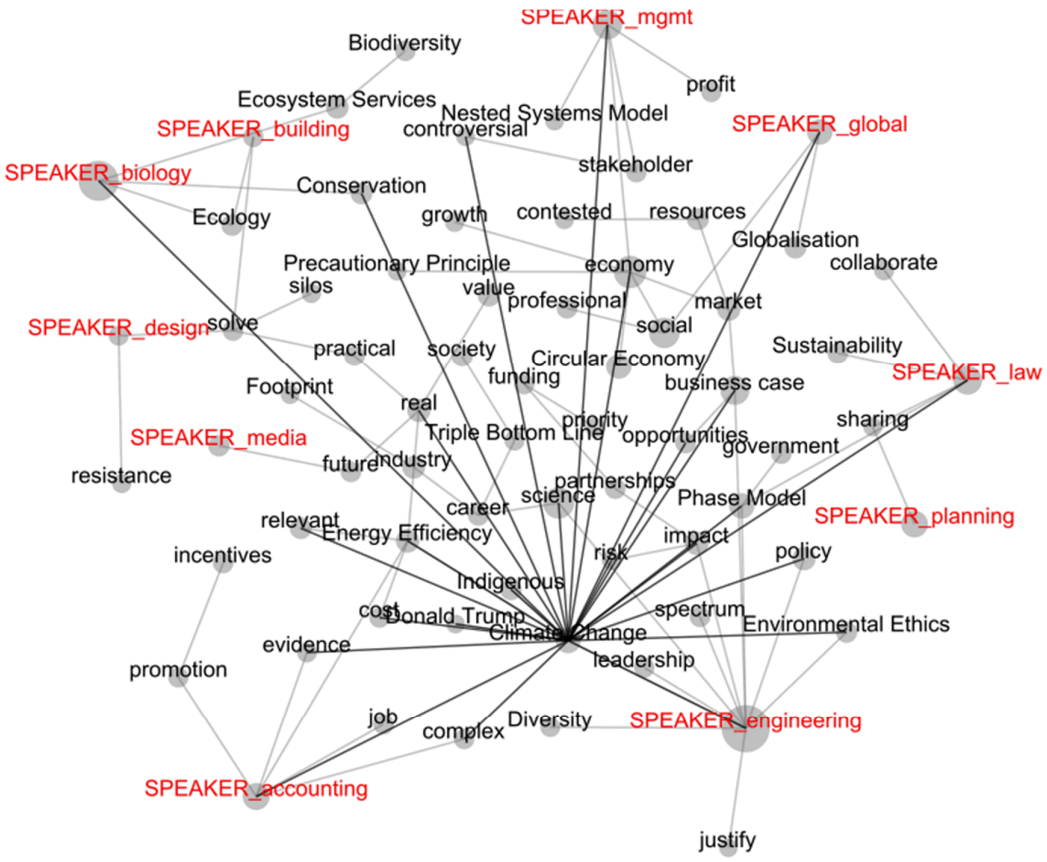


FIGURE 2

Sample Relational Map for the Climate Change Concept



Box 1: Illustrative text of contestation around the 'Ecosystem Services' concept

Biology: I teach my students in the Environmental Sciences the role that biodiversity plays in driving ecosystems services and the idea that conserving biodiversity is important particularly for ecosystem processes and services that we benefit from.
Mgmt: ...Students always are fascinated by this idea of ecosystem services because we talk about services, service models and the economy…. and it's not my specialty area, but from a business point of view this is a service that's providing you with a vital source of energy or resources that is not costed or accounted for..
Biology: …. I published a paper…which had a triple approach to value the ecological and value the societal/cultural and the economic... There's a great example I give third year students about New York water catchments and water….it's a replacement cost or something they call it. I can't remember the details, you know, I'm a Biologist….
Engineering: Pricing ecosystem services?
Mgmt: When you present this concept then you present it as problematised?
Science: Yes, I do.
Mgmt: Contesting. Which is what we do in a sense. Although, we are probably coming from different starting points we also present it as being kind of contested and under looked and undervalued.

Box 2: Illustrative text of contestation around the 'Environmental Ethics' concept

Accounting: One of the other models we used was a continuum ...And we use that as a way of introducing the idea, what is the role of the organisation? What are they actually doing? Who are they doing it for? We have a few diagrams where we put up Milton Friedman's quote ..where they say the corporate responsibility of the organisation is to make profit and then we problematize that using Freeman…instead of pushing these views on the students we just went well this is the continuum and at either end you've probably got some problems.

Biology: I do the same thing too, but I do it in the concept of ethics, environmental ethics and talk about the same spectrum And they follow it up in a tutorial where they evaluate their own ethical position

Accounting: Yeah, yeah, it's probably pretty common

Biology: I do cause I introduced them the first example I give to them is a negative one, cause I talk about environmental management systems and examples where corporations have implemented environmental management systems. And then I introduce the concept of green washing and then I say there's a really good paper where someone has analysed the implementation of environmental management systems. It has made a difference in air emissions but not in water quality, it hasn't led to water quality improvements. The conclusion was people see air emissions and improvements but they can't see changes in water quality. Even if they're saying they're putting the effort into it they are putting effort into air emissions because it's driven by public perception, public image

Mgmt: It's at that point where I think ethics comes in as a good framework for helping people rationalise, understand and analyse decision making in a way that they can resolve it personally if not for the point of view for the company that they're looking at. We looked at the spectrum of different ethics from virtue ethics to utilitarian ethics frameworks and then talk about the fact that the economy really does operate on utilitarian ethics and that some companies are trying to use more of a virtue approach but in trying to operate in a system that's operating on a utilitarian basis they are often in conflict and that's, people think "ok, oh I see, right". That's why it's often unresolved. It doesn't mean businesses are necessarily bad, often they think they are doing what they need to do to get the greatest good for the greatest number of people, but their means of doing that are not entirely negative or nil in their impact.