Transforming knowledge for sustainability: towards adaptive academic institutions

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Abstract
Purpose – The purpose of this paper is to argue that the types of and ways in which academic institutions produce knowledge are insufficient to contribute to a transition to sustainability.

Design/methodology/approach – Reflecting on experiences at the School of Sustainability, the authors contend that a different kind of knowledge is needed, what we call sustainability knowledge. A conceptual approach is taken wherein the authors propose several characteristics of sustainability knowledge and offer some proposals on how academic institutions must be structured to produce it.

Findings – Sustainability knowledge has several characteristics including social robustness, recognition of system complexity and uncertainty, acknowledgement of multiple ways of knowing and the incorporation of normative and ethical premises. In order to produce sustainability knowledge, the knowledge production process itself must be changed to be more adaptive and engaged with society. Two organizing characteristics for institutions seeking to produce such knowledge are proposed – epistemological pluralism and reflexivity. The adaptive cycle from resilience theory is then used as a heuristic to illustrate how these design characteristics play out in making the institution (and individual) more adaptive.

Practical implications – As more academic institutions move to address sustainability, this paper does not offer a roadmap; rather, it raises important issues that must be addressed in performing research and education for sustainability.

Originality/value – The paper shows that type of knowledge that academia must produce and how it might produce it are redefined for sustainability problems.

Keywords Universities, Knowledge creation, Sustainable development, Adaptability

Paper type Conceptual paper

I. Introduction
The unique features of sustainability and its problems have a profound effect on the way academic institutions are structured, interdisciplinary research and problem-based education, and the very function and role of academia and scientific knowledge in society. In this paper, it is argued that academic institutions, particularly in the North American context, as currently structured are fundamentally unable to address
such issues (our contact with universities in other parts of the world lead us to believe this is a global shortcoming). Despite aspects of these challenges having been addressed by others (Clark, 2007; Nowotny et al., 2001), issues remain. Conceptual frameworks to guide institutional reorganization necessary for sustainability are generally lacking. As the authors’ home institution, the School of Sustainability (SOS) at Arizona State University (ASU), moves to produce knowledge for sustainability, they have recognized that merely producing reliable knowledge (Gibbons, 1999), or descriptions about the current state of the world and predictions about the future with a limited ability to adapt to changing societal conditions and framing of problems or to understand and address the normative nature of sustainability issues, is insufficient.

In this conceptual paper, the authors contend that building sustainability knowledge requires a fundamentally different approach to the ways academic institutions organize research and education and relate to society. A definition of sustainability knowledge is provided and key conditions – epistemological pluralism and reflexivity – that are necessary if academia is to produce such knowledge and become a key player in the sustainability transition are proposed. Epistemological pluralism is the recognition and combination of multiple ways of knowing. Contrary to epistemological sovereignty in which “the object of inquiry is often defined by one discipline, thereby privileging their methodological approach and epistemology, imposing a particular set of values” (Miller et al., 2008), epistemological pluralism involves promoting the use of all relevant knowledge, perspectives, and viewpoints in a structured, rigorous manner (Healy, 2003). Reflexivity involves the understanding that the institution itself is part of the dynamics of the system that it seeks to change, thus it continually reexamines and reevaluates the foundational assumptions of its work by “opening up” its boundaries to multiple representations and discourses outside the institution (Miller, 2008; Stirling, 2004; Vob and Kemp, 2005).

Drawing from the authors’ own experiences as students, faculty, and director as well as the literature on sustainability and knowledge production, a framework for transforming the organization and role of an academic institution producing sustainability knowledge is presented. Resilience theory’s adaptive cycle (Holling and Gunderson, 2002) is used as a heuristic device to reconceptualize various aspects of (or stages in) knowledge production for sustainability. The adaptive cycle has been used as a tool in the context of resource management organizations and social innovation (Westley et al., 2006) and here it is useful in understanding the operation of academic institutions as well (after all, what the authors are proposing is essentially social innovation in academia). The authors present the adaptive cycle in the context of experience in building SOS as a new academic program, as well as through interactions with members of other institutions addressing sustainability and tackling similar challenges to knowledge production in academia. The adaptive cycle allows those who are shaping academic research and education programs to think where and when the constructs of epistemological pluralism and reflexivity are most critical in the context of knowledge processing and learning in academic institutions. First, sustainability knowledge must be defined.

II. Characteristics of sustainability knowledge
Owing to the nature of sustainability, much scientific knowledge is not invalid but insufficient (Crow, 2007). Some have argued that new social contract for science is required which obliges science to address societal needs and solve problems
(Lubchenco, 1998; Nowotny et al., 2001). The university knowledge portfolio needs to expand to also include applied and user-defined research (Stokes, 1997). Such proposals, however, are insufficiently pluralistic and reflexive and would still fail to produce sustainability knowledge. Sustainability knowledge is defined below as knowledge that:

- recognizes the complexity of system dynamics;
- is socially robust;
- acknowledged by multiple epistemic cultures; and
- incorporates normative criteria (several of which will be examined below but may and should change in different contexts).

Elements of sustainability problems could fit comfortably into existing disciplinary approaches such as those of ecology, chemistry, physics, geography, history, sociology, government, and economics. What distinguishes sustainability problems from the topics these disciplinary approaches typically study is that in the real world they actually exist as more complex, “wicked” problems (Funtowicz and Ravetz, 1993; Norton, 2005; Rittel and Webber, 1973). That is, they are important, urgent real world challenges that are complex requiring systems dynamics thinking, not yielding to easy solutions or optimal tradeoffs, and are best understood in the context of specific places although their impact and scale of operation may vary in both space and time. Sustainability problems include such significant challenges as adequate access to water supplies, advancing cleaner energy, mitigating health impact of pollution, enhancing agricultural production, making more effective use of natural resources, and encouraging more benign trajectories for rapid urbanization (Clark, 2007). Many of the kinds and ways in which academia produces knowledge are insufficient to understand and act on the wickedness of the system and address the potential trade-offs between and amongst these various problem domains. Such knowledge usually attempts to isolate certain variables of concern (e.g. fish stocks) without accounting for other fast and slow moving variables that might affect the system, especially its social aspects. In other words, currently generated knowledge is too static for such a complex adaptive world.

Following Nowotny et al. (2001), sustainability knowledge must be socially robust. Socially robust knowledge is valid both inside and outside academia. Validity of knowledge is achieved by involving an extended group of experts (including lay experts) revealing divergent perspectives upstream in the knowledge production process (Gibbons, 1999). Reliable knowledge, on the other hand, “works” to the extent that disciplinary norms guide knowledge production within certain boundaries. Socially robust knowledge (and, by extension, sustainability knowledge) requires such the erasure of such boundaries and the ability to work between epistemic cultures (Lee, 1993). Sustainability knowledge then must work with multiple epistemic cultures, i.e. understand the culture that produced certain knowledge and made sense of it as well as the culture(s) that will act upon such knowledge.

It should not be taken for granted that traditional paradigms and current academic institutions produce the types of knowledge that are necessary for informing decision-making towards sustainability (Sheila Jasanoff, personal communication). Knowledge is an emergent property of social systems, Thus the focus is on knowledge processing instead of just knowledge sharing or transfer (McElroy, 2003). Diverse epistemologies play a key role in this process, as in interdisciplinary research projects, through framing and bringing to bear multiple ways of knowing on complex
social-ecological research and management problems (Miller et al., 2008). Recent research on sustainable rangeland management in Northern Arizona illustrates this point. Research ecologists from Northern Arizona University (NAU) have been working with social scientists, land managers, and ranchers to develop a research and monitoring program for managing rangeland resources in a sustainable manner (Loeser et al., 2001; Sisk and Palumbo, 2005; Muñoz-Erickson et al., 2007). Conventional rangeland ecology and management has long been concerned with the effects of grazing versus no-grazing strategies on the resource, which tends to minimize the complexity of rangeland ecosystems. The transfer of this simplistic knowledge and either/or frames to policy have supported highly contentious debates over grazing and provided minimal solutions to achieve rangeland sustainability (Loeser et al., 2001). To counteract the inflexibility of the conventional scientific frame, the NAU research group employed a collaborative science approach in which the research questions, experimental design, and monitoring objectives emerged from their engagement with their social science and policy collaborators and stakeholders. Incorporating multiple ways of knowing into the science process has produced new frames, and potentially new solutions, that have been applied and tested through the scientific approach while remaining useful to policy and community goals (Sisk and Palumbo, 2005).

Not only are the underlying system dynamics of wicked problems complex and uncertain, but the social values associated with these systems are often contested and changing. Furthermore, regardless of discrepancies in definition, sustainability has distinct normative characteristics including valuing ecological systems, social justice, and the welfare of future generations. The authors contend that in order to define an empirical inquiry that seeks to produce sustainability knowledge, a normative discussion in necessary. One broad and illustrative example is climate change and climate science. How might sustainability knowledge for climate change differ from the scientific knowledge currently produced? Currently, climate science is at the forefront of research for climate change as it examines the dynamics of the climate systems, how greenhouse gas emissions are affecting this dynamic and seeks to reduce and characterize uncertainties. Normative discussions, to the extent that they occur, take place after knowledge has been produced and often have no or little bearing on future research. This discussion must be moved upstream in the research process so that it might be more relevant to the values and concerns of society. Rather than first seeking to understand the fundamental dynamics of the climate system, one might ask “why do we care about climate change?” The answer is because it has the potential to cause harm. Efforts might then seek to understand what harms are caused not just by climate change but also natural weather and climate variability (Sarewitz and Pielke, 2005). If the concern is to reduce the harm caused by climate and weather, the sources of social vulnerability to climate and how to enhance the ability of vulnerable populations to adapt to both climate change and current variability in weather in climate might become the research priorities. Such questions are more likely to result from a discussion regarding normative issues such as justice and are beginning to shift in this direction (Lobell et al., 2008; Barnett, 2010).

Institutions seeking to produce sustainability knowledge might establish several normative premises (i.e. what an entity seeking to produce knowledge for sustainability ought to do) to reflect on the value-contexts of societal needs and sustainability. These are certainly not the “right” or only normative premises that sustainability knowledge must consider for these will depend on the context and who is involved in the dialogue.
Furthermore, they should be critically engaged at every level of the research process. These should be viewed as the start of the dialogue as to whether such premises are appropriate at all and, if so, which ones should be established. At SOS, it has been suggested (and debated) that the student, scientist or citizen fully consider five fundamental principles of any solutions proposed: an “awareness” of the complexity of the problem and cascading implications of alternate actions, a sense of “stewardship” of limited natural resources and fundamental ecosystem or earth system services, the “creativity” to discover technological solutions and encourage new patterns of behavior, the insight to promote “institutions” that continually learn and adapt to changing circumstances, and a sense of “justice” that ensure that actions taken are for the benefit of the widest range of citizens possible.

All too often problems are formulated in a way that the outcomes explicitly address one or two of these, but may lead to serious shortcomings in the other aspects. Historically, societies (or the forces that control them) appear to have addressed (solved) problems by implementing solutions that have further advantaged some members of the society over others (or their society over another) and/or have led to a diminution in natural resources (Redman, 1999). Unless evaluated in the context of all five of these perspectives, the authors fear that solutions being proposed for such far-reaching challenges such as global climate change will have dire consequences for just relations among people and stewardship of natural resources. To be most effective these principles should be treated as normative criteria in knowledge production and at several stages of an adaptive process of research design project implementation. But how might this be accomplished?

III. Institutional foundations of sustainability knowledge: an adaptive framework

Like many new programs, ASU’s SOS is an experiment in producing sustainability knowledge and contributing to the solution of real world problems at the local to global scales. While the increased understanding of system complexity has become a major research priority (Liu et al., 2007), integrating the normative and epistemological cultures that are central part of the ability to produce sustainability knowledge have received little attention. Several institutional changes need to take place in order to produce such knowledge. In this section, changes are suggested and a framework for navigating those changes and the knowledge production process itself is offered.

Sustainability is not a smooth, cumulative, or linear process or a single desired end state. Instead, sustainability often requires social transformations that are complex and continuously changing. An adaptive approach to learning and producing knowledge is then necessary to face these changes and respond to them without limiting the ability of the academic institution to sustain itself. While all academic institutions go through cycles of learning, traditional institutions are shielded by the stability that a cumulative, disciplinary way of knowledge production brings. Institutions like SOS face a much different situation. In order to operationalize the propositions made in this paper, knowledge production process is re-conceptualized with the adaptive cycle from resilience theory (Gunderson et al., 1995). Specifically, the adaptive cycle is used as a heuristic device (Figure 1) to analyze the processes and strategies that might build adaptability into knowledge production and illustrate the centrality of epistemological pluralism and reflexivity. This framework, however, will not be appropriate for every
institutions concerned with sustainability. Before describing this framework, the concept of resilience and the adaptive cycle are reviewed.

The adaptive cycle

Resilience is “the capacity of a system to absorb and utilize or even benefit from perturbations and changes” (Holling, 1973; Gunderson and Holling, 2002). The insight resilience theory offers is that though these systems may seem stable, they are in fact rigid and vulnerable to collapse as their resources are tied up in maintaining the current structure of the systems rather than being available to deal with perturbations. A perturbation may lead to a release of resources as the structure of the system breaks down (Ω-phase). This collapse may come after a long period of decline or may be instigated at what seems to be the peak of K-phase power. As resources become reconnected once again in the α-phase, the system reassembles resources, sometimes in novel ways, as it reorganizes. This reorganization often takes a different form from what the system had looked like in the K-phase. This is a state transformation wherein the state has moved from one basin of attraction to another (Walker and Salt, 2006). As connectedness increases in the new state, the system again accumulates capital in the growth, or r-phase.

The primary implication of using resilience theory as a metaphor for our purposes is that systems always face perturbations (in the case of this paper, the challenge of transitioning to sustainability). Institutions must work and change with them, rather than against them, seeking opportunities for positive transformation and continual flexibility. While resilience and the adaptive cycle was originally applied to ecological systems, it has also been increasingly applied to social and social-ecological systems, such as ancient societies (Redman and Kinzig, 2003), resource management regimes (Anderies, 2006) and social innovation (Westley et al., 2006). More importantly, resilience theory places close attention to the “back loop” of the adaptive cycle (the K and Ω phases) in which ecological and social systems are turbulent and uncertain but at the same time where invention and re-assortment are maximized (Holling, 1973), properties which the authors believe are critical for institutions steering a transition to sustainability. However, the adaptive cycle is not predictive, that members of the system do not know for certain how they will emerge from the α-phase when they breakdown. Systems may typically move along the cycle in the way described above, but they can also get stuck.
at certain points, particularly in the back loop of $\Omega$ and $\alpha$ phases (e.g. poverty trap is a highly resilient system). Much of our purpose in proposing this framework is to design social structures that recognize and encourage change at appropriate times and that guides individuals and institution through collapse and reorganization gracefully (i.e. with minimum loss of recognition and resources).

For academic institutions this requires that the knowledge production structures and processes are capable of adapting gracefully through challenging times. Many current configurations of academic institutions, however, even those attempting to address societal needs or do interdisciplinary research have been lured by perceived stability of the K-phase, allocating their financial, intellectual, and social capital toward increasingly narrowly defined issues/perspectives. The same can be said of individual students and faculty who, quite understandably, are deemed successful to the extent that they have built expertise in a discipline, connecting their own intellectual resources and energy to the solution of a problem in a narrowly defined manner. In the K-phase, disciplinary expertise is valued, at both the individual and institutional levels, characterized by a stable set of methodologies and epistemologies. The extent to which they are in a stable and successful K-phase might be measured by the number and prestige of articles published in academic journals, for example. This model is valuable in certain contexts but incongruent with the demands of sustainability, that is, of addressing problems in a world where the rules and relationships are in constant flux. Similarly, academia often strives for a value-free science (Douglas, 2009), as such it is ill equipped to address the normative criteria and the challenges that producing knowledge for sustainability presents. There is a risk of falling into our own expert or rigidity trap (Holling et al., 2002; Westley et al., 2006) rendering the new discipline or knowledge structure unable to recognize and adapt to changing conditions.

In order to remain adaptive, reflexivity must be encouraged both from within the institution (internal reflexivity), by challenging conventional wisdom and recognizing the wickedness of the problem, and outside (external reflexivity) by working with society to frame problems as well as conduct research and education (Figure 2). This entails building the expectation that reflexivity is an integral part of the institution via both structural responsibilities (e.g. dissertation committee rules, faculty evaluations, monitoring program outcomes, etc.) and, more generally, in evolution of the culture of the home institution. In terms of sustainability, it is about being pre-emptive to the trade-offs and technological implications that steering development will involve, as well as responsive to the various players/agents, discourses, representations, and epistemologies that society has about development pathways. In other words, science shapes and is

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**Figure 2.**
The adaptive cycle showing where reflexivity and epistemological pluralism are critical conditions for the academic institution to navigate the cycle and induce epiphanies in the knowledge production process
shaped by society. Reflexive approaches specifically involve strategies with positive feedback loops between the knowledge producing institution and society, such as through participatory processes, interactive strategy development, scenario building, and expansion of review mechanisms (Vob and Kemp, 2005). Upon a release, the configuration of the reorganization is not predetermined. In fact, as Westley et al. (2006) argue, a release is necessary to unleash trapped resources and foster creativity.

As new problems form or old problems are viewed anew, a breakdown may be induced from within or from outside (society), requiring the release and reorganization of the individual’s or the organization’s resources. Changes in academic units, however, are often thought of as “evolutionary” with new elements being added and gradually the nature of the unit changes. Groups of faculty are comfortable with this type of gradual change, but this usually ends up emphasizing tradition more than innovation and when viewed from the outside the university appears as a very conservative institution. To adequately participate in meeting the challenges of sustainability problem solving, universities or at least relevant units within universities must transform themselves in more radical ways suggested above and more accurately represented by the adaptive cycle. An excellent case study of this type of continuing transformation to meet the needs of sustainability is the establishment and recent history of SOS at ASU that the authors have experienced firsthand.

The impetus for the establishment of the school came from the top of the university hierarchy when the president decided that sustainability should be emphasized across the curriculum and efforts should be focused in a new Global Institute of Sustainability and its academic arm, SOS. This was to grow out of what had been a relatively typical and quite successful research center, the Center for Environmental Studies (was in a K-phase). The shock came from above and the center was disestablished (Ω-phase) with the following year being spent debating what a sustainability school would look like and the year following that taking those ideas and formulating them into a starting program and curriculum that could be approved by the university committees and the State Board of Regents (α-phase). Before the creation of SOS, ASU and its faculty had established a strong and diverse set of interdisciplinary research and education programs with the Center for Environmental Studies, Central Arizona-Phoenix Long-Term Ecological Research Project and the National Science Foundation Integrated Graduate Education and Research Training program in urban ecology.

At that point, July 2006, the School existed on paper and a pilot class of six graduate students was admitted for January 2007. Following that a full graduate class of 25 enrolled in August 2007. The school expanded its program further by introducing undergraduate BA and BS majors in August 2008 (as well as accepting a new graduate class). In August 2009, the undergraduate and graduate programs both grew apace (2007-2009 as r-phase). With rapidly growing enrollments, high student retention, and a general excitement of the faculty and students and substantial positive media coverage the school could be considered a success and could have continued in this widely heralded K-phase condition.

However, rather that maintaining their seemingly successful trajectory (maintain in the K-phase) the school experienced a shock from below during the Summer 2009 that has set it in motion around the adaptive cycle again. In the original development of the school the underlying concept held by participants was that sustainability should be approached through a high level of interdisciplinary collaboration and community engagement.
The principle was to bring the necessary disciplines together to solve problems, and implicitly that approach acknowledged that existing disciplinary methodologies were sufficient if brought together in creative ways. For most of the faculty who had been trained and hired into disciplinary units before the School was created this seemed sufficiently innovative, but to some of the new junior faculty who had applied to and joined SOS directly, this was insufficient. For them sustainability was not just an advanced form of work in traditional disciplines, but required a newly devised set of methodologies and conceptual frameworks specifically tailored to meet sustainability challenges in new and transformational ways. Senior faculty was sufficiently receptive to open up the basic premise of the School to debate and complete reformulation. The school entered an Ω-phase without a clear pathway out. It was essential that as an institution that it maintain support from both strong elements of its own constituency (a portion of the senior faculty) and brought on board other parts of the “panarchy”. Toward that end, the University President was invited to the faculty retreat and soon thereafter the students were brought into the discussion. Based on these early meetings a process was established and the School is well into the α-phase (reorganization) while maintaining its operations (classes and degree granting) according to the former rules and concepts.

The key aspect of this process that allows positive interventions are that individuals and institutions of which they are a part most likely do not all go through the cycle simultaneously. More resilient institutions will have members at different scales in different phases of the cycle. While this may sacrifice some of the potential capital gained when all scales are in sync in the K-phase, it encourages mutualism helping to ensure that the institution or individual does not get stuck at any point in the cycle. Even if some of the members of the institution do experience the Ω and α phases in concert with their home institution, the timing of funding cycles and legacies of reputations allows them to each be supportive of the other during periods of greatest vulnerability. Hence, what the authors are recommending is a mutualism wherein individuals use their influence to encourage their institutions to experience change and that institutions are organized in such a way to encourage and provide support for individuals to go through substantial change and redirection. This relationship can foster epiphanies from the top-down or the bottom-up (or some mix of the two as in the case of the formation of GIOS and SOS).

A release is likely to quickly give way to venues for epistemological pluralism negotiations in the α-phase (Figure 2), which as Westley et al. (2006) note, “can be a heady time of exploration; anything seems possible and the mood is optimistic.” Following Miller et al. (2008), a release and reorganization would entail an iterative process of negotiation. Therefore, the precise characteristics of the reconfiguration would be dependent on the process. As resources become increasingly interconnected, the problem is re-framed and one might begin question formulation and actually conducting research in the r-phase. SOS is attempting to build epistemological pluralism by being maximally inclusive at the outset and incorporating different scientific disciplines and perspectives from engineering, business and the arts. This presents a great challenge, however, as these approaches traditionally rely on a different set of criteria, norms and practices. It seems that SOS is on the cusp of reorganization as faculty and students begin to link to approach issues in an organized manner, embarking on their dissertation research and applying for grants. As questions are formed and research begins under the new problem frame, the r-phase sees resources organized around a topic. Even this is an iterative process of action, learning and adjustment. All perspectives will not be equally
important in addressing specific sustainability problems and that the question of how best to evaluate such knowledge is an open one. Finally, as questions are answered and a certain type of expertise gained, the process begins anew.

The use of the adaptive cycle as a metaphor to better understand the processes involved with knowledge production of institutions rather than the more common idea that science advances via iterative cycles of refinement-experiment-refinement, offers several key insights. The first insight is that evidence leading to the collapse or rejection of an approach to solving a problem often does not wait to emerge until after long periods of dissatisfaction and deteriorating confidence, but may occur near the pinnacle of acceptance of that approach. This is why awareness and pro-active strategies to navigate the “back loop” are necessary. The second insight is that when the approach or paradigm collapses its replacement is not necessarily apparent and the individual or institution must go through a phase of reorganization or deciding among competing ideas. There are important implications to these insights; first, just when change should happen, people will still be very confident that the old way is correct and there will be great resistance among some to change; and second, a further deterrent to welcoming change is that if one does not know what approach will replace the fallen one the reorganization phase can be seen as a period of chaos during which personal and institutional confidence is threatened. These very characteristics that inhibit change underlie the rationale for implementing the pluralistic and reflexive approach the authors have advocated to create academic career and institutional settings that are open to new ideas and encourage creative solutions.

III A. Navigating the adaptive cycle. What strategies can academic institutions employ to nudge it out of its complacency while in the K-phase and allow it to navigate the “back loop” of the adaptive cycle gracefully? Some strategies, such as building interdisciplinary and collaboration skills into a student’s curriculum, are already being employed by institutions across the country. As mentioned above, SOS is building epistemological pluralism by including various disciplinary perspectives into the community. This is not enough, however, as the individual, students, and faculty alike, needs to be able to recognize and understand the epistemic cultures that underlie different disciplines, such as expectations, research practices and standards, and worldviews. Promoting these skills solely at the individual level and not linking them to institutional processes will not build epistemological pluralism and reflexivity at the institutional level. Institutions must embrace these skills, as well as develop rigorous measures of excellence to evaluate such skills, as part of the success criteria of the institution, just as grades, diplomas, tenure promotions, and other measures, to evaluate progress of the academic program. Other skills or roles that should be encouraged to promote change in academic organizations are knowledge brokering (Grunwald, 2004), facilitation (Olson and Eoyang, 2001), and epistemological mediation (Wiek, 2007). Along with the depth and breadth of knowledge that a student acquires about sustainability problems (e.g. resource allocation, poverty reduction, water management, etc.), these skills can allow the individual to recognize and work across different epistemic cultures.

Strategies that build reflexivity are much less common and accepted in academic institutions. These involve inclusive and participatory approaches, such as participatory research, collaborative scenario building, and the like, that engage non-academic actors upstream in the research and knowledge production process (Stirling, 2004;
More challenging strategies involve opening up the peer review process to outside entities or be willing to openly deal with academic controversies or disputes such that underlying assumptions about the research are made evident to the public. Funtowicz and Ravetz (1993) refer to “extended peer communities” as a mechanism by which to open up this process and facilitate a re-conceptualization of the complexity of the problem, the narratives or discourses that are shaping it, and their potential solutions. Epstein’s (1996) account of the disputes behind AIDS research and treatment practices in the late 1980s and early 1990s illustrate the significant impact that reflexive strategies can have on the scientific process. AIDS patients and activist organizations became involved in decisions regarding the selection of methodologies and experimental design and their participation was instrumental to develop knowledge that was relevant and representative of the reality of the development of the AIDS epidemic. These actors brought crucial first-hand knowledge and experience about the social practices that affected the pathways of the disease and how infections could be prevented. This knowledge also helped break down stereotypes surrounding the AIDS community that were influencing key epidemiological assumptions about the disease. Importantly, this reflexive relationship between the AIDS research community and the AIDS political community permitted the redirection of research resources and energy to experiment with strategies that were more likely to yield solutions to the problem. In other words, it helped develop socially robust knowledge.

The purpose of the strategies mentioned here is not solely to make the knowledge production process more democratic, which in itself can be a normative criterion of the sustainability institution. These strategies also offer a means to assess the social robustness of its knowledge and anticipate potential consequences that may otherwise not be revealed. These strategies allow the institution to change with society and develop the knowledge needed to face uncertain conditions. However, a key question that emerges is, how are we to evaluate sustainability knowledge producers or to educate students to produce knowledge that may be different for different situations – in other words, contextual? At the very core of the strategies mentioned above, institutional incentives that reward students, faculty, and the institution are necessary. Therefore, funding structures, tenure criteria, and graduation requirements should evaluate success by turning the definition of sustainability in on itself and incorporate criteria of robustness, pluralism, and norms alongside traditional academic criteria. At the individual level or even at the institutional, a “Sustainability Compass” might be used to qualitatively navigate between depth in a given field(s) of study, the ability to help bridge science and society (science-society bridging), understanding and awareness of normative premises of both knowledge itself as well as societal values, and the ability to mediate between various epistemic cultures (Figure 3). Any given individual would not be expected to rank very high on all of these elements, but there should be some level of competence throughout these elements and excellence in several. These elements can also be built into the organization itself. The contribution made here beyond the aspects of sustainability knowledge that have already been discussed is to add epistemic understanding, normative awareness and ability to bridge science and society to the more traditional interdisciplinary characteristics of expertise in both the natural and social sciences (or some combination of disciplines or fields of study). Just as there are complementarities between these various axes there are also inherent trade-offs. For example, a qualitative increase in an ability to navigate epistemic cultures may also result in a decrease in traditional depth in a field of study.
The authors hope that the importance of the relationship between the individual and the institution as a necessary strategy to encourage dynamic, adaptive careers as reflected by the aggressive, yet graceful, way they navigate the cycle has been made clear. There will be situations where the institution will want to attempt to induce a positive breakdown. For example, as mentioned above, when students first begin their studies their world may be turned upside down! At other points, the institution may assist in connecting resources for knowledge building. Similarly, individuals will have a hand in the ways the organization may move through the cycle. Finally, following Westley et al. (2006), while massive change may occur, the core values and functions of the individual and organization should to be maintained. In fact, change must occur in order for these values and functions to be maintained.

IV. Conclusion
Sustainability and the proliferation of wicked problems present unique challenges to the knowledge-producing and problem-solving capabilities of academia. The characteristics of sustainability knowledge are different and its evaluative criteria enhanced according to:

1. how it recognizes the wickedness of systems dynamics;
2. extent to which it is socially robust;
3. extent to which it is acknowledged by multiple epistemic cultures; and
4. meets a set of (contextualized) normative criteria.

In order to meet these challenges, academic institutions must break with the more traditional, disciplinary structure of science in order to remain adaptive to changing societal needs and co-produce with society knowledge for sustainability. Epistemological pluralism and reflexivity, along with a normative vision, must form the core of...
an academic institution’s effort to build knowledge for sustainability. Organizing the institution’s and individual’s efforts around this framework encourages institutions and individuals to exploit opportunities presented by changes and transformations in approaches to producing knowledge. Resilience theory’s adaptive cycle was employed to conceptualize the relationship between the institution and individual and the dynamic nature of the knowledge production process that has been proposed. Changes and transformations in the ways knowledge is produced should be encouraged. In fact, they are vital to academia’s efforts in producing knowledge for sustainability.

This is not a time for despair over the difficulty of transitioning to sustainability. Quite to the contrary, in order for anything like the framework presented to take shape and produce results, this must be viewed as a time of opportunity and innovation – opportunity to re-work the relationship between science and society and a chance to utilize new and innovative metrics for the evaluation of good and useful knowledge. Through epistemological pluralism and reflexivity the authors have proposed to learn from what is known about the social aspects of science and reconceptualize not just sustainability but the processes used to produce sustainability knowledge. These two points as well as the framework presented here must be borne out by further conceptual work and, more importantly, experience.

References


Redman, C.L. (1999), *Human Impacts on Ancient Environments*, University of Arizona Press, Tucson, AZ.


Further reading


About the authors

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knowledge production and our academic institutions to produce knowledge that might result in beneficial societal outcomes. Thaddeus R. Miller also holds an MPA in Environmental Science and Policy from Columbia University’s School of International and Public Affairs. His other ongoing collaborative projects include the ethical dimensions of debates in international conservation, evaluating science-society research collaborations for sustainability and examining the meaning and usefulness of social resilience. Thaddeus R. Miller is the corresponding author and can be contacted at: thad.miller@asu.edu

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