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Proposing a path for sustainability curricula: Identifying core thinking and learning elements for sustainability higher education

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Proposing a Path for Sustainability Curricula:

Identifying Core Thinking and Learning Elements

for Sustainability Higher Education

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Abstract

Research indicates that sustainability higher education (SHE) has been promoted since the 1970s but has not achieved satisfactory progress in meeting original goals. Reflecting the evasive nature of sustainability as a goal, SHE programs appear stunted and there is little overall guidance with regard to curricula development. This dissertation addresses this issue by conducting a comprehensive literature research and sampling of those in sustainability post-graduate programs in an effort to determine an articulable set of core thinking and learning elements to assist in implementing SHE programs. Initial research identified fifteen core element candidates. These were incorporated into a survey sent to seventeen existing sustainability post-graduate programs. Survey responses were limited but provided insight into the opinions of sustainability scholars. The core elements were further researched to determine their significance to others researching sustainability education. It was found that the proposed core elements represented a hierarchy of critical thinking concepts, ranging from those generically applicable to sustainable decision-making, to those which influence results but may change over time, to those which are tools of implementation, to those which are tools which aid in understanding relevant issues and implementing/monitoring solutions. This hierarchy was organized in the context of those elements which should be included in all programs and those which represent optional choices and/or specialties for differing programs. The dissertation concludes by the presentation of these in a logical fashion and by identifying important reasons why adoption of the proposed approach will result in the furtherance of sustainability higher education.

List of Acronyms

CAS – Complex Adaptive Systems

EE – Environmental Education

HE – Higher Education

SHE – Sustainability Higher Education

UNESCO – United Nations Educational, Scientific and Cultural Organization

UNDESD – United Nations Decade for Education for Sustainable Development

WCED – World Commission on Environment & Development

Preface

> *Look around you. What do you see? Everything you see is the result of someone's decision, and some of the things you see are the result of your own decision. … So how can we make better decisions, in the face of uncertainty, to ensure the carrying capacity of the Earth, quality of life for all things, a bright future for generations that follow?* (Mortensen, 2000, p15).

The buzz of sustainability surrounds contemporary society, with many different voices promoting it, often so loudly that no clear message can be heard. The term itself defies resistance as it can be refuted only by implication that failing to sustain is a viable option. Yet its connection both by inference and stated goal to some version of the 'bright future for generations that follow' referred to by Ms. Mortensen above, requires those in the present to consider things yet to come. The difficulty lies in sorting out the basis for that equation, the ability to 'make better decisions, in the face of uncertainty…' which is the operative means of achieving sustainability.

This writing does not attempt to define the path to sustainability, but is enforced by the premise that higher education (HE) should, and will, play a strong role in forming leadership with the capacity to make better decisions. Among HE strengths are ‘critical capacity, influence over professions and societal activities and the contact with the younger generation’ which are necessary to increase awareness of human and planetary connections (Berry, 1996). More specifically, the central theme herein is that we can identify core elements of thinking and learning in HE programs which will in turn educate and train leaders to better answer Ms. Mortensen’s fundamental question. Inherent to this hypothesis are two main points to be addressed: 1) what are the core elements of thinking and learning in sustainability decision-making, and 2) how can these be presented in the format of HE?

Thinking and learning elements for sustainability higher education curricula are not succinctly defined in the literature, and this report seeks address this deficiency. They can be summarized as those skills which are required for the comprehensive recognition, analysis and creative synthesis of wide-ranging and complex problems in order to develop workable plans for achieving sustainable progress. This is distinguishable from domain knowledge describing ‘what is’, and philosophy describing ‘what should be.’ In these terms thinking skills are those which help move ‘what is’ toward the sustainability goal of decision-making that ‘meets the needs of the present without compromising the ability of future generations to meet their own needs’ (Brundtland, 1987).

Superficially this appears an easy goal, we simply need to think harder and be more careful about what we do. But in a world of booming population, instant information, virtual realities, diminishing resources, conflicted politics and global connectivity, where will we find the leadership to deal with untold complexity and uncertainty, to communicate with adequate authority to convince industrial societies to refrain from destructive practices, and still find the resources to satisfy exponentially increasing demand? How do global populations decide between productive but increasingly polluting fish farms versus continuing to harvest sharply declining wild fisheries? How can we encourage the equity promise of globalization, but avoid corporate anarchy? What about problems we have not yet encountered, are we capable of addressing them? While these specific questions will not confront most of tomorrow's sustainability post-graduates, many will be asked to assume new responsibility for the cumulative impact of millions of individually benign, yet collectively unsustainable acts.

In short, the exercise is academic, but the stakes are high. Sustainability is not a simple concept or task; it faces rapid changes and interconnected systems. The fundamental dichotomy is meeting the task of securing a 'bright future' while inescapably tied to knowledge from the past. Goals have been articulated but it is known that sustainability is a continuing process rather than a destination. It is complex and based in sciences, but it is not a discipline, nor a department, and requires collaborative approaches and new solutions. Some say it is 'transformative' and will change the way we solve problems. HE has a crucial role in this and will need to stretch from its comfort zone to lead in the face of uncertainty. Perhaps one path to this is by strengthening and invigorating the ways we think and learn about new things.

I. Background:

History and Status of Sustainability Education

Pursuit of sustainability, at least insofar as use of the term is concerned, dates far back, even to the Age of the Enlightenment. But for the purposes of this research a brief history will begin with modern references initiated in the 1970s. That era followed dramatic incidences of pollution and toxic catastrophes which heightened awareness of planetary limitations (Meadows, 1972) and spawned the development of HE curricula intended to emphasize environmental awareness and protection. Multidisciplinary programs were becoming somewhat common, and there was a call for integration of science, engineering and even humanities to explore new options. The field of environmental education (EE) was introduced in the United Nations Educational, Scientific and Cultural Organization (UNESCO) Belgrade Charter (1975) and formally recognized in the Tbilisi Declaration of 1977 (Wright, 2004). The latter declaration called upon universities in particular to provide leadership, training and expertise in human-environmental relationships. Since that time the number of related programs has increased dramatically. As of 2008, 832 HE programs in environmental education/integrated environmental education were identified as existing in the United States alone (Vincent, 2010).

The profusion of EE programs since the mandates of the Tbilisi Declaration has provided critical expertise in and about the function and measure of ecological systems (Sterling, 2004). But, as discussed in sections below, this accomplishment did not lead to a consensus that issues relating to sustainability were being adequately addressed. By 1987 this was taken up by the Brundtland Report of the World Commission on Environment and Development (WCED) and in a follow-up UNCED conference in 1992, where the term 'sustainable development' was officially launched (Brundtland, 1987, p4). The observation of that report described the entanglement of human and natural systems as a 'seamless net of causes and effects' (Brundtland, p5). Starting with the Talloires Declaration of 1990, there were seven additional U.N. declarations for sustainability HE, each adding new elements of protocol, substantive areas of concern and implementation plans.[1] Each of these was fueled in part by concerns over the lack of progress in achieving the Tbilisi education goals.

The UN Conference on the Human Environment of 1972 provided the original guide to addressing environmental concerns through education, known as Recommendation 96. Sustainability education had been raised at that 1972 Stockholm conference, which included discussion of wealth factors and

[1] For a fuller examination of the history of declarations supporting sustainability higher education see Wright, Tara; *The Evolution of Sustainability Declarations in Higher Education*; ch. 1 pp3-19 in Corcoran, P.B and Wals, A.E.J (ed.); Higher Education and the Challenge of Sustainability; Kluwer Publishers; Dordrecht/Boston/London (2004)

intergenerational equity as well as environmental issues (Paden, 2000). As EE programs expanded in light of expectations regarding sustainability education, there was a continuum of stated concern about the adequacy of the educational response to the broader concept of sustainability (Gough & Scott, 2007). During that time many specifically questioned the ability of EE to adequately address broader human-natural system interrelationships (Wright, 2004).

The details of these concerns are sometimes finely distinguished, but the crux is the belief that EE programs rooted in environmental values cannot without bias consider the social, built, political, food, poverty, economic, etc. factors which are integral to sustainability, and as included in the original Tbilisi Declaration (Paden, 2000).

More recently, there has been a stronger push to establish sustainability education separate from EE. In 2005, the United Nations capsulized this in declaring the Decade of Education for Sustainable Development, 2005-2014 (UNDESD). That specific effort had been catalyzed by earlier work resulting in the 2002 Framework for a Draft International Implementation Scheme (UNESCO, 2002, p8), which lamented that “much of current education falls short of what is required…[which is education] that retains commitment to critical analysis while fostering creativity and innovation.” This international effort increased the call for sustainability education programs as the only option to meet sustainability goals, though the efforts of EE are anticipated to play a strong supporting role in the transformation (Tilbury, 2004).

To a lesser extent, debate is also noted over the various named versions of sustainability HE (SHE). As well, perhaps due to a competition-driven need to distinguish different-named approaches, several writers call for 'radical' or 'transformative' changes in the institution of education in order to implement sustainability education (Glasser, 2004; Walker, 2004; Cortese, 2003; Huckle, 1997). This has led to an apparent 'paradox' as the more significant the change advocated, the greater resistance to implementing it (Sterling, 2004).

This writer was unable to find a published accounting of currently existing post-graduate programs in sustainability. There may be several reasons for that. For one, some prior-existing EE programs have likely changed their focus to pursue sustainability HE goals, but may be difficult to identify by name. Second, as discussed below in survey development, many programs have incorporated the term 'sustainable' by name or within stated goals, but course content is limited as the focus remains another specific, usually professional discipline; e.g. sustainable business, sustainable buildings, etc. Third, there has been a profusion of terms claiming to describe sustainability education, including but not limited to: environmental education, integrated environmental education, development education, education for change, education for sustainable development, education for sustainability, and sustainability HE (SHE).[2] This proliferation tends to confuse

[2] For the purposes of this writing, all of these terms are acceptable if the programs meet the criterion of sustainability as the central focus, and all are incorporated in use of the term SHE.

research (Cotton, 2010).

Perhaps the vagaries in terminology are symptomatic of the difficulty in succinctly defining sustainability and sustainability education, and this has stunted the growth of programs. From the perspective of the research conducted herein, and with some disclaimer regarding the ability of this researcher to conduct exhaustive research, there are currently only a handful of strong, clearly defined SHE post-graduate programs. At the same time many new ones are under development, though there is no guarantee of their outcome. The current state of SHE remains in early stages, and a ripe area for significant and rapid improvement.

II. Problem Statement and Project Goal

A. Problem Statement

Research and academic writing examining SHE have developed significantly over the past decade, embellishing unifying statements from the original call for action of the United Nations at Stockholm in 1972, Tbilisi in 1977 and as most recently as contained in the United Nations Decade for Education in Sustainable Development (2005-2014). There remains some rhetorical debate over the name of this effort, but for the most part learned scholars agree on the values and principles which should be included.

SHE programs have been slow to emerge from the original impetus of the founding declarations. Environmental education programs, related to but distinguishable from sustainability, still predominate in number and perception of value. Based on this research, programs citing 'sustainable/sustainability' in their names are common in a variety of disciplines, but those emphasizing sustainability approaches as the central focus remain limited. Of these few, curricula are inconsistent. In the United States, HE institutions citing sustainability curricula goals are numerous (Vincent, 2009), though few offer post-graduate degrees or extensive coursework.

The conclusion that 'research in sustainability in HE remains predominantly theoretical… [and] does not problematize practice' (Walker et. al., 2004) means that there is expansive theoretical discourse, but curricula elements have not been settled to the point that programs can be readily established.

Existing programs have obviously taken guidance from the literature, but there is no consistency in their offerings or apparent philosophy. At the same time there appear to be many institutions interested in developing a sustainability curriculum had they guidance in how to do so (Vincent, 2009). The current lack of better definition and curriculum guidance is systemic at this time, which constitutes a barrier to the development and implementation of meaningful sustainability programs in HE.

As discussed below, there is strong consensus in the literature that effective sustainability programs require significant and deep changes in the development of thinking and 'second order' learning skills for better decision-making (Glasser, 2004; Blewitt, 2004; Sterling, 2000, 2004; Esbjorn-Hargans, 2006; Tilbury, 2004; Fazey, I., 2010; Pace, 2010). The research and literature contain adequate history, analysis, case studies and justification to catalyze the rapid implementation of sustainability programs in HE. Missing is the organization of this information and presentation in a format readily decipherable by educators and administrators with the will to develop sustainability programs.

B. Project Goal

The goal of this dissertation addresses the simple, yet apparently still unanswered query of one well-known writer as he noted the broad research offerings and texts which have attempted to address the inadequacy of comprehensive materials. "Are there key concepts, ideas and values which link the texts together and provide for a common focus on sustainability?" (Huckle, 2004, p34). By collecting, reviewing and analyzing existing literature and canvassing students, faculty and administrators in existing programs, it is the goal of this project to articulate a workable list of the core elements of thinking and learning strategies for inclusion in SHE curricula which, combined with various domain knowledge coursework available in all institutions, can provide a clearer starting point for the development and expansion of effective programs.

III. Methodology

The methodology undertaken in this report for identifying potential core elements for sustainability programs in graduate education included both a literature-based research stage and a original research via survey phase.

A. *Preliminary Research:* At the outset, a number of academic writings on the state of sustainability HE were summarily reviewed to determine the question for deeper research. Once the topic was settled, this effort was extended as a survey of existing literature, including academic articles, books, reports, academic program information and miscellaneous writings. Sources were found using physical library catalogues at the University of Malta and the University of Washington, virtual catalogues from James Madison University, and internet scholarly resources such as Google Scholar. This course of research remained limited to those resources which addressed the issue of HE and sustainability from an overall point of view. The purpose of this limitation was to maintain a broad view of those academic and other professional sources in an attempt to identify recurring and particularly relevant concepts for thinking and learning about sustainability in HE.

B. *Synthesis of Core Elements:* This research was analyzed and then synthesized into high level categories made up of similar and closely related concepts. In some instances these were very broad and over-arching, as with the concept of 'systems thinking.' In other cases the concept was much more nuanced and restricted in its recognition and application, such as with 'exponential growth.' Many of the categories included a combination of a number of related concepts under one umbrella designation, combining synonyms and related terms where applicable. Each category label intended to keep the meaning of the term broad and recognizable to a diverse audience. For example, 'policymaking' included law and regulation, politics and civics in one concept describing the means of organizing and implementing strategies and plans.

The re-occurrence of a term/concept in several writings was perhaps the largest factor in determining its significance at this level. Once it became clear that an element was commonly a part of the SHE discussion, additional research on it in this phase was limited to specifying its meaning. At the conclusion of this phase, effort shifted to compare and combine separate concepts as was deemed appropriate by a) their significance and priority in the literature, the more significant being less likely to be combined, and b) the similarity of one concept to another, the more similar the more effort being made to combine them if not independently significant. It was preferred that the total number of categories be within a manageable range of ten to twenty elements. The result was fifteen categories, each including a title, general definition and list of 'related terms'. In creating the title and definition, generic terms were used when possible, ones which incorporated all related terms and would not likely be narrowly interpreted, particularly in instances of potentially conflicting, technical or restricted interpretation. Thus the term 'globalization', likely to be limited to economic construction by some, was listed as a related term under the more broadly defined 'globalism'.

C. *Survey Development :* The resultant fifteen categories were incorporated into a survey format using online tool Survey Monkey (survey attached as *Appendix I*). The survey was prefaced with two preliminary questions regarding the school affiliation and student or faculty status of the respondent. No other personal information was requested. Thereafter followed fifteen two-part questions, one for each category, or element. Each question provided the title, definition and related terms for each element, and then proceeded to ask two multiple choice questions.

The first question asked the respondent to identify and rate the significance of that element in their sustainability graduate program experience. This quest specifically sought to determine the incidence of and the degree to which each element was present in the respondent's program. A choice of one of five answers was allowed, ranging from ‘a distinct topic’, to a shared topic, to ‘not addressed.’ The purpose of this inquiry was to gain an ‘on the ground’ view of the status of programs, and reciprocally to give a baseline for program activity related to elements on this report’s list.

The second question asked the opinion of the respondent with regard to what degree a ‘quality graduate’ program in sustainability should include the element. Again, one of five answers was offered in a multiple choice format, ranging from ‘fundamental’ to ‘important’, ‘secondary’, ‘marginal’ or ‘unimportant.’ Responses to this question were intended to help weight the most important core elements, and to allow comparison of respondents’ opinions to their answers about the program they experienced.

While some consideration was given to customizing available responses for different elements, it was concluded that keeping them the same would best allow side-by-side comparison of responses, without additional interpretation. At the conclusion of each element, and again at the end of the survey, participants were offered the opportunity to comment in a text box.

A draft version of the survey was sent out to a short list of recognized current sustainability educators, asking for comments. Their comments resulted in adjustments to wording and presentation of elements and the survey structure. A copy of the final survey is contained in *Appendix I*.

D. *Existing Program Research:* In this activity, existing graduate programs in sustainability were explored with the purpose of identifying those which would be asked to participate in the survey. This research was conducted concurrent with survey development, using online resources to identify existing graduate level programs in sustainability. In early stages various search terms were used, such as 'sustainability', 'sustainable', and 'environmental' in a program title, as there are programs which emphasize sustainability but do not use that term in their title. However, the number of results which derived even from the inclusion of 'sustainable/sustainability' by title was high. Following this determination, the focus of the program research turned toward examining them in enough detail to determine if their overall program focus and goals were consistent with goals of this project.

In addition to individual program searches, attempts were made to identify programs through broader organizations or affiliations which would list relevant programs. While some were identified in this manner, this was the result of additional review beyond the referral, as this researcher found no web site, organization or group which reliably identified graduate programs focusing on sustainability as the main course of study. More likely this led to sub-program of another discipline; such as architecture, business, environment, agriculture, forestry, education (usually K-12), economics or the like. Ultimately, when the program focus remained unclear after an initial analysis, criteria matches were determined by review of course offerings and stated program emphasis.

Ultimately this process identified fifteen programs which met the report criteria. A list is provided in *Appendix II*. Even with this modest total, there remained some disconnect between stated goals and the program offerings, for the most part due to added emphasis on environmental coursework. For example, one offered a course in 'environmental advocacy', which may or may not be an enlightening course, but such a show of bias would generally not meet the criteria. Several are very young programs, with no more than a year or two of course offerings, and their program offerings remain under development. Several others were announced but not yet underway. Overall these programs offer some challenge of 'leadership' for understanding and implementing sustainable practices in the community at large.

E. *Survey Submittal:* The original project timeline anticipated survey submittal to target program coordinators by early June in order to catch school participants before they dispersed for the summer. However, finalization of the survey was significantly delayed by processing through the James Madison University's Institutional Review Board. The survey was sent to program targets the first week of August, 2011.

F. *Survey Results:* Overall response to the survey was very low, although additional insights were gained from the narrative insights shared by a few respondents. Only twenty-nine responses were initiated, and of these twenty were fully completed. While not a significant sample for the original purposes of the project, the responses, together with the comments, provide opportunity for analysis and comparison. The raw survey results are reported in *Appendix III*, and the data is evaluated in the Analysis section below.

G. *Detailed Element Research:* Pending the approval of the survey, research explored more deeply into the elements and related topics. Topical research was first limited to a sustainability context. If that failed to produce adequate material, research followed the literature to ensure that pertinent information and/or examples could be provided in the discussion of each core element. Caution was taken to seek out information in the context of that topic's place in the project's sustainability discussion on learning and thinking elements for education. This research is reported in detail in the Core Elements section below.

H. *Analysis, Synthesis and Conclusions:* The remainder of this writing seeks to identify and prioritize the most significant core elements in the context of HE. This was both a quantitative and qualitative approach, mostly reliant on the literature-based research, but also considering survey input to underscore the points to be emphasized. Initial analysis was then synthesized to create a hierarchy of curricula components. In order to justify this, three specific areas of this process are explained in more detail, relating to the concepts of distinguishing sustainability education, examining interdisciplinarity and a means of prioritizing potentially conflicting issues. This segment wraps up with recommendations and a final conclusion.

IV. Core Element Research

A. Individual Elements

This research provided significant enlightenment in regards important pieces of the sustainability education puzzle. Completed research also verified that the elements derived initially and used for survey development were an acceptable representation of the scope of issues, and these were used to frame this more detailed definition and analysis.

Systems Thinking

Natural Systems

Exponential Change

Inter/transdisciplinarity

Full Costs/impacts

Equitable Perspective

Adaptive Capacity

Policymaking

Expertise/technology

Uncertainty

Resource Efficiency

Globalism

Pricing

Personal Responsibility

Conflict/risk Management

Other terms might have been used, and *Appendix IV* summarizes lists of sustainability curricula priorities provided by several other writers. This section includes a research overview for each of the fifteen survey topics in the context of SHE. This is followed by a summary. Topics are presented in the same order as in the survey, which has no bearing on their perceived significance.

1. Systems Thinking

> *The world is a complex, interconnected, finite, ecological-social-psychological-economic system. We treat it as if it were not, as if it were divisible, separable, and infinite. Our persistent, intractable, global problems arise directly from this mismatch* (Meadows, 1982, p101).

The concepts deriving from systems thinking and systems approaches are predominantly, if not unanimously considered integral to sustainability decision-making. As with sustainability itself, systems approaches are used in a multitude of contexts. Generically, systems thinking - when one includes references to 'system approaches', 'systems', 'systemic views', etc. - is contained in the vast majority of lists of key elements of sustainability education programs (Wheeler, 2000; Byrne, 2000; Sterling, 2004; Sherren, 2006; Porter, 2009; Jones, 2010; and others). It is considered by more than one scholar as critical to the shift from 'reductionist', or linear thinking, to more holistic and less constrained 'constructivist' learning and thinking (Pittman, 2000; Fazey, 2007).

A key starting point in considering systems thinking is the need for awareness of natural systems, which are both foundational to sustainability principles and provide excellent teaching opportunities to illustrate the interrelationships which define systems (Itard, 2010). Natural systems are considered 'hard' systems, which are characterized by defined boundaries and finite capacities, and generally are considered 'goal-seeking' toward equilibrium (Roling, 2004). Examples would include the hydrologic or carbon cycles taught in undergraduate classrooms. Systems approaches also apply to social, economic and cultural systems, among others. It is important to note, however, that many of these human systems are considered 'soft systems', which are characterized by unconstrained resources, negotiable boundaries and which usually require agreement to move ahead (Checkland, 1981; Roling, 2004). These are important distinctions in the case of systems conflict, as considered below.

At a more detailed level, it is the interrelations between different systems, sub-systems and meta-systems which are critical. Even more so, it is the means by which different systems and their components interrelate, not the components themselves, which are central to systems thinking (Sterling, 2004). Because of the applicability of this concept to virtually all planetary functions, natural or human constructed, many see 'whole systems thinking' as one of, or even the most important element in all of sustainability study (Wheeler, 2000; Sterling, 2004). At its heart is the growing, but still insufficient understanding of the extent of the interrelation between the carrying capacity of the Earth's natural systems and those systems built by humans (Huckle, 1997).

In addition to identifying, and perhaps characterizing relations between systems and system components, it is at least as important to understand the results of their functional relationships. Generically this is referred to as system feedback, which is particularly important when considering a system change. Spontaneous changes can positively or negatively affect the system, or change can be imposed; still the ultimate impacts must be predicted and considered. In the common instance that our perception is incomplete, human 'mental models' must be changed, and systems models and illustrations can be profoundly effective in meeting that end. This has become a classic base model for the way in which decisions and changes occur, as shown in Figure 1 (Sterman, 2000).

Figure 1 - Double-loop Learning (Sterman, 2000)

The literature also contains other technical explanations of the role of systems thinking in sustainability decision-making. As a further means of understanding them, three types of systems thinking have been introduced:

functionalist, interpretivist and complex adaptive systems (Porter, 2009). The first type relates to classic linear systems and engineered solutions, essentially identifying components, relations and interrelations, then applying parameters, including 'sustainability parameters' to optimize functions (Sawyer, 2005; Bausch, 2001). Interpretivist theory provides more opportunity for human perspective, fallibility and apparent uncertainty, even providing for conflict resolution processes as needed (Cooperider, 2004). Complex adaptive systems (CAS) leave even more room for uncertainty. They are characterized by multiple sub-systems and agents (Griffiths, 2004). The concepts of self-organization, emergence and bottom-up change ultimately determine the health/survival of the complex system itself (Porter, 2009; Wilson, J., 2002). Because most natural systems are complex adaptive, and because of the consensus on the use of systems thinking to pursue sustainability goals , systems thinking concepts are pertinent to both the evolution of sustainability awareness and the incorporation of the concepts into SHE.

Despite the broad appeal and support for systems thinking as an integral part of sustainability decision-making, there remain some questions. Leery of the plentitude of non-scientific references to the ultimately technical field of systems thinking, some have voiced concern over the 'fashionable' promotion of systems thinking as too simplistic to truly reach the much deeper concerns relating to ecological science (Porter, 2009; Guntram, 1993). These writers argue that, despite their utility and applicability, systems are the mental constructs of humans, and do not have an independent objective existence. In an advanced article on complex systems, the common theory that natural or other complex adaptive systems are predictably goal seeking was questioned by another writer, with the persuasive conclusion that adaptivity from observation is a more effective means of dealing collaboratively with ecosystems than is predictive systems modeling (Wilson, J., 2002). According to Wilson, the identification of patterns and slow changing components are the best indicators of complex system health.

While these technical observations are important and likely candidates to be taught in a sustainability curriculum, systems thinking is at the center of an even larger and more important consideration for sustainability education. This entails the overall shift from the reductionist methodology and viewpoint, characterized by the dissection of issues and fields into apparently more manageable parts, to a broader constructionist view of the world and its functions (Sterling, 2004). Concern over the increased complexity of considering multiple systems simultaneously has likely catalyzed distilled formats such as the 'triple bottom line' mantra of ecology, economics and society. But conventional, compartmentalized approaches are not truly systems-based and have led to unintended and harmful results (Cortese, 2003). Increasing understanding of the link between behavior and resultant problems using a systems approach is an effective use of SHE as a societal tool (Fazey, 2010), whether to address global scale issues, community development plans or limited business functions (Porter, 2009).

Even persons lacking expertise in systems thinking can readily grasp its applicability as a tool for better-conceived decisions. A basic recognition of the interactions, patterns and feedback/limits in a variety of systems important to humans – water, atmosphere, transportation, communities, etc. – provides a 'whole picture of the phenomenon' reducing the likelihood of overlooking related ramifications. Systems thinking entails more than analysis of components and functions, it is an independent manner of thinking and addressing problems (Sterling, 2004; Dobson, 1990) emphasizing the initial step of broadly surveying the ripple-affected zone of any proposed decision. In this generic sense the approach lends itself to any contemporary problem, and specifically to those that necessarily include a broad range of issues and influences. This characteristic establishes its role as a critical element of sustainability processes, providing both a consistent theme of inclusivity and a jump-off point for various other important thinking and decision-making steps that follow.

2. Natural Systems

Healthy natural systems left to their own are generally considered sustainable even as they adapt and change over time. Questions arise when humans enter the picture: are we part of the natural system or separate from it? Can we be both? What is our obligation to ensure that natural systems remain viable, even as we harvest, extract and impact them on an ever-increasing basis? Various natural elements provide a number of ecosystem services, sometimes creating conflicting human benefits. For example, harvesting timber provides wood, paper and fuel but results in the loss of carbon sequestration, increases in erosion and loss of habitat. Do the benefits we derive from consuming these resources justify the trade-off and subsequent loss of value suffered by the natural system? (Fisher, 2011).

Whatever the response to these queries, we know that most issues which we characterize as pressing sustainability problems derive from the ways by which human-instigated change affects other (natural) components of the Earth, and from a common lack of understanding about how these interrelations work (Huckle, 2004). For the purposes of this writing we will ignore the opportunity for rhetorical debate, and establish that the term 'natural systems' includes all those things which are capable of existing independent of human construction, modification or maintenance. Related terms include natural resources, environment, ecosystem services, natural cycles, carrying capacity and perhaps others.

As indicated, human-generated social, cultural and economic values are embedded in natural systems analysis. As evolved practices, these both impact and are impacted by environmental and natural system conditions and policies (Hugby, 2004; Bowers, 2000). A fiscal estimate of the value of global ecosystems services, purely in terms of benefits to humans, was developed in 1997 in a seminal report which calculated the monetary equivalent of thirty-eight trillion dollars (Costanza, 1998). Since that publication there have been scores of objections to its valuation being too high or too low, or generally inconceivable (Pimm, 1997; Toman, 1998). A more recent micro-scale analysis has reported that ecosystems can be valued by the energy work capacity generated by the system, which can then be priced comparative to other energy sources (Jorgensen, 2010). Other objective works have sought to understand these values, though they point out the difficulty in measuring the value of many functions which are effectively irreplaceable (El Serafy, 1998; Schmitz, 2010).

The foundational inquiry from this implication is 'why do we value intact natural systems?' It is perhaps with some sense of irony, given the difficulty in determining where humans stand as part of the natural system that our ability to understand the value of natural systems necessarily derives from our human perspective. In 2005 the United Nations' Millennium Ecosystem Assessment (MEA, 2005) developed a comprehensive, high level structure for the classification of benefits provided to humans by natural systems. Ecosystem services were classified into three categories. 1) Provisioning Services refer to the supply of resources—food, fiber, water, fuel, and other needed materials and energy. 2) Regulation Services are associated with climate, floods, disease, water quality, and other factors involved in control of provisioning. 3) Cultural Services include aesthetic, spiritual, educational, and recreational aspects of ecosystems (Patten, 2010, p282).

In truth, human civilization relies fully on its adaptation to the many benefits of natural systems. Altering the system balance raises the issue of replacement materials and functions which are likely to be much more uncomfortable, expensive or even unbearable. This can be from big picture items, such as overtaxing clean water or food production capacities, or it can be a chronic reduction in quality of life; loss of convenient energy sources, diminished air quality, expensive food items or lack of recreational opportunities (NRC, 2005). Consistent with other sustainability themes, the long list of human necessities, couched as natural system benefits, fully discloses the importance of natural systems to human survival. In the context of natural systems, the base logic of sustainability hinges on the common meaning of the term ‘sustain’ (the only apparent alternative being an end point), coupled with the above references to critical human support systems. Thus it lies within even a cynic’s interest to sustain human abundance by protecting, preserving and maintaining the ability to reap the benefits of ecosystem services.

Despite our reliance on them, startling statistics documenting the decline of natural systems and ecosystem services are readily available and growing consistently. For example, it is estimated that as of 2008, 82% of global fishery stocks are fully or over-exploited, yet constitute a main protein staple for approximately one-half of the world's population (FAO, 2008). The recent and dramatic decline of the European honeybee (*Apis mellifera*) has cost agricultural industry billions of dollars in pollinator replacement services, and jeopardized the availability of fresh fruits and vegetables (Chaplin-Kramer et. al., 2011; Kremen, 2002). As of 2000 it was estimated that at least one billion people do not have access to reliable sources of drinking water, and some estimate that by 2050 this will include one-half of the global human population (Diamond, 2006). And the documented correlation between increased human emissions, rising carbon dioxide levels and climate deviations from norms is overwhelming (IPCC, 2007).

While our retrospective view allows that natural system degradation has occurred as unintended and at the time 'unforeseen' consequences, system analysis regards it as the product of acting without acknowledging the double-loop feedback function of human-nature relations illustrated in Figure 1 above (Glasser, 2004; Sterman, 2000). Given human reliance on these resources for our very existence, it is useless to plead ignorance to destroying them; the sustainability imperative is to do a better job of foreseeing impacts and ramifications. Thus, achieving progress toward sustainability requires that we view it 'not as an objective property of a given ecosystem but [as] the emergent property of human interaction' with our supporting ecosystems (Roling, 2004, p184). In other words, sustainability actually derives from the functions of soft, human systems (Checkland, 1981).

Implicit in the reference to 'emergent' is the need for human restraint from over-exploitation, and knowledge of natural systems processes sheds light on better means of both preserving and benefitting from them. As discussed above in systems thinking, natural systems are generally hard, or closed loop systems, meaning they are finite and bounded (Uhl, 1996). They are sustained through a tenuous balance of accumulation (stocks) and dissipation (flows) as their components rely on one another (Seto, 2010; Kazanci, 2009). Broken into sub-systems, ecosystems are in fact a series of trophic interactions involving producer and consumer elements whose individual and systemic survival depend on persistent, reliable and resilient recycling of critical elements (Schmitz, 2010). For example, forest system functions simply described consist of interrelationships between micro-organisms, soils, nutrients, growth and decay, the latter leading to the recycling of material and continuing processes (Perry, 1994).

Most critical to ecosystem function is the concept of their equilibrium, or steady state. Complex mathematical analysis has shown that a healthy ecosystem is constrained to operate when internal and relevant external components are within a close range of balance between growth and decline (Patten, 2009). Other studies have shown that the health of an ecosystem is directly proportional to its biodiversity (Hopper, 2004). In the same analysis of four important properties of healthy ecosystems, factors which affect the viability or number of any component are considered 'controls'. Healthy systems have a variety of controls, and if one becomes dominant, the entire system is jeopardized (Patten, 2009).

Human exploitation is a form of control, one which is outside the normal function of the system and is likely to select specific components for extra-system purposes. Because of our ability to obtain and generate knowledge, humans may also be capable of determining what degree of control or extraction may be within the range of system viability. While still in the process of refinement, using the criteria derived above, for example, allows a better analysis of different ways to meet sustainability goals (Patten, 2009). Those which do not alter the pre-exploitation properties of the ecosystem are most promising, such as organic farming (Phelan, 2004) and ecosystem mimicking (Lefroy et al., 1999).

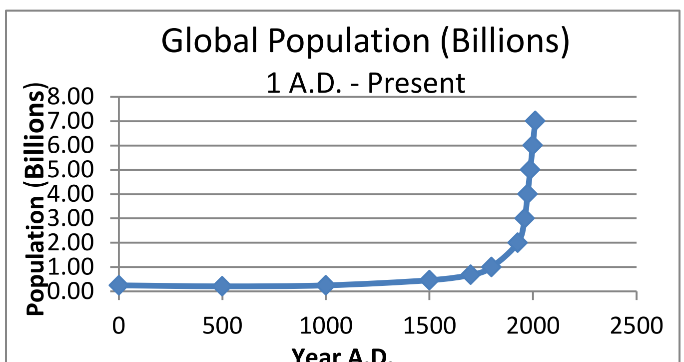
According to the Millennium Ecosystem Assessment of 2005:

> "Humans are fully dependent on Earth's ecosystems and the services that they provide, such as food, clean water, disease regulation, climate regulation, spiritual fulfillment, and aesthetic enjoyment... When an ecosystem service is abundant relative to the demand, a marginal increase in ecosystem services generally contributes only slightly to human well-being (or may even diminish it). But when the service is relatively scarce, a small decrease can substantially reduce human well-being." (MEA, 2005)

Perhaps the above statement sums up the sustainability dilemma surrounding natural resources. Ecosystem services are critical to humans, yet humans are their chief danger. Humans are capable of protecting natural systems, but humans often fail to 'foresee' the damage to them until it has occurred. What is needed are effective means of restraining human activities intended to produce benefits – i.e. energy, food, convenience, etc. – but for which the cost, or degradation to ecosystem services is too high. This is now a global issue, at some point requiring consistent global responses (Blanco, 2009). While the science of natural systems stands at the forefront to support sustainable solutions, it is too often diluted by the shorter term influences of economic and social issues, industries, communities and politics (Porter, 2009; Roling, 2004). Thus HE and leadership will be tasked with demonstrating across these disciplines when and how the science leads to more sustainable results.

3. *Exponential Change*

While the factor of exponential change, or rapid growth, is fairly straight-forward and easily described, it represents a phenomenon which is at the root of both the problems and the potential successes inherent to



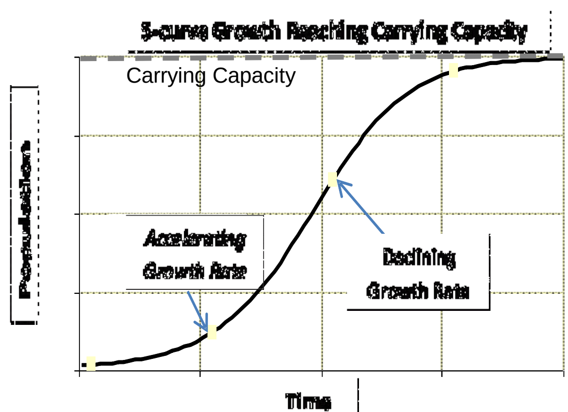
This chart, using data from the U.S. Census International Data Base provides a look at the stunning exponential growth of the world's population over the past two thousand years. tp://www.census.gov/population/international/data/idb/worldhis.pl

Figure 2 - Global Population Curve

sustainability. Thus, some consider it critical: "*The greatest shortcoming of the human race is our inability to understand the exponential function.*"(Bartlett, 2004, p68). At its core is the concept of doubling time; that is the relation of the percentage growth per time unit to the amount of time it will take to double its number. Purely a mathematical calculation, the amount of time is roughly seventy-two (72) divided by the percentage growth rate in that time (Meadows, 2004). If the growth rate remains constant, the number continues to double at the same time interval, again and again (Sterman, 2000). Thus a starting population of 100, for example, first doubles to 200, then 400, etc. By the occurrence of the tenth 'double' it will be 102,400. And importantly, the next net increase will be another 102,400, in the same amount of time it took to grow from 100 to 200 (Uhl, 1996). It is said that this phenomenon applies most aptly to populations and bank accounts. It also applies to trends in traffic, oil/coal consumption, grain production, etc., which are linked to population via consumption per capita (Sterman, 2000).

As originally presented by Thomas Malthus' work An *Essay on the Principle of Population,* published in London by J. Johnson in 1798, the mathematical basis for the curve is the presence of a constant change *rate*, versus a constant number. The example of a bank account is often provided, where a constant rate of interest applied to an increasing principal without other variables produces a healthy increase in savings. The inverse this type of growth is termed 'exponential decay'. In this scenario, a specific number, classically a radioactivity half-life though also applicable to a biotic population, is reduced at a constant rate. In species populations, over time, a population may fall below a 'minimum viable population' and is thus unable to sustain itself, leading to the prospect of extinction.

The exponential growth and decay curves are generally considered to be indications of unsustainable systems, and particularly in regard to natural systems, as high growth cannot be sustained for long, and decay leads to extinction. In a healthy population there are generally other factors such as food supply, space, disease, etc., generically termed 'carrying capacity' which slow population growth naturally. A normal curve for a natural system is termed 'goal-seeking', an S-curve or 'logistics curve', the goal being equilibrium with interrelated systems. (Sterman, 2000). As noted by Figure 3, the population levels off at the point the goal is reached, thus representing equilibrium and likely sustainability.



As illustrated above, most natural system growth rates increase until they approach carrying capacity, when their growth slows to a population steady state.

Figure 3 - Generic S-curve

An over-expanding population can create obvious problems, but the most catastrophic is actually common in nature and is known as 'overshoot and collapse' (Sterman, 2000). As discussed in regard to systems thinking above, most natural, social and economic systems are considered complex by virtue of their reliance on other systems and interrelationships. The extent of the ability of other systems to provide support for a target population is considered the 'carrying capacity' of the overall system, which generally determines population limits. Frequently in natural systems, a population temporarily over-consumes its carrying capacity, creating a short term boost in its population but leading to an often abrupt, longer term depletion of carrying capacity. The resulting inflated population is the 'overshoot', and the result is its collapse due to the reduction in carrying capacity resources (Meadows, 1972, 2004), as illustrated in Figure 4 below. This is seen commonly as variations in hunter-prey systems, but has also occurred historically in complex human societies, such as on Easter Island or the Mayans of Central America (Diamond, 2006).

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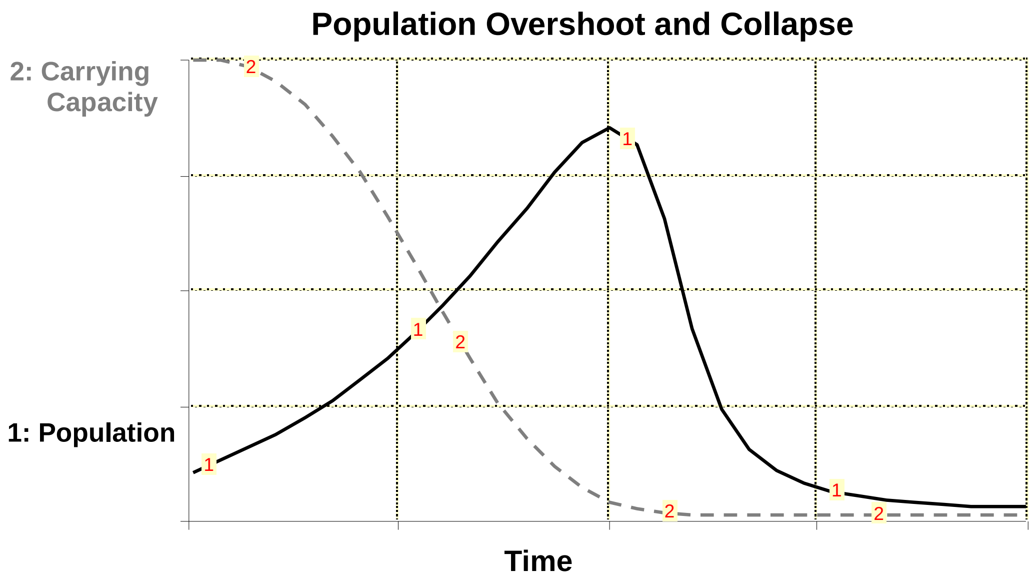


In a system illustrated by this generic graph, the exponential increase in population leads to diminished carrying capacity, resulting in the collapse of the population.

Figure 4 - Overshoot and Collapse

In most natural systems the increase in one factor, such as population, is directly tied to and directly influences others. As observed in a predator-prey scenario, the rapid increase in predators results in a decline of prey, which in turn causes predator populations to decline (Ripple, 2004). In cases where a consumer disappears altogether, the ramifications to the system may be extreme, as for example rapidly increasing prey populations leading to catastrophic reduction in food supplies overall, a phenomena known as 'trophic cascade' (Estes, 2001).

The concept of growth has largely been considered positive in Western societies, and remains that in many contexts. However, the trend or rate of growth is now better understood to give new evidence of the qualities of growth. The 'inverse J-curve', as the exponential growth curve is described, now shows up across the landscape of sustainability topics - population, petroleum consumption, greenhouse gas levels in the atmosphere - and recently in socio-economic issues such as housing market bubbles and the difference in income levels between rich and poor.

Within the context of sustainability education, an awareness of the properties and probabilities associated with exponential change is very important for those in decision-making positions. More subtle than other components described herein, nonetheless an understanding and wariness of exponential change is important due to the potential for ramifications to supporting systems, and for the risk of overshoot and collapse.

4. Inter/Transdisciplinarity

In terms of numbers of scholarly citations, the concept of interdisciplinarity – and to a lesser extent transdisciplinarity – rivals and perhaps even surpasses systems thinking as the most commonly emphasized element. It is closely related to systems thinking in its emphasis on reaching into and combining issues from conventionally separate disciplines. Other terms related to interdisciplinarity include liberal education, critical thinking and integration/integral theory (Esbjorn-Hargens, 2006; Brown, 2005); for transdisciplinarity these could be community-based education, action research and experiential education, among others. Many of these are also related to the equitable perspective discussion below. While there is widespread support for movement in this direction, the literature and experience demonstrate some inconsistency between the use of the term for academic purposes and its application to sustainability overall, as noted herein. As a result, this core element is one of the most significant as a means of making sustainability progress, yet has presented the greatest logistical concern for educational institutions.

Nuances exist in the use of these two terms, as well as others found in the literature; thus definitions are helpful. An interdisciplinary approach not only incorporates knowledge and expertise from more than one discipline, but synthesizes resultant information to develop and apply new knowledge and expertise. Transdisciplinarity refers to a similar result, but specifically adds collaboration between academicians and non-academic practitioners to better address 'real world' problems and experiences. Contrastingly, multidisciplinarity involves persons from more than one discipline, working together but without the development of new combined knowledge (Graybill, 2006; Tress, 2005).

There is effectively consensus in the literature about the importance of crossing over historic academic disciplines in order to understand and address contemporary sustainability problems, as no writings were found in opposition. The underlying premise driving interdisciplinarity is the use of 'problem-driven' approaches to issues and decision-making (Jones, 2010; Sherren, 2006; Meadows, 1982). Using this guiding principle, there is no predisposition to any response; rather the analysis focuses on finding the important issues, then seeking knowledge and expertise to appropriately address all of them, whatever their discipline (Jones, 2010).

In most conventional mono-discipline-based systems, administrators will reverse the sequence above, seeking to use known and available experts to both assess and solve the problem. The term 'silo' is frequently used to describe the practice of relegating an issue to the single domain department or expert which may be considered the best for the job. In doing so the resolution is certain to reflect that department/expert's perspective and likely only that one, in the process commonly overlooking a variety of other issues unknown to this specialized resource. As an example, the use of hybrid or zero emission cars is often promoted as the answer to urban pollution and climate chaos issues. However, while pollution is reduced, a decision to proliferate these eco-friendly vehicles exacerbates other similarly important concerns such as increasing vehicle trips, live-work separation and sprawl, increased highway lanes, and loss of agriculture lands and local food supplies (Fazey, 2007). In this example, the lack of traffic and planning knowledge may cause the clean technology engineer to promote a problematic solution. Generically, the isolation of expertise in business, government, educational institutions or other significant entities runs against the developing principles of sustainability. In effect, conventional methods of organizing and specializing knowledge close interfaces which could allow decision-making and educational processes to more closely align with reality (Esbjorn-Hargens, 2006). Conceptual boundaries, be they segregated departments or disciplines, result in closed , and likely failed, attempts at sustainability, as all other disciplines and practices appear outside of the boundary. And, as there is little or no incorporation of relevant knowledge, those outside the boundary are left feeling that their expertise is outside of the sustainable response (Sterling, 2004).

The reality is that single discipline expertise remains the prevalent approach. Reportedly it originated in the Middle Ages as a means of organizing knowledge (Jones, 2010). No matter the contemporary nature of the subject, it continues in the form of 'adjectival' disciplines; human rights, peace studies, and public health to name a few. While these are very important issues, they must be part of a sustainable society which includes consideration of other relevant concerns or risk avoidable error (Paden, 2000). If sustainability is the goal, the overall framework must provide thinking skills to transcend the confinement of any arbitrarily designated single discipline (Blewitt, 2004). The alternative of compartmentalized and often competitive knowledge domains is much more prone to ineffective or even harmful results due to a lack of emphasis on the recognition of the interconnected nature of systems, practices and knowledge (Cortese, 2003).

Although ‘generalist’ skills of recognizing the interconnectedness of systems and interdisciplinary issues are critical, this does not diminish the role of discipline experts in their respective fields. While the generalist may appropriately identify the bigger picture issues and help shape complementary solutions, domain specialists are necessary for achieving individual results, and HE must be available to provide their training (Klein, 1995). In the ideal scenario, experts in their respective fields will also have training to recognize the interrelationships of matters outside their expertise and be adept at working in interdisciplinary teams (Uhl, 1996). Similarly and reciprocally, students of sustainability will be more effective having been exposed to the varied expertise and technology such as modeling, information and computational systems and sciences (Porter, 2009). In fact, at least one scholar opines that interdisciplinarity has relied and always will rely on a disciplinary base to construct complementary practices (Jones, 2010).

A means of articulating the apparent dichotomy of the higher level generalist versus domain specialist is by consideration of their respective contributions in different dimensions (Sterling, 2004). The generalist, actually a specialist in sustainability thinking, looks horizontally across the landscape of disciplines and issues to identify the connected systems, resources and potential costs. Another term used for this skill is ‘knowledge broker’, defined as a facilitator of the flow of different forms of knowledge and know-how contained in interacting parties or systems in order to optimize the process of problem solving (Mansfield, 2005). The specialist, whose role is further described below as expert, then drills down in those areas identified as needing detailed understanding to contribute to the process. Individually, a single person may not possess the skills and knowledge to play both roles in complex situations, but a team including generalist and specialists offers the best chance of illuminating a sustainable result (Sherren, 2006).

There is growing recognition for the body of knowledge which rests in the non-academic community, and increased appreciation for exposure to community, working professionals and different cultural experience through transdisciplinary collaboration (Pittman, 2004). The influence and effect of this experience can provide benefit on at least two levels. For one, individuals gain self-knowledge, perspective, ethics and additional expertise from personal interactions. Secondly their professional work product will improve from the additional issues identified and insights shared by their transdisciplinary partners (Sherren, 2006). Because of this continuing benefit, scholars have called for educational approaches which will enhance a student's abilities to learn and assimilate skills and knowledge from connections outside the classroom and to accept change in a rapidly changing world (Fazey, 2007: Blewitt, 2004).

Despite the theoretical benefits of interdisciplinary education, there is ample concern in the literature about the education community's role in maintaining a very different approach. “The ongoing fragmentation of knowledge and resulting chaos in philosophy are not reflections of the real world but artifacts of scholarship.” (Wilson, E.O., 1999, p6). Whatever the origin of disciplinary education, institutions have been slow to provide more interdisciplinary offerings. Scholars point out that policymakers and educators themselves must undergo ‘deep learning’ in order to understand and pursue new courses (Huckle, 2004). Due to the increase in fluidity of knowledge, governing boards and regulators have a difficult time modifying standards which they deem critical to their honest duties (Corcoran & Walsch, 2004). Coordination of faculty is often difficult, for at least three reasons. For one, several members may be required to co-teach courses. Secondly they are often asked to move outside their expertise to develop new interdisciplinary research and content. This combination often upsets existing workload metrics (Sherren, 2006; Pittman, 2004), and the results are inconsistent. Even when branded as interdisciplinary, many projects result in at best multidisciplinary conglomerates, or allow one discipline to effectively dominate the program (Tress, 2003).

Researchers report that there are many barriers and few incentives offered to those educators willing to push the edges into interdisciplinary offerings (Conrad, 2002; Golde, 1999). This includes attempts to incorporate transdisciplinary expertise into curricula. Compounding the difficulty in an education world which has lost much of its liberal arts foundation, modern market-focused students select courses which they, in their perhaps narrowed perspective, deem relevant to their careers (Sherren, 2006). This feeds the vicious cycle; students lacking exposure to broader thinking self-select segregated disciplinary fields, and upon becoming educators guard their expertise by perpetuating the status quo (Moore, 2007).

While there is broad advocacy in the literature about the benefits of, and the difficulties in establishing interdisciplinary coursework, one perhaps subtle point seemed to be missing. Perhaps the best way to describe it is by comparison to the systems thinking discussion above. From that research one can rather easily imagine a curriculum-based approach to training students to identify and understand systems and interrelationships. One the other hand, how would one go about that in the 'field' of interdisciplinarity? Proposed methods include team teaching and analysis of the benefits of studying interconnections; in many ways similar to systems thinking. But this is a different point, and the literature found by this researcher seems to miss it.

In a real-world setting, the problem driven inquiry for a particular scenario cannot be anticipated or rehearsed, and the universe of interdisciplinary possibilities is likely infinite. Therefore, the training and preparation to lead in these situations must come from skills development, such as in the practice of systems thinking among others, and from exercising a broad view in controlled situations and case studies.

> "*Higher education and lifelong learning must develop a culture in which actual and metaphorical conversations about sustainability take place. This view of education requires a cooperative and collaborative approach to learning that is forward looking and may take place in the classroom, the work place or the community.*" (Blewitt, 2004).

Because this issue is critical to the implementation of sustainability curricula, additional discussion follows in the Analysis below.

5. Full Costs/Impacts

One can certainly argue that a failure to fully predict and account for the full range and amount of impacts deriving from a human response is central to unsustainable results. It therefore follows that better anticipation of outcomes and ramifications, particularly those resulting in additional economic, societal and environmental costs, represents progress toward sustainability.

The scope of related terms is an indicator of the ongoing work in this arena. It precedes wide use of the term sustainability, though appears closely coincident as a key data link to the regulatory/command and control structures of early environmental protection of the 1970's. By the 1980's market-based approaches focused on 'cost-effectiveness' and internalized costs as the market would allow (Mazmanian, 2009). More recently, there has been a shift to outcome-based analysis and with it the emphasis on systems approaches and development of alternative scenarios based on aggregated impacts of human behaviors, indicators and adaptation (Roling, 2004).

A recent writing described an iterative model designed to identify and compare the sustainability of two options for expanding a locality's electricity generation. The options were coal plant expansion or a new biomass facility. The analysis included the development of an impact matrix to include criteria applicable to all impacts, normalized for better comparison and quantified using a combination of assessment and simulation tools including Life Cycle Assessment, economic analysis, and others. Its product is a calculated probability of the preference of one option over the other. Its goal is the provision of a tool with useful information leading to a more informed decision (Dorini, 2011).

Throughout the short history which has evolved into contemporary sustainability thinking, cost analysis has been coupled with benefits analysis in order to determine an overall score for a proposed action. This continues today and is supported as a means of allowing the transition to more sustainable concepts without having to show that all barriers have been removed (Pittman, 2004). This viewpoint notes that the precautionary principle itself, long a cornerstone of environmental and sustainable thought, can act as an aversion to rational action (Blewitt, 2004). Others are less secure in this liberalized view, noting that cost compilations are generally estimates and inadequate replacements for the precautionary principle (Finnveden, 2000).

These perspectives point out that the ongoing efforts to identify and quantify costs and impacts, though empirical in design, are not fool proof. Sophisticated process such as Life Cycle Assessment, described as one which "considers all attributes or aspects of natural environment, human health and resources…" are also "constantly running into uncertainty…" (Finnveden, 2000, p2). Others note the difficulty of evaluating impacts which may occur in different locations, to different populations and at different times (Cortese, 2003). Indeed, even the attempt to remove uncertainty carries a danger of acting under the misconception that all uncertainty has been removed, perhaps leading to worse results, particularly with complex adaptive systems (Wilson, J., 2000).

A variety of technological models have been developed to measure these factors, including previously mentioned Life Cycle Assessment, Economic Analysis, Environmental Analysis, Energy Analysis, Cost-Benefit Analysis, and others. Each of these has a particular purpose, such as extraction efficiency, though as indicated there has been effort to broaden or combine their scope to become a more inclusive analysis (Finnveden, 2009; Dorini, 2011). Current forms of regulation and education continue to rely on data to identify and usually quantify the acceptable degree of impact, or in some cases to develop indicators of system integrity (Cassar & Conrad, 2008). Ultimately, costs become part of the broader conversation about policy and pricing, and other topics addressed herein. The futility of attempts to consider all costs is analogous to the uncertainty of complex adaptive systems in that the assumption that all can be accounted for carries the danger of false confidence. A fairly simple mathematical formula, developed to keep this principle in mind, actually demonstrates the difficulty of quantification when human systems are involved. I = PAT, where I is total environmental impact, P is population, A is affluence and T is technology (Daily, 1992). How, for example, does one actually measure affluence or technology as a single factor? The only answer is by human assignment of value, which returns the data to more qualitative concerns.

The conversation about costs, therefore, is a continuation of the methodologies described for systems thinking and adaptive capacity which form the central sustainability thinking concept. The critical goal is improvement in the system overall, not just a piece (Cortese, 2003). For innovations to be sustainable they must provide a greater benefit than cost – not for the extraction or production or pricing elements in isolation, but to all elements perceived by the interdisciplinary viewpoint.

6. Equitable Perspective

If collaboration among experts is essential to technical knowledge, incorporation of the knowledge of affected populations is the key to understanding the human sustainability elements of decision-making. The means of doing so come in the form of standard research, action research, stakeholder development, public participation and community sampling, to name a few mechanisms. The scope can be global, recognizing the shared responsibilities and opportunities of globalization (Cullingford, 2004), national (UNESCO, 2005) or limited to a specific community. Equitable perspective, as used in this writing, refers to a proactive approach designed to identify and determine the perspectives of, evaluate the impacts of change to, and give credence to all populations impacted or likely to be impacted (i.e. the stakeholders) by an action or decision.

The literature indicates a broad range of reasons why it is important to seek out a broader perspective. Increasing perspectives will result in the formulation of new questions, answers to which will strengthen a proposal (Corcoran & Walsch, 2004). Establishing platforms for diverse stakeholders on shared strategies will more likely lead to a common vision (Roling, 2004). Bringing new voices into the debate may slow a process in the early stages, but is likely to achieve a result which is more durable and able to cope in a changing environment (Porter, 2009). Under the theory of 'cultural bioconservatism' it is impossible to separate a culture from its impact on natural systems, and individuals are vessels for cultural knowledge, patterns, behaviors, etc. (Bowers, 2000).

There are indirect benefits as well. An individual's exposure to other experiences generates a new capacity to recognize and remain open to other new perspectives and can increase awareness of linkages between behavior and result (Fazey, 2005). In many instances proposed decisions are beyond the scope of regulation, and the need for voluntary compliance requires the development of alternatives (Porter, 2009). The concept of cosmopolitanism originated in ancient Greece, but has been revived as a means of pursuing greater global equity. For example, there has been a call for broader education of American students to help broaden perspective on international issues (Sherren, 2006).

In addition to the different means of outreach, methods for skill-building are also evident. Interpretive systems approaches often provide for specific interventions to heighten interpersonal sensitivities and self-awareness in circumstances of potential conflict (Porter, 2009). These processes strive to ensure that different stakeholders be solicited, heard and their perspectives openly debated as part of building agreement. New educational programs require students to engage with new settings, different cultures and uncertainty in order to develop appropriate skills (Blewitt, 2004). There is recognition that, in order to truly engage community perspective, practitioners must be able to meet with and understand others in their own communities, using their own values and finding ways to relate proposals to their "natural motivational flows." (Brown, 2005, p12). In many instances facilitation skills are required to connect stakeholders, for which training is readily available (Roling, 2004).

One researcher hypothesized that differing value systems are a barrier to implementation of otherwise worthy sustainability initiatives. The different lens through which people of different perspectives see the same thing differently may demand that projects or proposals are adaptable to differing views (Brown, 2005).

It should be noted that the lines between equitable perspective and conflict management tend to blur. Both are proactive approaches to reduce antagonism among affected persons, both involve skills of listening and learning. This concept however, brings focus to the equity aspect, recognizing that globally some are born with decided disadvantages in wealth, health, respect, support and a myriad of other qualities others take for granted. It is that recognition which drives the proactivity thrust in order to engage those who may be incapable of doing so themselves. As with vulnerable natural systems, well-trained sustainability experts will know of these populations, and how to deal with the political aspects of protecting their interests.

The inclusion of equitable perspective as an initial core element in this writing indicates agreement with the school of thought that its effective practice requires unique skills and thinking (Sherren, 2006). Extending from the edges of theory that human behaviors are the central focus of sustainability progress, development of curricula and practices to facilitate expansion of perspective is an act of responsibility both to humanity and global sustainability.

7. Adaptive Capacity

The third of the broadest and most commonly discussed elements is herein labeled Adaptive Capacity. This incorporates 'life-long learning', 'deliberate learning', 'reflexive learning', 'second order learning' and in truth the longer term process of evolution. In systems terminology it can be described as the ability to 're-organize or renew' as a response to recognition of changing circumstances (Gunderson, 2002; Carpenter, 2006). Another companion term is resilience, which refers to the ability of a system to accept new circumstances without undergoing radical changes to its core character, most often by adapting to the new circumstances (Fazey, 2007; Gunderson, 2002). Thus adaptation can be said to be a critical function of survival if the system's surrounding environment is undergoing change (Roling, 2004).

Life-long learning as a related term has more than a single construction. In a work- related scenario it can refer to the need to be aware of rapidly changing issues of globalization, technology, economic and financial conditions and knowledge in order to remain competitive (Blewitt, 2004). The term incorporates two subtly distinctive concepts. One refers to the individual pursuit of knowledge over the course of a life as a means of personal development (Sherren, 2006). The second is a more cumulative context, emphasizing that learning is continual, not static, incomplete, far from perfect; (Walters, 1990) but is the basis for positive adaptive change on a societal basis (Longworth, 1996). Despite its self-defined limitations, this is the optimal approach so far as we know it, because failing to adapt and change effectively reduces resilience, adaptive capacity and the means of survival of all our known systems (Fazey, 2007).

These generic concepts show up in a variety of everyday situations. Ecosystems represent adaptive management systems whose survival continually depends on their adaptive capacities, high bio-diversity and the means of response in order to survive significant change from climate and human disruptions in particular (Fazey, 2007). This process is articulated by Figure 1 above for systems thinking, wherein the survival of basic system function depends strongly on its response to feedback. In a more humanistic example from above, developers of the Life Cycle Assessment model readily admit that the concept remains 'under development' as it responds to uncertainty, error and changing demands for its application (Finnveden, 2009). The key elements to survival in any of these contexts are related to their resilience, or ability to note dysfunction, to incorporate feedback, then to abandon if necessary those things built or organized around faulty functions and to establish new more effective functions (Roling, 2004). In a sustainability context, where so often the issue is the impact of human disruption to natural supporting systems, this requires an ability to determine the impact of our choices on the physical carrying capacity of the system, and to adapt our decisions to minimize accompanying risks (Glasser, 2004).

Adaptations are not always successful. Some have responded to perceived problems, but resulted in prolongation or even exacerbation of the actual problem, as exemplified by the construction of levees on the Mississippi River delta, which reduced minor floods but increased larger flooding and created other problems (Boyden, 1987; Congleton, 2006; Fazey, 2007). For the most part, faulty solutions are the result of limited, first order learning, without the processing of feedback as necessary to change mental models and locking into status quo thinking (Sterman, 2000; Sterling, 2004; Wilson, 2000; Fazey, I., 2010). Second order learning approaches allow for feedback and adjustment as needed to develop and continually improve new and better solutions (Glasser, 2004).

The key then is the ability to predict, and to continually monitor predictions and results in order to achieve the higher learning processes necessary for truly adaptive solutions. While this entails the accumulation of new knowledge and skills, it also requires the acceptance that even new knowledge is temporal, and evolving; that learning must be continuous and prepared to adapt to new circumstances and changes to natural systems and social structures (Folke, 2005; Fazey, 2007). The more we learn about issues, the more we understand the uncertainty in our knowledge base. Tools are under development to help with these processes. There has been significant emphasis on the sophistication and improvement of benchmarks as a means of measuring impacts to an ecosystem (Shriberg, 2004; Cassar & Conrad, 2008). The need for hypothetical testing has resulted in growing use of modeling technology and metaphorical discussion methodologies (Sterling, 2004). As noted above, uncertainty about the results of action or inaction is the subject of new theory for complex adaptive system management and the evolution of institutions (Wilson, 2000). This has extended into scholarly discussion of the role of adaptation in making democratic decisions in human societies (Porter, 2009).

While this premise of truly life-long, unending change and adaptation is fundamental to the pursuit of sustainability, it does not appear to be fully accepted in the world of education (Smith, 2000). In addition to some of the issues noted in discussing environmental education above, the radical change is the prerequisite admission by educational institutions that much of our knowledge is not certain and even more that our ability to acquire and process new knowledge will remain constrained over time (Glasser, 2004). As noted, this strikes at the core of conventional education, which is rooted in the accumulation, organization and restructuring of knowledge for the purposes of curriculum development. This is sometimes referred to as the 'destination' view (Jickling, 1998). Contemporary researchers and scholars have urged that these approaches be reconsidered in a sustainability context and replaced with a more adaptive education experience, wherein the process of learning, rather than the knowledge itself is the critical focus (Cortese, 2003; Blewitt, 2004; Wheeler, 2000; Mortensen, 2004; Sterling, 2004; Sherren, 2006; Fazey, I.; 2010). This applies even to sustainability concepts, skills and principles; which if considered 'ends' in themselves may result in a chilling of necessary debate and critical thinking, and the narrowing of knowledge which would bring about the same first order decisions and solutions (Wals, 2002).

The desired end of the proposed change in educational approach is the enhanced ability to effect positive change and the matriculation of effective change agents (Pittman, 2004). For many this is described as 'transformative ' change, which may begin with individuals willing to accept change in their personal behaviors (Keen, 2005) and thereby increase the potential for institutional change (Fazey, 2007). While educational institutions are targeted as needing to change, if this critical societal body embraces the need to advance and teach the importance of adaptive capacity/management, its function in doing so may include embracing change as a leadership role rather than a concession of failure (Sterling, 2004) It is apparent that there are means of teaching necessary skills which remain well within the existing education structure. Metacognitive skills development courses, useful in practicing methods of thinking in changing circumstances are currently available (Bransford, 2000). According to one family of experts, skills in dealing with unexpected situations, and thereby reducing the likelihood of disruption to understanding (Proust, 2004), can be increased by practicing new situations. The attainable goal is the development of adaptive expertise (Fazey, I & J., 2010).

While all systems and species are both equipped with and influenced by their survival instincts, at least in our anthropocentric view humans are distinguished by the ability to learn from current circumstances and project them into the future, a process sometimes called 'rapid deliberate learning' (Roling, 2004), or pursuit of sustainability. According to this research, education as an institution has not been successful in transitioning to programs which recognize that the rate of change in our world requires new skills in order to progress toward sustainability. While it would be inappropriate that HE as an institution immediately disavow single-discipline or domain-based knowledge instruction, there is a wealth of opportunity to advance learning environments that are more reflective of contemporary changing society.

8. Policymaking

Viewed as a step in the process of achieving sustainability progress, the act of policymaking applies to governments, businesses, educational institutions, and perhaps even to families and individuals. The definition provided in the survey was intentionally broad, yet it captures the essence of this term which connotes two elements: 1) the articulation of a plan or course of action, and 2) the intention to be guided or influenced by said plan.

The term is not well-defined in writings reviewed for this thesis, yet the use of decision-making authority is clearly and strongly inferred (Nabukenya, 2011). Because it indicates that choices have been considered, decisions have been made and consistent future behavior is intended, its results may facilitate or impede sustainability progress. The topic at hand is the policymaking process, distinguished from any specific 'policy', which is the result of the process.

In conventional academic settings instruction relating to policy is commonly focused on the generic steps involved in policymaking, such as issue identification, consideration of options, the formal processes of writing, presenting and passing policy, and monitoring phases (Bridgman, 2003). While this is helpful as a means of understanding generic processes, it provides little insight into means of affecting the quality of the policy product.

Matters of more relevance from a sustainability standpoint derive from studies of various areas of policy; such as social, environmental, energy, transportation, water, foreign, education, etc. For example, a four-decade review of environmental policy in the United States clearly mimics sustainability trends overall - moving from point of harm/command-control response in the 1970s to local and market based enforcement through the 1990s, toward a contemporary systems and resource-based approach, emphasizing indicators, biodiversity and footprints today (Mazmanian, 2009). While analyses of this nature are often retrospective, they underscore the obvious fact that policies are also reflections of an entity's approach. If true efforts toward sustainability have been pursued, it will be reflected in policies (Nabukenya, 2011). Thus policymaking, likely a precursor to action, resource allocation or regulation, is both an early step in the process of making sustainability progress and an indicator of the extent to which an entity has adopted sustainability as its ultimate policy.

The interplay of policy and sustainability applies across disciplines and affects outcomes at different levels. For example, most researchers note the symbiotic relation between effective social policy and environmental policy (Hugby, 2004). By providing a better environmental living experience, policies may also catalyze self-improvement in neighborhoods as community pride leads to better awareness, health, participation and even reduced energy use (Lucas, 2000). On the other hand, the failure to account for the full scope of the issue is likely to result in failed policy, such as in efforts to reduce greenhouse gas emissions from a regional perspective (Schreuder, 2009). In a sustainable society, policy as an implementation step, must meet the parameters for sustainability thinking generally.

As stated above, many sustainability scholars believe that educational policies have not met the expectations of United Nations and other calls for action. Some refer to an overabundance of declarations signed by often large numbers of institutions, but just as often a failure to enact new strategies

(NWF, 2008; Glasser, 2004; Pace, 2010). Perhaps this is due in part to the common call for 'transformative' or 'radical' change. While beyond the scope of this paper to prove, one could speculate that the difficulty of enacting required changes will be proportionate to the degree to which it is considered to be radical policy. Avoiding that characterization may be a valid alternative.

Policymaking is included in this list as it is the first implementation step, the stated 'shared ideal' (Pittman, 2004) of sustainability. As indicated in the literature, policymaking will both influence and be influenced by sustainability education, due at least in part to the need for policymakers to be more fully exposed to the benefits of sustainability approaches (Sterling, 2004). Concepts integral to sustainability curriculum development, i.e. interdisciplinarity, systems approaches, adaptive capacity, etc. are the keys to effective policy development (O'Riordan, 1998; Blewitt, 2004). This leaves a kind of 'chicken or egg' dilemma, going back to the role of education in society. At least one voice is unequivocal on the issue, bluntly opining, "If HE does not lead the sustainability effort in society, who will?" (Cortese, 2003, p.20). In this light, the role of policy in HE for sustainability, and vice versa, must be addressed, and provides a compelling case study in an educational setting.

9. Role of Expertise and Technology

Depending on the circumstances and the opinion reviewed, technology is either the cause of a disassociation of humankind from the rest of the world or an opportunity to bridge and foster better understanding and connections between the two (Bawden, 2004; Borgmann, 1984). In this paper technology and expertise are linked as the penultimate results of specialization, representing the deepest of the 'vertical' dimension of knowledge and often the most isolated (Sterling, 2000, 2004).

There is unanimity in the literature that the increasing complexity of issues caused by human populations is largely the result of technological advances (Cortese, 2003). As discussed below, over-reliance on perceived advantages to precision can lead to a mechanistic attitude emphasizing quantification without regard to surrounding system limitations (Sterling, 2004). On the other hand, the attempted use of an institutional technology designed for simpler closed systems is likely to lead to mistake if applied to complex adaptive systems with higher degrees of uncertainty (Wilson, J., 2000).

In considering these and other scenarios the insights of Richard Bawden above become clearer. As technology and expertise are human-derived concepts, they must remain accountable to human values – an extension of the 'garbage in, garbage out' adage for computers. If not at least two failings may occur. For one, over-reliance on expert or technical solutions may result in the failure to consider that a change in human behaviors is the better answer (Sherren, 2006). Or, valuable, non-quantifiable human qualities such as relationships or symbolism may be lost in the conversion to data, and less technologically advanced, yet sophisticated cultural solutions may be overlooked (Bowers, 2000).

On the other hand, properly designed and used technology and expertise may offer the best means of addressing complexity, thus contributing significantly to sustainable progress. As with policy evolution, in many instances technology and expertise has led to more efficiency and less impact (Mazmanian, 2009). Information technology can help educate and inform (Bawden, 2004). Ecosystem indicators and modeling expertise can offer much improvement on predictive capacities for the longer term (Cassar & Conrad, 2008; Blewitt, 2004; Schriberg, 2004; Finnveden, 2009). They can also be used to test and monitor results of policy choices (ESDI, 2003). Work to combine the benefits of established analytical models such as Life Cycle Assessment and Economic Analysis is ongoing and could provide important new insights (Dorini, 2011). A recent complex study used spatial integrated models to quantify agricultural land use changes and develop economic projections and recommendations regarding public versus private values of potential scenarios (Fisher et. al., 2010).

An emerging aspect in this area pertains to the likely metamorphosis of our understanding of 'expertise' in the face of complexity and sustainability theory. Clearly, given the rate patterns of technology development there is a requirement for life-long learning in order to remain current (Blewitt, 2004). In fact, the literature further describes the applicability and importance of modern experts' understanding of higher level sustainability concepts, or specifically how their area of expertise fits into a larger picture (Uhl, 1996; Sherren, 2006). This is analogous to the distinction between environmental experts and sustainability experts; the latter mostly engaged in the understanding of the interconnections between natural and human systems rather than specializing in knowledge about ecosystems themselves (Cortese, 2003; Paden, 2000; Roling, 2004). In education terms this is often referred to as the value of a liberal education, (Sherren, 2006) though others see it as a new form of broad education, or even expertise (Huckle, 2004; Wals & Jickling, 2002).

At first, existing experts may be put off by the premise that current knowledge is 'subsumed' by newer understanding. But more broadly, the validity of earlier knowledge is not in issue, though one may question its sufficiency to provide fully sustainable guidance (Sterling, 2004). Since expertise derives from observation and interpretation, this should come as no surprise, given the nature of change. And truth be told, it is technology itself, derived from adaptive expertise, which is driving much of our rapid change, both good and bad. The fact of rapid change is unlikely to abate, and a failure to adapt risks obsolescence. To counter this, one's facility with adaptive expertise can be improved with education and practice (Fazey, I., 2010), which are proper roles for sustainability HE.

10. Uncertainty

The same complexity driving and driven by technology and expertise is accompanied by increasing uncertainty (Wals, 2002). Gaps in knowledge come from inconsistent data as well as the unknown (Wilson, J., 2000). As our meta-knowledge base widens to understand interrelationships and complex systems awareness, we can see that CASs, both natural and human constructs, are continually adapting from the bottom up, improving their hardiness and survival rates, but making them continuously unpredictable (Hatch, 2003; Porter, 2009). Knowledge about these things is different. We can see what they have been, and what they do, but we cannot know what they will become. As stated above, the more we learn about many things, the more we recognize the uncertainty in our knowledge base. The quest is how to deal with that.

Conventional 'reductionist' methodologies require that assumptions derive from known data, which is ineffective in dealing with CAS (Wilson, J., 2000). Ignoring the lack of knowledge and acting on the presumption of full knowledge can lead to errors worse than acknowledging uncertainty, so alternative approaches are required. One such approach is resilience thinking, described above, while others fall under the more general category of adaptive management (Fazey, J. , 2007). In fact, when applying resilience thinking strategies, knowledge is considered to be temporary or even tentative in order to avoid over-simplification (Fazey, I., 2010). This also allows more room for interpretation, examination of the interpreter's perspective, the use of non-conventional knowledge from indigenous or other cultural systems and the use of real world problems to practice skills (Fazey, I., 2010).

While the term 'adaptive' used in the context of uncertainty implies a reactive approach to changing circumstances, it can also be proactive. Making decisions in the face of uncertainty, with full awareness of it and a willingness to change behaviors as necessary, provide an opportunity to affect the future (Fazey, J., 2007). Concerns over the arbitrary nature of results are constantly being reduced by the development of new and better modeling and simulation tools, as discussed above, and as specifically discussed in the context of refinement of Life Cycle Assessment into a more holistically available tool (Finnveden, 2009).

If these attempts to extrapolate facts run a risk of error, others argue that the use of assumptions like the precautionary principle avoid more thoughtful alternatives (Blewitt, 2004). It has been the tendency of HE to emphasize static knowledge, in the process perhaps undervaluing the development of new knowledge in everyday thinking (Glasserech, 2004). This reticence may be changing however, as indicated by the inclusion of uncertainty on the list of competencies developed for the European Portfolio for Environmental Education in 2005 (Pace, 2010).

It does not appear that the need to make decisions despite uncertainty will diminish despite increasing knowledge and understanding. While the potential for teaching about the unknown seems inconsistent with common education, developing the means to deal with change and uncertainty is fully consistent with sustainability education. Relevant curricula can expect to be accompanied by advances in other fields of expertise and technologies which help alleviate the likelihood of amplified error.

11. Resource Efficiency

Resource Efficiency is fully anthropocentric in perspective, looking at the methods and means by which humans use resources, many derived from nature. Its significance is that it relates directly to, and perhaps provides the point of divergence between natural and human systems; the natural system providing, and humans both using and preserving resources (Said et al., 2005).

In the logic of this premise, the focus of Resource Efficiency derives from three assumptions: 1) some resources have been and will continue to be exploited for human purposes, 2) critical resources are those which either are limited or diminishing, and 3) it is imperative to maximize efficiency of these resources, which includes minimizing impacts from their extraction/use, in order to have any chance of meeting overall sustainability goals.

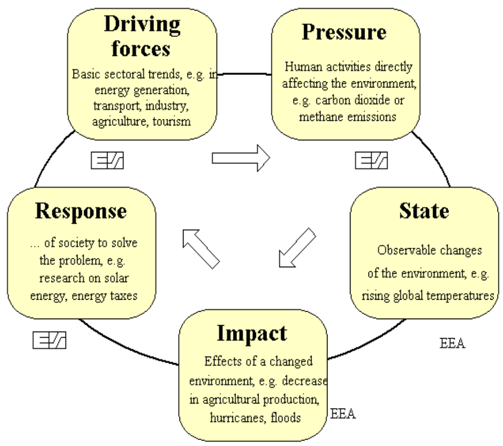
The basic measurement of efficiency is the ratio of physical inputs consumed to physical outputs; consumption by using up, rather than merely using resources, and including pollution and negative impacts as well as resource destruction (Princen, 2002). Many previously mentioned tools such as Life Cycle Assessment, Economic Analysis, Environmental Analysis, Energy Analysis, and Cost-Benefit Analysis add sophistication to the base equation. Many of these also analyze resource extraction efficiency, which is a companion analysis of the extraction process and impacts use efficiency.

Further research indicates there is more to this discussion even, and perhaps particularly, at the level of sustainability generalist (Alexander, 2008). Contemporary economics-based research includes time, labor, and financial resource efficiencies; much more complex analyses than pure mechanical or technological efficiency. The effective result of this drive for economic is the potential trade-offs between human and natural resources (Wackernagel, et. al., 1996).

It is indicated in the literature regarding natural resources that only in fairly recent times has the world begun to understand the limiting impacts of resources on economic development (Meadows, 1972; Cortese, 2003). However, quite some time ago there was important discussion, in the context of preservation of the coal resource in Scotland, about the impact of efficiency policies. The previously used example of hybrid fuel-efficient cars to address greenhouse gas emissions continues to apply. The principle, known as Jarvon's Paradox, provides that gains in efficiency will likely reduce demand, which in turn reduces price, thereby introducing new demand and ultimately causing an increase in consumption (Alcott, 2005). This 'rebound' effect could increase the use of cars overall, leading to another maladaptation as described above. In instances such as this, a quota or cap system provides a more effective means of resource and impact protection than does a push for efficiency (Daly, 1980).

While efficiency measurement is closely related to costs analysis, the distinction is 'vertical'; efficiency analysis, as defined above, provides a more precise tool for the better understanding of costs. The means for doing so start with identification of criteria and parameters which will allow a relevant analysis, and includes a means to quantify or otherwise articulate them in a manner which allows comparable analysis to other options (Dorini, 2011). In many respects this approach, by limiting the analysis to predetermined factors, runs afoul of other sustainability principles discussed herein.

Strong argument is made for using broader sustainability indicators rather than precise but isolated tools, but this effort is blunted by the lack of empirical studies and results defining sustainability measurement (Pezzey, 2002). A promising approach addresses this by establishing baselines from data, then observing and adapting to changes (Cassar & Conrad, 2008). The array of indicators can be customized for particular decision-makers, situations or studies (Costanza, 2000). In some instances these may be compiled in order to provide a broader view of the state of sustainability as regards the environment; thus better indicating overall system state, as illustrated by the diagram to left. More sophisticated models link individual indicators with cause and effect system functions, as shown in Figure 5. Contemporary approaches use ecosystem and biodiversity indicators for a variety of purposes, establishing this as the best practice for systems protection (Mazmanian, 2009). Another promising approach involves a version of 'eco-design', which incorporates environmental issues as an equal consideration at the beginning of the design process (Bradley, 2004)



The Driving force-Pressure-State-Impact-Response model viewed at http://esl.jrc.it/envind/theory/handb_03.htm

Figure 5 - DPSIR Model

This element is perhaps the most technical of those included in the original core elements list, and is perhaps not as well-suited for the classification of "higher thinking and learning skills." Measurements can be made, but effective use of measurements requires the consideration of behaviors affecting measured outcomes (Fazey, I., 2007). The higher purpose must kept in mind, that of preserving the integrity of natural or other support systems under the influence of human interactions, even as data points are collected at a lower level (Daly, 1980). Understanding the limitations of the empirical approach is important to one seeking to best anticipate and understand the ramification of significant decision.

12. Globalism

While this report is not the place for a full discussion of globalism, this concept is seen both as a component of and as a principle which impacts sustainability (Paden, 2000: Cullingford, 2004). The use of this term, as opposed to 'globalization' was intentional in this writing in order to avoid the limitation imposed on the latter as purely a term of economics (Bhagwati, 2004). The entanglement of sustainability with increasing access and mobility is much deeper, inferring increasing global interconnectivity in communication, policy, transportation, environmental issues, resource management, human societies, corporatism and many other pressing contemporary issues (Cullingford, 2004). In the context of sustainability one must consider both the perceived benefits, for example trade or cheap labor from foreign supplies; and the impacts, as in emissions, social conditions, natural resource depletion, etc., wherever they occur. This is descriptive not of what should or should not be, but what is, and helps determine and underscore the spatial and moral breadth of sustainability (Bawden, 2004).

While globalization, the popular term, continually refers to soft human systems such as economics, communications, etc., it can be argued that its relevant human behaviors are intrinsically linked to the natural system, or bounded within hard and limited systems (Costanza, 2011). The production-side demand for materials and labor has been at the fore of global movement by international business. But even as exploitation of new resources continues, we know there are only so many people to provide cheap labor, and limited resource material on the planet. The growth in human population and subsequent exploitation of wood, coal, whale oil and fossil fuels caused only local concerns historically. We now understand that social upheaval and local emissions anywhere contribute to global problems. This leaves us with gaping holes in governance infrastructure taxed with ensuring that problems cannot merely relocate and continue their disruptions and degradation from a less restrictive jurisdiction (Schreuder, 2009). On more than one occasion wars have been ignited by the perception that another country has overly appropriated a transboundary natural resource, such as water (Bitterman, 2007). Reciprocally, how do countries without necessary resources build infrastructure re;iant on foreign suppliers over which they have no control?

One approach to resolving most of these issues is an expansion of international cooperation and governance structure (Schavan, 2010). Certainly there is a need for shared information and education. The rapid change associated with globalism gives proactive adaptive management and lifelong learning a global scope as well, whether the goal is competitiveness or matters of conscience (Longworth, 1996). Yet without global authority there are no guarantees that equitable sharing will occur. Some refute this path to sustainability, stating that resolution depends on education about the value of life forms over global competition and encroachment, not on development of more global infrastructure (O'Sullivan, 2004).

Globalism differs from other core elements due to its potential for grand politicization, but it exhibits predictable and often familiar properties which make it an appropriate field of study. At least by analogy it is perhaps suitably linked to cosmopolitanism. In a sustainability setting, it serves as the bounds for understanding the various perspectives and issues, and their linkages by virtue of systems connections, evolving toward a 'world view' on matters of similar interest (Brown, 2005).

13. Pricing

At the crux of market-based economics and commonly referred to as one of the '4 P's of Marketing', a price is fundamentally defined as that value agreed upon by buyer and seller as the basis for an exchange (Pels, 2005; Gayer, 2011). In that respect, a price may or may not reflect manufacturing costs, transportation costs, profits, common infrastructure costs, environmental degradation costs or any others. And there is no requirement that the buyer, or seller for that matter, have knowledge of how the price was derived. It is in their individual discretion to take or break the deal (Dixon, 1990).

In a systemic sense pricing is ‘soft’, as in a soft or open system, which operates without established boundaries or limitations, and is generally the subject of negotiation (Roling, 2004). More generically, the term ‘arbitrary’ has a very similar definition: *determined by whim or caprice; based on or subject to individual judgment or discretion (*American Heritage Dictionary).

Of course in a more complex society prices are not merely individual decisions. The ‘market’ establishes the price based upon generalized consumer demand and supply constraints, though again there is no guarantee that purchase decisions are made logically or that they account properly for costs of production (Vargo, 2004; Gayer, 2011).

Pricing systems as they impact sustainability issues vary widely, though perhaps mostly as between private versus public sellers. For example public water purveyors, particularly in regions of water scarcity, tend to be torn between seemingly conflicting factors of human subsistence needs and marginal cost of production, which includes environmental costs (Ward, 2009). Sustainable management of a resource requires that it pay close heed to maintaining the adequacy and quality of the supply, but on an increasing basis also that the full cost of resource provision is paid from the charges to users (Said, et. al., 2005). In this scenario prices are likely to be no higher than marginal cost as politics more so than profit motive determines these pricing parameters.

On the other hand, the 'agreed' aspect of pricing is more subtle for products in a private market scenario. As shown by at least one contemporary marketing view, the original supply and demand economic theory of Adam Smith is not always relevant in a more sophisticated market system (Dixon, 1990). Marketing, as the driver behind pricing, is no longer based on tangible output (i.e. goods and services) but on perception. "Consumers do not buy goods or services… they buy offerings which render services which create value" (Gummesson, 1985, p250). This reflects a theory that resources are not inherently valuable, but only become valuable once humans determine what to do with them. "Essentially, resources are not: they become." (Vargo, 2004, p8). An additional complicating factor in pricing occurs when the transaction, including the original production of the subject of the transaction, affects another person or persons, thus creating 'external costs.' From a strictly economic perspective, if a known third party is affected, the situation is mitigated by the provision of compensation for private property rights (Gayer, 2011). The more complex situation occurs when ownership is unclear – mostly in the context of loss of or damage to common resources such as water, air, quiet, etc. In this instance, the private transaction has no motivation on its own to pay for the external cost, and a companion resistance to increasing prices to pay for the externality. This illustrates the direct conflict between the 'free market system', based solely on individual gain, and sustainability, which also includes a commitment to preserve limited resources.

The result of the failures of private pricing to account for external cost has been the emergence of government influence to protect the common interest. Original response was largely via regulatory command and control, then in the 1980s began to focus on "efficiency based" mechanisms which emphasized internalization of these costs into pricing and more efficient processes (Mazmanian, 2009). More recently, the use of cap and trade or pollution taxes has taken hold in Europe, though it remains uncommon in the United States (Schreuder, 2009). Many argue that these mechanisms are the most appropriate as they can both limit the total external cost and provide more flexible response by regulated companies (Gayer, 2011). The net result is higher consumer pricing, conceived both as a deterrent to increasing external costs and as a revenue source to mitigate common resource damages.

This dual role for pricing – income generator and market incentive/deterrent – lies at the center of the issue as affects sustainability. A common and complex example is the price of gasoline, which can be linked to so many other common resources such as air and water quality, highway capacity and public transportation, atmosphere, personal time budgets, land use and others. While some argue regulation is needed to provide a balanced approach, others believe the market will do so even in the absence of regulation. Still others would see this as the justification that economic and political systems, not just education, must undergo a transformation (Huckle, 2004).

As the value of pricing is purely perception, it has been linked to the rate of SHE implementation. Since institutions operate on a financial bottom line, the perceived 'price' of transformation to more sustainable approaches is, over the short term, a difficult barrier (Pittman, 2004). For some this barrier risks forcing compromise which will dilute the critical aspects of sustainability education by virtue of avoiding the constructive critique of conventional practices (Sterling, 2004). A discussion about the impact of pricing on achieving broader sustainability goals can quickly spiral into a debate over the value of life forms versus marketplace (O'Sullivan, 2004), 'economistic preoccupation' (Blewitt, 2004), or capitalism versus common resource interests (Huckle, 1996). This is due to 'expensive' or apparently non-profitable central themes of sustainability: natural system protection, systems and feedback priority, entanglement of social issues and the like. As with gasoline, rising prices for many 'services' deemed necessary for human subsistence – food, heat, fuel, transportation, electricity, etc. – drive short term social concerns, which in turn tend to de-prioritize more sustainable longer term solutions (Hugby, 2004).

Given that the concept of pricing, as the quantification of complex transactions has been the justification for delaying the abolition of slavery[3] and a national inability to afford clean energy technology[4]; understanding how prices are derived, what they do and do not include, and their variable or arbitrary nature is important for competent sustainability decision-making.

14. Personal Responsibility

Most who read this report have probably experienced a lack of understanding about sustainability in the general public. A common description heard by this writer goes something like: "oh yeah, that's using better light bulbs and driving little cars and recycling and things like that." It seems this simplistic impression is shared by well-educated persons also:

> *When I started learning about sustainability, I thought it meant riding your bike to school every day and recycling tin cans. I assumed that sustainability was a new word for environmentalism. I had little understanding of the complexities of the social world until I moved from science to social science to pursue a doctoral degree. I have since come to understand that sustainability encompasses much broader and more complex issues than transportation choices and recycling, including social, ecological, economic, political and spiritual components… (Moore, 2007 p538).*

[3] See Klein, Herbert S. and Jacob Klein. The Atlantic Slave Trade. Cambridge University Press, 1999.
[4] See *Climate Change: Analysis of Two Studies of Estimated Costs of Implementing the Kyoto Protocol;* United States General Accounting Office; letter to Honorable Ernest F. Hollings and Honorable John F. Kerry dated July 30, 2004;

The clear message is that sustainability remains a mystery to many, but because it has penetrated the media, commerce and general perception it is the subject of significant misunderstanding or cliché (Vincent & Focht, 2008; Cullingford, 2004). The same applies with sustainability education. Certainly many in education and the general population equate it with environmental education, though there may be little agreement on what even that means.

Sifting through the literature from a variety of angles does however produce a good deal of consensus on sustainability, including the role of individuals and the importance of education. These include many personal behaviors which apply to all, such as respect for persons of different cultures and perspectives (Blewitt, 2004; Bowers, 2000); understanding and respect for the environment and supporting ecosystems (Martin, 2004; Blanco, 2009); awareness of the issues relating to climate change and the ramifications of personal choices (Kadmer, 2010) and knowledge of decision-making systems and how to participate in them (Sherren, 2006). This list could be much more extensive, but this is not the focus of the SHE discussion.

This writing assumes that a person engaging in graduate sustainability study (the focus of this writing) intends to use gained knowledge to work toward progress on sustainability goals. That may come by applying knowledge to real world issues and initiatives, or by working to assist others in gaining a better awareness of deeper sustainability concepts, including guarding against generalizations which may trivialize important values addressed by sustainability approaches (Cullingford, 2004). This being the case, the role of the individual takes on a more proactive meaning than self-contained personal responsibility.

As this report began with the quote that "everything is someone's decision…", so it can also be said that any effective change of behaviors must start with one or more individuals assuming a leadership role, which then grows to include additional participants (Fazey, I., 2007; Pace, 2010). If this can be accepted as true, the skills provided for persons in these programs must include personal and individual skills which assist in this leadership task.

While this could apply to some extent to all students, this point should be emphasized for sustainability programs which remain 'on the fringe' of conventional curricula. But the role of leadership in this context is not to impose or champion particular outcomes; it is to illuminate processes of critical thinking which lead to holistic and thoughtful results (Sterling, 2000; Sherren, 2006). This includes an understanding of the importance of dealing with persons according to their own worldview and addressing their values, helping them accept change when necessary (Brown, 2005; Keen, 2005).

In order to practice these skills students must experience issues as well as study them, including experiences which help one challenge their own perspective and the origin of their knowledge (Fazey, I., 2010, 2007; Martin, 2004). This will enhance one's ability to help another see a new perspective as a reasonable opinion when it appears to be a difference in fact (Porter, 2009). Each of these skills can be honed with existing coursework and practice, much as discussed in adaptive management above.

Within the context of leadership for change, personal skills and responsibilities are logical and necessary. However, their inclusion in sustainability curricula likely generates resistance to sustainability education from a number of vantage points, seen as a "fuzzy" change from existing environmental education where the curriculum is more firmly established in science (Vincent & Focht, 2008). Students driven to seek degrees relevant to job security are unlikely to choose interdisciplinary studies unless taught their value (Moore, 2007; Jones, 2010). However, the skills provided as personal tools for sustainability leadership are easily applicable to almost any field, and in fact may already exist in some institutions (Fazey, I., 2007). Thus, once the logic of the conversation permeates a broader range of interests, the enhanced interpersonal skills demanded by sustainability have every opportunity to be well-received by students and institutions alike.

15. Conflict Management

Conflict management in this writing is intended as a general term applicable to methods and practices aimed at reducing or mitigating possible external barriers to reaching resolution. As 'conflict resolution' it connotes dealing with issues between disagreeing or potentially disagreeing people and their interests. These include pre-emptive approaches stressing stakeholder participation and partnerships, or more reactive approaches including facilitation or mediation of existing disputes. On the other hand, risk management usually deals with problems from almost anything else; including but not limited to natural disasters, building hazards, environmental contamination, legal or regulatory liability, boycotts, the rights of employees, customers, shareholders and the like (Anderson, 2009). Here they are combined as having in common a problem-causing element, usually involving an external source, which ideally would be addressed ahead of time, rather than after having arisen.

While approaches to the two concepts are quite different, each can be helpful toward achieving sustainable goals. Most conflict resolution processes emphasize the need to remain open and dynamic, without a predetermined goal (Furlong, G., 2005). In the generic model a structure allows persons of differing interests to state their concerns and to listen to those of others in attempt to find common ground. In this sense, participants are encouraged to speak as individuals whenever possible, to be accountable for their input, and to change their minds if appropriate (Thomas, et. al., 1998).

By contrast, risk management is the realm of established engineered models and calculations. For the most part these require the firm identification of criteria deemed relevant to the overall concern, which are then quantified under a series of possible scenarios to produce optional outcomes (Krysiak, 2009). Uncertainty is considered the same as risk, so every effort is made to minimize it. Thus, even when making every effort to provide a neutral, or even sustainable result, (Krysiak, 2009) outcomes will ultimately depend on the judgments which identified the criteria and how they should be weighed (Dorini, 2011).

The practice of risk management is most often implemented in a business or corporate setting, and in the context of cost reduction for practicing entities (Anderson, 2009). Newer approaches address sustainability. In fact, the often used term 'triple bottom line' (TBL) was coined first in this setting, accompanied by a basic formula for reducing overall costs, where TBL = financial performance – (environmental risk + social responsibility risk) (Elkington, 1998). A more sophisticated version focuses directly on the attainment of sustainable results in a generic sense. This model establishes a baseline, then uses criteria intended to represent the balance between the risks imposed on future populations versus the benefit of any given proposal (Krysiak, 2009). Frustrations to the model include the ambiguities seen in the definition of sustainability overall because of the difficulty of standardization (Robinson, 2004). Another effort combines technology and conflict resolution. This involves a sustainable water resources conflict resolution model, using multi-criterion decision-making techniques (Ryu, et. al., 2009). The four-fold goal of the process includes 1) insight into what generates conflicts, 2) the interests and perspectives of all participants, 3) equitable benefits for all, and 4) opportunity for a high level of involvement by all (Keyes and Palmer, 1992). A highly interactive computer simulation model provides the opportunity for participants to see the results of their choices and is intended to move them toward a commonly accepted result (Ryu, 2009).

Finally, another research proposal highlights the current gap between technological and human-based approaches to Conflict Management. It intertwines sustainable development and conflict resolution by using the former as a structure for avoiding and reducing conflict (Bitterman et. al., 2007). A basic premise is that a primary cause of human conflict is the unyielding drive of people to meet their individual, group and societal needs (Marker, 2003). Degradation of ecological systems can lead to social unrest, which can then exacerbate ecosystem decline as the conflicted society becomes absorbed in destructive and vicious cycles (Robèrt et al., 2004). The authors point out that the use of scientific fact can leverage neutrality in negotiations (Schultz, 2006), and use of sustainability principles can lead to shared goals, often facilitating a paradigm shift which allows people involved to see a way around historic conflict (Conca, 2005; Bitterman, 2007).

The last example illustrates a potential for sustainability as a mechanism for conflict resolution. At the same time, mechanisms inherent to alternative dispute resolution; such as active listening, expanded perspective, acknowledging common interests and the value of neutral guidance; are pertinent to sustainability actions and education, especially in implementation efforts. From the other extreme, the advancement of technology to promote risk management remains heavily weighted toward the presumption that uncertainty can be obviated, but progress has been made and should be further encouraged in the education sector.

B. Elements Analysis Summary

The research outcomes provided insights into consistent trends which affect sustainability education. Some of these are noted below. Less specifically, what emerged is the acceptance that sustainability is not known in the sense of a defined path, but that many advances in education, thinking and practice have been established to help illuminate the path and recur throughout the topics. These are summarily articulated in the comprehensive analysis below as a means of organizing and approaching the inclusion of this progress in sustainability curricula.

V. Survey of Existing Programs

A. Survey Background

As described in the above Methodology section, development of the survey was a direct result of preliminary research of core elements. Fifteen elements were established from broad research categories; thereafter students and faculty from existing sustainability programs were queried about 1) the existence and importance of each element in their program("Existing"), and 2) their opinion as to the value of each in a quality sustainability post-graduate program ("Opinion").

As also described, response to the survey was too low to reliably indicate the current state of programs. However, the responses provided adequate data to establish trends which can be reviewed and considered as 'advisory' in the preparation of research conclusions.

B. Programs Surveyed

Programs were a product of the methodology spelled out above, with some variety in approach but with common criteria of addressing sustainability as a distinct field of study. A table of surveyed programs is included in *Appendix II*.

C. Survey Data Analysis

The following two questions were asked about each of the fifteen core elements:

'*Existing*' program data

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

'*Opinion*' program data

	In my opinion, in a quality sustainability program at the graduate (post-graduate) level this topic:
	Is a **fundamental** component of any graduate level sustainability program.
	Is one of several **important** concepts which should be included.
	Should be included, but perhaps **secondarily** in the context of other topics.
	Has limited or **marginal** relevance to sustainability education.
	Is **not important** in sustainability programs.

As the survey provided multiple choices for response, and the choices are somewhat nuanced as compared to a numeric scale, there are several means by which the results could be evaluated.

The data is divided by the two parts of the basic question into information about 'Existing' programs, which queried about SHE programs the respondents had experienced, and their 'Opinion' about what should be included in a hypothetical program. These divisions are represented by the left and right boxes of multiple choices shown above.

1) *Raw Data (Appendix III)*

   The raw data combines all responses. Each element is provided a percentage rate for each of the multiple choices, as represented by the small boxes checked along the left side of each of the two larger boxes above. These raw data percentages are found in *Appendix III*.

2) *Weighted Opinion Scores (Figure 6)*

   Opinion was deemed the primary value. In the chart below, Opinion raw percentages were progressively weighted by response rank. Thus the 'fundamental' rating was multiplied by 3, 'important' by 2, 'secondary' by 1, 'marginal' by 0.5 and 'not relevant' values dropped. Numeric values in the chart are normalized on a scale of 0 – 100, with a higher score reflecting higher opinion of importance.

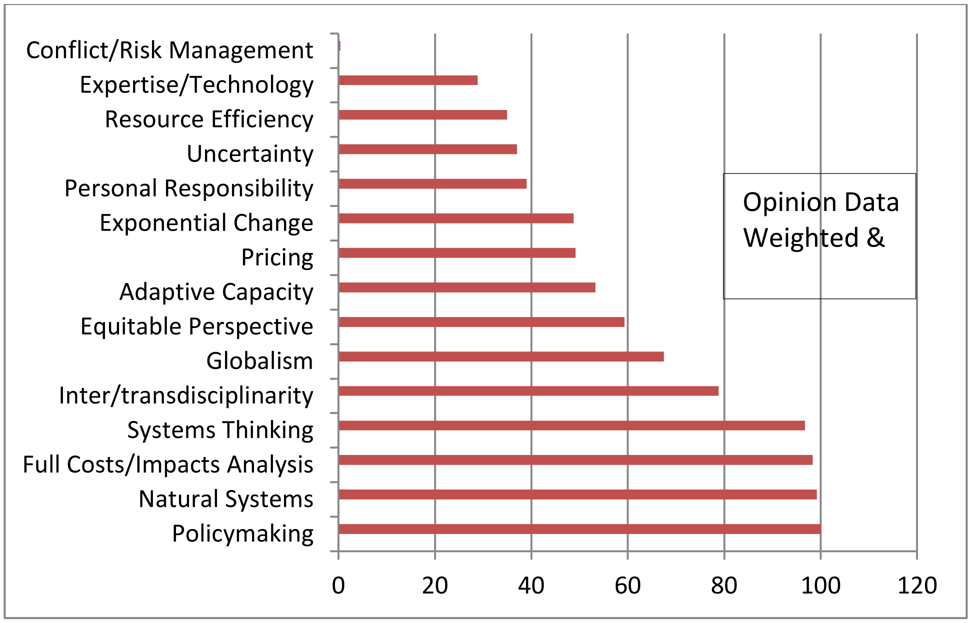


Figure 6 - Survey Weighted Opinions

3) *Difference between Existing and Opinion (Figure 7)*

Knowing that many programs are young, the opinions about potential improvements to them were considered particularly valuable. As a first step to fuller analysis, in Figure 6 weighted, normalized scores of Existing and Opinion are compared to determine the match of existing programs to respondents' opinions. The chart values are the difference between Existing minus Opinion for each element. As this gave a negative value for some elements, the results were again normalized on a scale of 0 to 100.

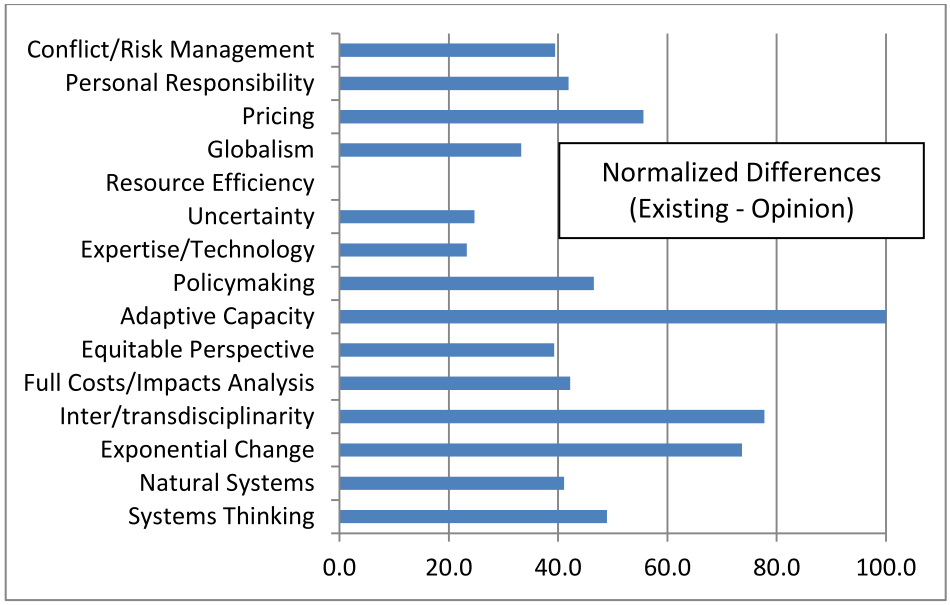


Figure 7 - Survey Differences Existing – Opinion

4) *Weighted Total with Difference from Existing to Opinion (Figure 8)*

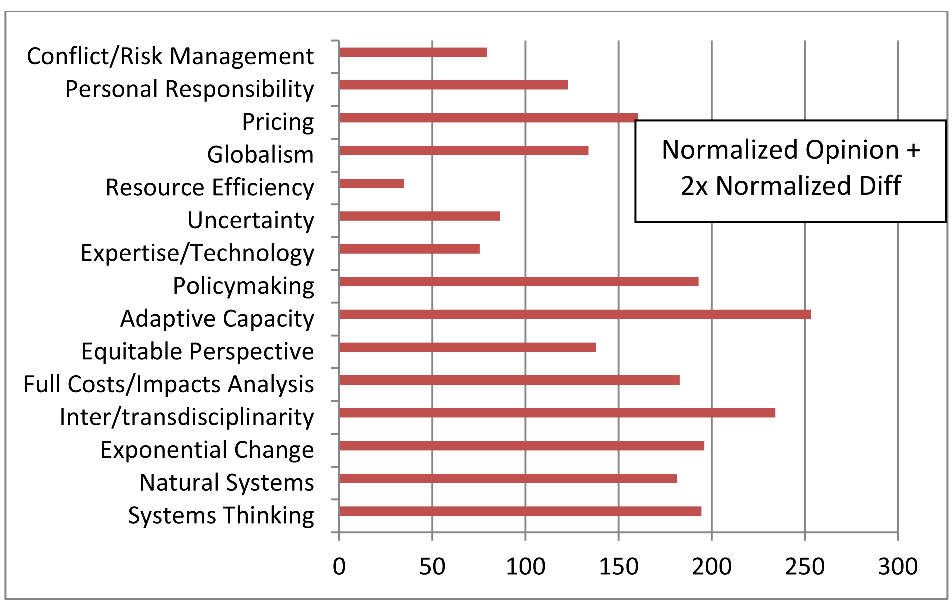


Figure 8 - Survey Opinion + Differences

In this final analysis, the difference between Existing and Opinion (Figure 7 results) is given additional weight (2x) and combined with original normalized Opinion (Figure 6) scores for a new total, as shown in Figure 8.

The absolute difference between the lowest and highest difference for all the elements in Figure 8 is ninety-one, so normalizing this result does not significantly alter the scale. The weighting bias is meant to underscore elements which the survey data shows should be the target of curricula improvements. Because Adaptive Capacity, for example, was little addressed in existing programs but valued in respondent opinions, it scores very high. Globalism on the other hand was just the opposite and moved down. Since Resource Efficiency actually was more prevalent as an existing emphasis than survey respondents valued in their opinions, it received a negative 'difference' and would be de-emphasized under this analysis.

The Figure 8 survey chart provides the most insight from information received from those having experience in SHE. It incorporates both the qualities of their program experience and their collective wisdom about where programs should be heading.

The lack of data volume restricts its significance somewhat, but respondent preferences are a valuable consideration.

VI. Comprehensive Analysis/Synthesis of Survey Results and Research

A. Combined Research and Survey Insights

It is important to keep in mind that survey responses, though limited, directly addressed the issue of 'most important learning and thinking elements'. There was no such specificity in the literature review. At the same time, the literature drove the compilation of elements. There was only one indication from survey responses that an element should not have been included, that being concerns about Exponential Change. One other comment was concerned with the quantitative measurement tendency of the Full Costs element, which resulted in a survey modification.

1) Overview

In the background of all writings researched was an ever-present reference to human interactions with Natural Systems. Research notes indicate that scholarly writings consistently and continually referred to Systems Thinking and Interdisciplinary approaches most often and most thoroughly. Less directly, but almost as often articles also addressed the need for a continual refinement of knowledge and solutions and the inclusion of relevant populations in the face of change - clear references to Adaptive Management and Equitable Perspective.

A few elements were inadequately described in sustainability education literature and required targeted research to examine their significance. Specifically, Full Costs, Resource Efficiency and Conflict Management were more pervasive in technical reports. Pricing and Conflict Resolution, except for the notable exception discussed above, were the realm of experts in their respective fields, not routinely associated with sustainability goals. Exponential Change was rarely mentioned, though the issues surrounding and concerns about rapid growth/decline were pervasive.

In between were the elements routinely mentioned by sustainability authors, but with little depth unless one sought more specificity. Uncertainty was commonly mentioned, but rarely in conjunction with insightful analysis. Globalism and Expertise/Technology were each derided as the roots of unsustainability and also hailed as potential saviors. Policymaking was a given necessity and Personal Responsibility the ethical core; each was the object of many artful arguments, but not as the central concept in a sustainability context.

2) Element Overlaps

For the most part, core elements defined herein reflect the 'stream of causes and effects' articulated by the UNDESD above. They are ultimately interrelated, both by their direct flows and by overriding common themes.

For example, the process of systems thinking leads to the use of interdisciplinary and equitable practices to comprehend and address issues. As issues are refined, expertise and technology provide the means of vertically addressing complexity and change, which in reality constitute uncertainty. Efficiency, costs and pricing are applications which allow a sense of comparative analysis.

The role of anthropocentricity was evident in all elements. For example it is the impetus for structure; as in systems, disciplines, expertise, pricing and technology. It is the basis for values of preservation, equity, law, and conflict. Sustainability itself is a human construct, perhaps first driven by conscience, but at some point looming as essential for survival. The means by which we deal with change and uncertainty, and our efforts at technology, policy and even education reflect back to a constant and perhaps increasing awareness of our limited perspective. One can fairly argue; is the interrelated character of sustainability elements a convenience of our limited perception, or a welcome sign of our growing understanding of an ordered world?

For this writer, the finding of consistency generally strengthened the conviction that sense can be made despite the cacophony, that we can learn how to progress through education and inquiry, and that it can be done today.

3) Element Hierarchy

Upon analysis an association may be observed between the frequency/significance of the various elements and their respective roles in sustainability education. Perhaps not without coincidence, the relation may be analogous to the discussion of interdisciplinarity and horizontal versus vertical expertise.

i. Level One – Thinking Elements

Horizontal or general expertise refers to the ability to observe and assimilate the full context of the issue at hand, traversing disciplinary, cultural, spatial or other disparate dimensions in order to foresee and understand ramifications over a longer term. Sometimes this requires the use of specialized knowledge for assessment purposes, under the auspices of the broad view. This is the core level of thinking sustainably, necessary and pertinent to any circumstance and includes the following core elements:

a. *Systems Thinking*

This represents the ***breadth*** of a sustainable approach, a continuing practice of overview and assessment. What are the elements, functions and systems involved? At what points are there conflicts which disrupt the steady state of the systems? What feedback is occurring? How will these change? Is more expertise needed?

b. *Interdisciplinarity*

The appropriate ***depth*** to the inquiry is gained by the use of additional knowledge, expertise and technology from a diversity of fields, flowing from a problem driven approach. The generalist must act as 'knowledge broker' to know what, and who to ask. Additional perspectives may embellish the systems overview, or provide deeper assessment of fact/uncertainty, stronger solutions, monitoring or offer a host of other advantages.

c. *Equitable Perspective*

Determining which ***people*** will be affected. Perhaps better termed 'stakeholder perspective', to include both equitable and political bases for understanding, this is awareness of who to include and how to involve them. Skills of outreach, facilitation, listening, learning, etc. are critical.

d. *Adaptive Capacity*

Effectively this provides the ***durability*** for a course or decision. It requires acceptance of new circumstances, uncertainty, feedback, change and the limits of knowledge. It may become adaptive management, but from the outset it is an understanding of human limits of knowledge which keeps system solutions open to change.

ii. Level Two – Dynamic Background Elements

Distinct from thinking elements, these are principles which affect outcomes and of which a sustainability expert must be aware. Some are subject to natural law and are not likely to change, while other human-related factors may change more readily. Certainly this list can be much longer, including such things as economic conditions, climate disruption or regime change.

a. *Exponential Growth*

   What is the doubling time of the various functional elements? Are they in decline? How will the system resources handle their dynamic?

b. *Uncertainty*

   Do we even know what we do not know? What are our assumptions? Should we risk being wrong and affect the outcome, or should we retain the status quo and choose different indicators and models?

c. *Globalism*

   Have we accounted for the spatial and jurisdictional fluidity which may be present? Can or should we try to affect it? What are the tools for doing so?

d. *Equity*

   Raised here as the other half of perspective. Is fairness and long term social stability an issue? How can affected populations be engaged?

iii. Level Three – Implementation Elements

The awareness of how a solution will be implemented is important to the development of a sustainable approach.

These are in essence scalable by human participants, but may be articulated in other means.

a. *Personal Responsibility*

This includes not only individual acts undertaken on a personal level, but also includes the recognition that most change derives from single acts, which give rise to more single acts, and ultimately community behaviors.

b. *Policymaking*

Used in the broadest sense, policy is the determination of more than one person to act. Of course the means for facilitating or discouraging action varies and the understanding of how policies are developed, implemented and used may be critical.

c. *Pricing*

In contemporary western society at least, pricing is perhaps the ultimate implementation of a result which will impact sustainability, sometimes incorporating policy influences. Is it consistent with sustainability practice? Does it provide a disincentive to sustainable results? Can/should it be affected?

iv. Level Four – Tools and Applications

Clearly only a sample list, these are among the numerous technologies, skills, models, or other specialized approaches which can be used to improve knowledge base, decision-making capacity, performance, monitoring, etc. These are similar to interdisciplinary vertical expertise, but not necessarily limited to any single discipline.

a. *Expertise/Technology*

The umbrella description of this tool set.

b. *Resource Efficiency/Effectiveness*

In essence these are empirical measurement applications which target specific indicators. Ongoing efforts may increase their holistic scope. These can also be powerful illustrative tools.

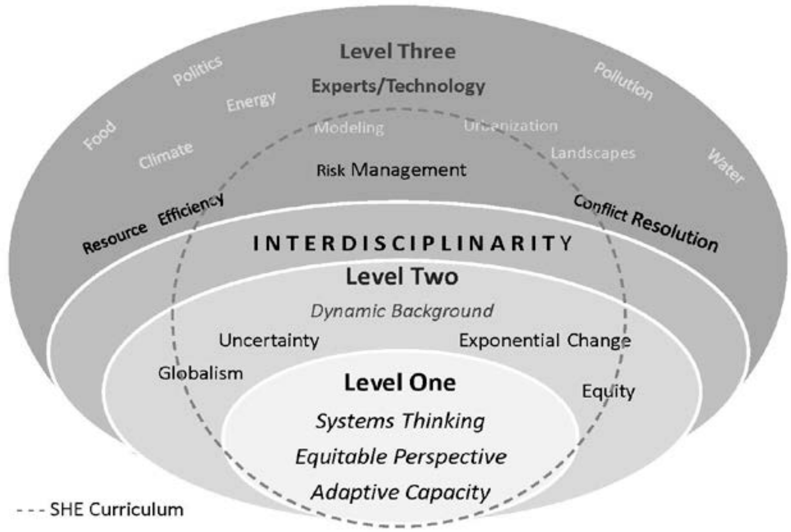
c. *Conflict resolution*

Increasingly effective mechanisms may help overcome or avoid human fears, apparent differences, histories, misperceptions and potential stalemate.

d. *Risk Management*

As shown above, processes may be available to assess and reduce risk in a variety of circumstances, not just in corporate loss reduction.

While the following condensed hierarchy illustration does not include all potential options, overall it may be helpful in establishing a core curriculum model for SHE.



In this illustration, the dashed line represents the SHE curriculum. While there are some optional elements in Level Two, the curriculum will only include a small piece of Level Three options, but it will always include Level One elements and the interdisciplinarity layer.

Figure 9 - Element Hierarchy for SHE

Obviously the thinking elements in level one above are most pertinent to the direct goals of this writing. However each level provides an opportunity for some degree of specialization and additional relevant learning opportunities as discussed below.

B. Distinguishing Sustainability Education

As a result of the emphasis on environmental education for almost forty years, the establishment of baselines and trends for various natural systems has brought home the reality of resource limitations predicted in the 1970s (Meadows, 1972). Whereas human and technological capital formerly defined the limits, it is now evident that the decline of natural capital – fish stocks, land, timber, minerals, etc. - is the 'greatest limiter of human economic development' (Cortese, 2003, p15). The growing realization of the role of human exploitation on natural systems and the resultant 'trophic cascade' of impacts to human systems and resources has led to a greater emphasis on sustainability and sustainability education.

While the movement toward sustainability education may be considered by some as an evolutionary progression for environmental education (Graybill, 2006), others strongly feel that an entirely new epistemological approach is required, emphasizing not only ecosystems as they are affected by human behaviors, but new ways of thinking and addressing problems. From this perspective environmental studies is regarded as a specialization insufficient to address all sustainability issues (Cortese, 2003; Paden, 2000). The same philosophical perspective drives concerns about the failure to see more progress in sustainability education, and the concerns are broad ranging. For some it is a failure to recognize the important role of education as protector of the future for society (Gough & Scott, 2010). Others point to the inclusion, mandated by the subsequent UN Thessaloniki Conference of 1997, of many elements not related to nor appropriate for classic environmental study but required for a holistic and sustainable education (Wright, 2004). A host of writers lament the lack of progress in development of true interdisciplinary coursework and knowledge (Graedel, 2010; Tilbury, 2004; Appel, 2004; Smith, 2000), and some point to the educational institutions themselves, saying that it boils down to administrative resistance to new programs from institutions which generally emphasize competition and specialization (Di Maggio, 2004; Appel, 2004; Abbott, 2001; Snow, 1959).

The concerns are global. A recent national study of sustainability programs in Germany concluded that environmental studies still tend to dominate, and most often focus on this single discipline, despite increasing efforts to broaden the scope consistent with sustainability principles (de Hahn, 2009). A report for Scotland in 2009 called for more support for fledgling SHE programs (Ryan, 2009). In a study of programs in Australia, it was concluded that an environmental bias may stunt progress in other sustainability fields and push academia toward technological solutions, rather than behavioral change (Sherren, 2006). In the United States, it is said there is more emphasis on the 'greening' of university campuses as a means of pursuing sustainability than on curriculum development (Wals & Blewitt, 2010).

Perhaps the most concerning point made by those favoring a shift away from conventional environmental education relates to bias and prioritization. It is hard to avoid the conclusion that our existing cultural-economic system has emphasized economic/fiscal and/or social issues, along with the exploitation of natural resources (Pittman, 2004). This has resulted in a cycle of severe degradation to natural systems, environmental education and advocacy, and often overwhelming economic/social justification in response. If left unchanged we will continue to observe degradation to natural systems, despite the strong evidence that damage to ecosystem services compromises the health and survival of human systems we seek to sustain (Fazey, 2007).

This enigma generates the call for 'transformative' change for society – and that HE play a strong role in helping redefine the value of natural and ecosystem health in terms understandable to a global marketplace (O'Sullivan, 2004). Assuming it is articulated in a balanced, comprehensive and logical manner, a strong benefit of sustainability as a focus of HE lies in its being perceived as a less biased, more inclusive approach to making decisions. This view provides strategic as well as academic advantage, addressing both the critical educational and political concerns of sustainability advancement.

Once one buys into the concept of SHE, research indicates a consensus around the need to dramatically change thinking and learning styles in order to be successful. "To achieve this, basic education must be reoriented to address sustainability and expanded to include critical-thinking skills, skills to organize and interpret data and information, and skills to formulate questions" (UNESCO, 2005, p29). The basis for this is the value of injecting human behaviors directly into the conversation about natural systems dynamics. New skills are called for in recognition of the need to examine all relevant issues in the same light (Sterling, 2004), and to allow better interpretation of preferred scenarios. The means of doing this, as discussed throughout this writing, requires use of knowledge, but perhaps more importantly new means of using and developing knowledge, and enhancement of thinking and analytic skills (Wheeler, 2000; Glasser, 2004).

For some, it is not necessarily from lack of progress that the field of 'environmentalism' perhaps subsides in political, if not educational significance (Sherren, 2006). In an unbiased and holistic approach to problem-solving, the value of natural systems rises as preconceived biases fade and the awareness of resource limits and systems integrity is tied to human sustainability. The routine acknowledgement of ecosystems services, just like commonly accepted values of efficiency, coordination or fairness, inherently realizes a stronger sense of environmentalism, purely as a fact of everyday existence and the need or more efficiency (O'Sullivan, 2004; Appel, 2004). While accepting this approach may come with some trepidation, it represents the soul of contemporary theory by a firm reliance on the value natural systems and on humankind's ability to recognize and sustain them.

C. The Nature of Interdisciplinarity

As described in the chapter so named above, the clamor for more interdisciplinarity in education rings as loudly as any other single concern in the research literature. As well, the term is even more common in program literature. This makes sense given the evidence that single-minded perspective, likely a product of narrow discipline education, can be pointed to as a significant cause for 'failing to foresee' problems which may be the realm of another department. Yet despite this significance, approaches in the literature promoting interdisciplinarity seem to overlook important considerations regarding the application of the principle in academic settings.

Interdisciplinarity as a concept is essential to more appropriate and sustainable responses to contemporary complex issues. A broad array of different perspectives, expertise and knowledge must be recruited to form holistic and durable solutions. How should this concept be applied in the context of education?

The literature cites various problems in implementing interdisciplinary coursework. These include the difficulties in assigning course development tasks, scheduling and compensating professors, and finding time for professors to collaborate on true, likely original interdisciplinary theory and research(Cotton & Winter, 2010). These concerns derive from institutional structure and provide more barriers than incentives to interdisciplinarity as promoted (Appel, 2004; Gallagher, 1999). The implication of these concerns is that the primary goal, and therefore the critical necessity, is finding the right professors in the right fields to teach specific courses in order to achieve interdisciplinarity.

But how does this jive with sustainability thinking? In fact, a better description of an interdisciplinary sustainable response is that it is problem-driven. By this it is meant that those responsible for a solution should pursue all available relevant perspectives, expertise and knowledge necessary to sufficiently address the issues of that particular circumstance. The distinction lies in the basic skill to be taught to the problem-solver which should be the ability to recognize – though not necessarily be expert in - the diverse, interdependent disciplines which may be subtly imbedded in real world problems. The means to do so includes 1) taking the step to look broadly at systems and functions, in order to 2) determine the scope of interdisciplinarity and, 3) recruit the necessary interdisciplinary resources. The resources would likely be a unique set of knowledge, skills, etc. for each different circumstance.

Because it is recognition skills and knowledge of interrelationships which is critical to determine the requirements of new circumstances, belaboring the specific professors or domain knowledge gained from interdisciplinary practice seems to miss the point. Coursework should emphasize the first steps; analyzing the affected systems, determining the boundaries of the inquiry, identifying the people necessarily involved. These skills, closely related to systems approaches, are uncommon in today's world of specialization and rapid response, but critical to sustainability practice.

Thus courses teaching interdisciplinarity may be better for emphasizing the skills, not by creating new defined sets of knowledge or theory to be shelved in students' mental libraries. This should not be 'an additional, imposed curriculum, but a perspective which permeates disciplines and creates a context' for the development of higher functioning solutions (Mortensen, 2004). As practicum for the skill, in addition to properly developing it, courses could stress the value of identifying issues and calling on related expertise, applying sophisticated modeling or interviewing people on the street to help develop the inquiry and solutions. This could be enhanced by pre-determined interdisciplinary perspectives of other fields or experts. Or, students could be given real or hypothetical circumstances, and asked to make the initial analysis described above, and then to seek out relevant resources in the act of interdisciplinary knowledge recruitment.

Upon recognition that interdisciplinary practice is truly wide open, using just a few guiding principles to foster truly interdisciplinary outcomes, the potential for practice in coursework is wide open. Thus, using faculty teams would be beneficial, but a course in interdisciplinarity could also be administered by a single faculty member, so long as she/he accepted and encouraged thoughtful and creative ways to use available resources in crafting sustainable solutions. Team teaching could be effective in demonstrating the relevance and interrelationship of several disciplines to a single case study or circumstance, and the ways in which new knowledge derives from collaborative approaches.

D. Establishing Priorities among Important Factors

Clearly any debate over the name and/or characterization of the educational approach followed to seek sustainability merely frames how to, not whether to protect natural systems. At the same time, the distinguishing feature of sustainability theory is to do so in the context of larger systems, including humans. Articulating this dynamic has led to short cut versions of sustainability practice. For example the 'triple bottom line' approach described above originated by declaring economic and social human sub-systems, along with the environment, as the triumvirate for sustainability review in business settings (Elkington, 1997; Bradley & Crowther, 2004; Anderson, 2009). Oversimplifying, this structure anticipates one consideration for natural systems and two considerations for human systems. Given the status and potential conflict between complex natural and human sub-systems, would it be more appropriate to split 'environment' into its components, such as water, air, soil, biota, etc., or by ecosystem services categories; such that there would be several natural and several human considerations to provide a more balanced equation?

On the other hand and from a sustainability education perspective, it may be argued that the propensity to categorize and separate fields in any fashion actually serves to diminish the role of natural systems, or any other factor, given the circumstance. As discussed above in regard to Systems Thinking, all systems are the product of human invention. As also discussed in various segments herein and throughout the literature, the battlefront for sustainability lies along the interface of human and natural systems,[5] and arises from intentional or unintentional degradation to life-supporting systems. As with mono- or multidisciplinary approaches, isolating any single area, or two or three, perpetuates the risk of bias and missing other unforeseen areas of systems failure. Alternatively, a problem driven approach ensures a more comprehensive scope, and does so without an arbitrary pre-determination of systems viability.

Nowhere in the literature is there allegation that ecosystems are degrading human systems; the problem is unilateral. The worst that could be said is that natural system protection might hinder growth of some human systems, such as consumption, profits or conveniences. But it can just as readily be argued that human invention is defined by an ability to find alternatives. This is because human systems are open, broad and adaptable, even at times

[5] Properly, sustainable analysis would also concern itself with human to human system conflicts, such as for poverty, human rights, etc. Those circumstances/population are recognized as similarly important, and in fact according to our definition may also be considered 'natural' systems made up of humans and requiring support.

arbitrary, as compared to natural system resources with limited carrying capacities due to their closed system characteristic.

We know that in the blurred line between natural and human systems, humans function on both sides of the fence. For example, an indigenous human population may very well be regarded as part of the natural landscape and subject to protection. Effectively, the same could be said for an impoverished or politically exploited modern population. This brings up two important points. The first relates to the structure of the systems at play. As noted above, natural systems are considered closed and finite. A reduction, reallocation or permanent change to any natural system component may result in a degraded system, smaller outputs at each function, or under worse conditions a fatal imbalance from which the system could not recover. It is logical that a rational approach would avoid damage to those systems which are vulnerable, and to prioritize alternatives which keep them functional.

A second point relates to the concept of stewardship. The very existence of stewardship as a human role indicates the recognition of value in protecting vulnerable systems, and confirms an ability to do so (Leopold, 1949). The bare concept implies that humans have a unilateral authority to determine outcomes. Unlike most, if not all natural systems, open human systems can replace components and shift priorities in order to manage and sustain critical resources. Whether in the name of ecosystem services for human prosperity, or for the inherent sake of natural system preservation, this forms a simple principle for prioritization: as system beneficiaries and stewards, it is to our advantage and within our capacity to maintain the health of our universal system by prioritizing the viability of important sub-systems which may not otherwise survive.

From this principle one can establish a rule of prioritization which is critical for sustainability decision-making, or at least the initial assumption thereof. If, in the analysis of a complex issue there is an irreconcilable conflict between two optional responses which affect systems differently, preservation of vulnerable, limited systems and components is assumed to be the priority, unless and until it can be demonstrated that there would be no significant impact to it, or it is known without uncertainty that it plays no unique role in other system functions.

This ‘prioritization theory’ provides fodder for education research and study. On the one hand it is only cursorily presented herein; on the other it represents a synthesis of a multitude of sustainability education approaches. It should be questioned, debated, changed if proven insufficient. But more importantly it represents the direction that sustainability education can take; that is moving toward the establishment of firmer working rules for sustainability decision-making.

VII. Report Limitations

While this report is perhaps most limited by the opportunity, time and global experience of the writer, there are several more specific deficiencies which can be reported to the benefit of future research:

1. Element Categories – as these were determined early on in order to develop the survey, they did not reflect the benefit of later research. Had there been time to complete research beforehand, categories could have been stronger and revised to provide better comparison. In a related vein, categories may have been refined to allow more emphasis on the final 'thinking' elements which were the focus of this report.

2. Survey Development Process – the process of formal survey approval, now apparently standard in U.S. universities, was not anticipated to be as time consuming nor as rigid as it was. This resulted in a single draft of the survey being used, with ripple effects as above. More time for development would have improved both the survey itself and allowed more time to browbeat non-responsive programs into better responses.

3. Survey Formatting – the survey was presented exactly the same to all participants. Some did not complete all answers, leaving the final questions with fewer responses. Using a random answer format could have prevented this.

4. Research Limitations – the effectiveness of the research remains somewhat unknown, as it was undertaken by an individual in a compressed time period. On one hand it is a solid evaluation of writings which specify sustainability education. But the broad and numerous 'elements' as topics mandated that research of any one remain somewhat superficial, though perhaps adequate in this context. This leaves open whether other viewpoints and options remain which could affect the analysis. But research did not reach related discourse on sustainability in general, other educational concepts and other experiences not in the literature, all of which could impact ultimate findings.

5. Uncertainty – As the existence of, and certainly the details in following a path to sustainability remain matters of faith as much as fact, there can be no warranty with regard the conclusions below. However on the flip side, it is equally clear that efforts toward progress cannot await perfection.

6. Singular Mental Model and Bias – while to me, the writer, all statements and conclusions herein provide the essence of fair consideration and logic, perhaps some will disagree. This report, its approach, concepts and implications would all be enhanced if others would challenge and expand them. And the products undoubtedly suffer from the lack of a crux requirement in sustainability thinking – the need for expanded perspective to identify and explore the broader horizon.

VIII. Recommendations/Conclusion

A. Recommendations

Stated again, “Are there key concepts, ideas and values which link the texts together and provide for a common focus on sustainability?” (see Problem Statement, Huckle, 2004). Happily, the answer to this inquiry appears to be yes, particularly in the context of an environment in which SHE 1) has a stated need to establish itself in the HE academic community, and 2) preaches the benefits of continual re-evaluation and adaptive management, tools which could well assist in the refinement of programs over time.

From the literature review it appears that programs may be reluctant to initiate a sustainability curriculum for fear of not getting it right or perhaps because of a lack of certainty over the way to proceed. Debate surfaces over which specific values should be incorporated in sustainability programs, and which should not, as if there is a single answer. In fact it appears that a better approach may be the development of a four-tiered curriculum which provides essential thinking skills-training as well as program freedom to develop greater expertise in a variety of fields, including:

- ✓ Core curriculum which immerses students in the critical context of sustainability thinking,
- ✓ Secondary exposure to contemporary background level implications,
- ✓ Prerequisite studies in natural systems,
- ✓ Incorporated implementation case studies and additional related adjectival coursework.

Four concepts are important to specify as part of this recommendation. These relate to 1) the anticipated role of the sustainability graduate, 2) the most critical thinking and learning elements for the sustainability graduate, 3) other elements a sustainability graduate curriculum might include and 4) the broader context of sustainability education.

i. Anticipated Role of the Graduate in Sustainability Efforts

An obvious element in determining the appropriate curriculum for students comes from their likely involvement in careers which follow their formal education. As discussed above and in the literature, a specialist in sustainability must possess the capacity to recognize the interconnected systems and issues pertinent to a problem or proposal, and have the means to oversee the coordination of expertise and human perspective necessary to address all important elements. This will include the foresight to anticipate, and the flexibility to respond to feedback over the longer term. Because the role could be important in almost any setting, it will require a strong background in human and natural systems connections and character, as well as knowledge in fields most relevant to the job, plus the awareness of and resourcefulness to call upon any other expertise necessary to assess, analyze and resolve issues at hand

ii. Critical Thinking and Learning Elements for a Sustainability Graduate Program

Given these requirements and the status of sustainability education theory, four of the reported core elements would be critical to include in any strong curriculum. These include 1) systems thinking, 2) interdisciplinarity/problem driven approaches, 3) equitable perspective and 4) adaptive capacity. It should be noted that these four taught components are tightly interrelated descriptions of an evolving thinking approach to sustainable decision-making and problem solving. These are consistent with the literature which consistently promotes new and better abilities to look at systems, interrelationships, broader perspectives, linked fields of knowledge, and monitoring and feedback in the context of potential change.

Thus, these skills are the primary tools for sustainability in practice and for demonstration.

Because these four skills will require practice beyond instruction in theory, a strong program will look to incorporate other important concepts into case studies or hypothetical situations. Specifically, the concepts of uncertainty, exponential change, pricing and globalism are important contemporary background concepts, as are climate disruption, corporatism, democracy and a host of others.

iii. Additional Sustainability Curriculum Elements

As indicated coursework in the four critical skills, including more than one course for at least some of them, does not and should not fill out the curriculum. A strong understanding of core natural systems affected by human interactions, such as water, ecosystems, oceans, energy and soils, is also very important. This is deemed intermediate due to the expectation that many graduate school students in sustainability may have met these requirements in undergraduate programs. If not these should be included in the program or made mandatory prerequisites.

Secondly and related, students can be encouraged to pursue disciplinary courses in background and implementation concepts described above, and/or from a broad range of fields which may include technology, environmental/ecological economics, urban studies, modeling and simulation, food systems, climate and atmospheric dynamics, just to name a few. Using creative formats to continue an emphasis on interdisciplinarity and critical thinking skills, such as by use of case studies or experiential research, would enhance both disciplinary and thinking skills.

iv. Broader Context of Sustainability Education

The role described in paragraph 1) for the sustainability specialist is actually that of generalist according to today's HE parameters. Consistent with true believers who feel the greater pursuit of sustainability requires a transformational change in education and society, the skills offered for sustainable thinking are likely applicable universally. This forebodes a new dichotomy: is sustainability education a specific emphasis or might its critical thinking skills be an overlay, i.e. a general education requirement for any successful student?

While many believe the latter is in the future (Appel, 2004; Uhl, 1996), implementation is the first step for sustainability education, with confidence that it will prosper according to its own merit.

B. Conclusion

Even as a broad view of existing research on the state and future of SHE sheds light on a path for success, one can see why success has been elusive so far. For one, definitions of sustainability itself are largely goal-oriented, failing to describe what actions to take in pursuing its promise. This status quite probably has led to a 'free-for-all' approach to program development, with each individual program using its own definitions and approaches.

While in some ways this is acceptable and even commendable, it leaves little assurance of progress on Brundtland's stated goal of assuring a quality of life for present and next generations. This is evidenced in the program described by one writer; her panel's systemic and systematic, rather than comprehensive approach to curriculum development consisted of a 'smorgasbord of frameworks, skills concept lists, indicative syllabus content lists, assessment modes, all customizable by discipline', including eighteen disciplines listed (Jones, 2010, p7) . No doubt this is a sophisticated and valid approach, but one may question its replicability. Can it be used by proponents less versed in sustainability education theory to develop a program? Will curriculum committees readily approve new programs which are so elusive by design? These questions are not just rhetorical; sustainability as the universal platter for sustainability education must be presented logically and simply enough for its sophisticated power to be evident for all.

A take away from this research has been a sometimes humbling feeling that we, all of us wishing so hard to help bring our societies to appreciate and utilize human capacity to slow degradation of our surrounding world, merely fail to listen to ourselves. Either simple logic or sophisticated research leads us to a common conclusion that we really just need to think harder about the ramifications of our acts and resource allocations before we set the cruise control. But who has not engaged in hours of discussion of myriad and detailed reflections on issues, answers and sustainability potential, only to leave with the feeling that we are still unsure what to do next? The volume and complexity can be overbearing.

Perhaps this cacophonic state is analogous to education. Not seeing the forest for the trees. Not seeing the path to sustainability due to the complex assortment of possible applications. Requiring students to learn about the complexities rather than how to think clearly in a circumstance of complexity. This is perhaps the transformative aspect so commonly called for in the literature. But maybe the transformation can be gentle and logical, even if comparatively radical. The means of transforming may just be the application of the well-thought out principles of systems thinking, adaptation, interdisciplinarity and perspective to our program development efforts.

It is the conclusion of this report that the missing, and fundamental element in sustainability education generally is the formal establishment of coursework and practice to enhance these thinking skills. If knowledgeable program developers start with this core concept, other benefits can flow:

- Graduates will be better suited to leadership and decision-making in a complex society.
- Successful curricula can be more easily constructed.
- Programs can be creative in offering case studies and specialization as applications of core principles.
- Program structures can become somewhat more standardized, facilitating (5) below.
- Comparative approaches and refinement of practices and programs can be more readily shared.
- Many of the thinking skills inherent to sustainability can be readily incorporated in many other disciplines, ultimately providing a path to the goal of sustainability as an 'overlay' to all disciplines and professions.
- Taking this approach does not restrict our evolving understanding of what sustainability truly means.

The determination of replicable means of teaching sustainable thinking and learning skills is a complex issue, yet worthy of the debate and resource it has consumed. Can the cacophony become symphonic? Maybe it is the noise around it rather than the movement toward sustainability which most complicates. This report describes a possible step toward building curricula which can train graduates to become sustainable thinkers and leaders. It builds on the work of scholars to date, and would require the attention of many more advanced scholars to broadly implement. Appropriately, a collaborative approach remains essential to advancement toward a more sustainable future.

Appendix I – Survey Form

Thank-you for agreeing to participate in this survey. I am asking for your help to determine the most important "thinking and learning" elements of sustainability education. We have learned that we need to change our approach to problems and issues, and we have studied problems of the day. Yet we also know new problems will arise. How will approach them? Or, perhaps even more so, how will we prepare new leadership to better resolve the critical issues which face us today and threaten our future.

With that in mind, PLEASE NOTE, this survey is not about defining sustainability in general. It is focused on identifying those thinking and learning processes which are most critical to graduate level sustainability programs. What analytic and thinking skills can we practice so that our leadership will result in decisions and results which best meet the principles of sustainability?

I am confident that once you begin the survey you will see where this is all heading. You have been provided with 15 topics which were selected following extensive research about advanced methods of sustainability analysis. Each topic is followed by a generic definition. In some cases 'related terms' are listed. The definitions are a synthesis of conceptual and applied uses and are intended to provide general, not technical guidance for your answers.

You are then asked to mark the importance of that topic, 1) in your sustainability program experience, and 2) giving your opinion about its importance for sustainability programs generally, your program notwithstanding. If you have participated in more than one program please use your current experience as a guide to your answers.

At the bottom of each topic page is a blank allowing you to comment on your answer if you so choose. This may be about the topic, the definition, or anything of your choosing. At the conclusion of the survey is another box for any additional comment you would like to make.

Thanks very much for participating. If you would like to see the results you will find instructions for seeking a copy at the conclusion of the survey.

Tim Botkin

Systems Thinking

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Systems thinking: *considering the role an issue, problem or decision may play in the function of surrounding systems or processes, including impacts which relate directly or indirectly to other significant processes and system, and the role of feedback loops in these processes.*

Related terms: Complex dynamical systems, Feedback loops

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate (post-graduate) level this topic:
	Is a **fundamental** component of any graduate level sustainability program.
	Is one of several **important** concepts which should be included.
	Should be included, but perhaps **secondarily** in the context of other topics.
	Has limited or **marginal** relevance to sustainability education.
	Is **not important** in sustainability programs.

Comments and/or explanation:

Natural Systems

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Natural Systems: *recognition of the unique characteristics, functions, roles and limitations of natural systems (e.g. hydrologic & carbon cycles, oceans, atmosphere, etc.); including the ecosystem services provided by them and understanding of planetary impacts if they are lost or damaged.*

Related terms: Closed loop systems, Natural cycles, Ecosystem services

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate (post-graduate) level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Exponential Change

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Exponential Change: the increasing rate of change, leading to rapid change as illustrated by the steepening 'J' curve which documents the rates of growth for critical factors such as population or population-related carbon dioxide emissions, and inversely the rapid decline in decimated/over-harvested resources or populations.

Related terms: Doubling time, Exponential decay, Minimum viable population, Overshoot and collapse

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Inter/Transdisciplinarity

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Inter/Transdisciplinarity: acceptance of a 'problem driven' approach to consider the entire breadth of a problem, issue or topic, regardless of its extension into many fields of study or expertise; by means of examination of the relevant interrelationships between the affected fields, the integration of new expertise generated from these dynamics, and including academic and non-academic knowledge and expertise.

Related terms: Liberal education, Community based education

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Full Costs/Impacts

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Full Costs/Impacts: use of sophisticated tools such as ecological economic analysis, least cost analysis or cost-benefit analysis in a concerted effort to determine and account for the entire 'cradle to grave' costs and impacts of a product, process or decision; including both direct and indirect results which would not have occurred but for the product, process or decision.

Related terms: Ecological economics, Environmental economics, Full cost analysis, Cost-benefit analysis

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Equitable Perspective

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Equitable Perspective: *the use of proactive processes designed to 1) determine the perspective of potentially affected persons of all cultural, socio-economic and/or political demographics, 2) evaluate the impact of the potential change to their specific circumstances, and 3) fairly weight these populations and impacts to them in determining the propriety of an action and/or decision.*

Related Terms: Social equity, Cosmopolitanism, Ethics

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Adaptive Capacity

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Adaptive Capacity: *the ability of a system or population to achieve positive modification of its behaviors in response to change. In humans this connotes the cognitive determination of the need for change and the ability to affect it.*

Related terms: Resilience Thinking,

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Policymaking

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Policymaking: *the processes, structures, systems and human elements which are the basis for translation of contemporary value sets into guiding principles for resource allocation, regulation and/or incentives by governments and other complex political systems.*

Related Terms: Civics, Politics, Law, Regulation

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Role of Expertise and Technology

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

***Role of Expertise and Technology**: inquiry into the most effective use of expert and technology tools in 1) examining and analyzing the scope, scale and qualities of facts, circumstances and problems, 2) collecting and managing data and 3) developing models, solutions and monitoring systems for implementing sustainable results.*

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Uncertainty

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Uncertainty: *the role of lack of knowledge or information in decision-making, the ways in which decision-makers act in response to it, and different means for proceeding to action without a complete awareness of the facts.*

Related terms: Precautionary principle, Legal standards

	In my graduate sustainability course this topic was:
☐	A distinct topic or unit.
☐	Raised and discussed extensively in the course of other units.
☐	Not emphasized but mentioned as a topic I should recognize.
☐	Somewhat familiar but discussed only in passing.
☐	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
☐	Is a fundamental component of any graduate level sustainability program.
☐	Is one of several important concepts which should be included.
☐	Should be included, but perhaps secondarily in the context of other topics.
☐	Has limited or marginal relevance to sustainability education.
☐	Is not important in sustainability programs.

Comments and/or explanation:

Resource Efficiency

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Resource Efficiency: *the amount of available asset ultimately provided to end users by a given resource versus the full potential utility of that resource prior to use.*

Related terms: Energy analysis, Waste management/reduction

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Globalism

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

***Globalism**: the phenomena by which activities, benefits, impacts, people and economic factors which are not constrained by geo-political boundaries or governments therefore flow to different nations, states, regions and/or continents.*

Related terms: Globalisation, Multi-national

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Pricing

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

***Pricing**: analysis of the amount actually paid by end-users for a product, service or resource as a result of regulated or unregulated market processes; which price may or may not include subsidies, penalties, surcharges, external costs, profits, production costs or other costs/information; as ultimately determined by the acquiescence of buyer and seller.*

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Personal Responsibility

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

Personal Responsibility: *the role of the individual in weighing personal gain and human/ecological values when making autonomous decisions which are likely to affect other persons, systems or resources.*

Related Terms: Ethics, Civics

	In my graduate sustainability course this topic was:
☐	A distinct topic or unit.
☐	Raised and discussed extensively in the course of other units.
☐	Not emphasized but mentioned as a topic I should recognize.
☐	Somewhat familiar but discussed only in passing.
☐	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
☐	Is a fundamental component of any graduate level sustainability program.
☐	Is one of several important concepts which should be included.
☐	Should be included, but perhaps secondarily in the context of other topics.
☐	Has limited or marginal relevance to sustainability education.
☐	Is not important in sustainability programs.

Comments and/or explanation:

Conflict Management

Note: For this topic a term and general definition is given. Please mark the best ONE answer in each box, using the general definition as a guide. At your option, please use the space provided to explain your answer.

***Conflict Management**: The processes involved in identifying, avoiding, minimizing and/or mitigating risks, potential conflicts, or actual conflicts between or among people, entities or things which may result in delay, misdirection or increased cost to an intended result.*

Related Terms: Conflict resolution, risk assessment/reduction

	In my graduate sustainability course this topic was:
	A distinct topic or unit.
	Raised and discussed extensively in the course of other units.
	Not emphasized but mentioned as a topic I should recognize.
	Somewhat familiar but discussed only in passing.
	Not addressed.

	In my opinion, in a quality sustainability program at the graduate level this topic:
	Is a fundamental component of any graduate level sustainability program.
	Is one of several important concepts which should be included.
	Should be included, but perhaps secondarily in the context of other topics.
	Has limited or marginal relevance to sustainability education.
	Is not important in sustainability programs.

Comments and/or explanation:

Appendix II - Programs contacted for Survey

Institution	***Program***
Antioch University	Environmental Education
Arizona State Univ	School of Sustainability
James Madison/U of Malta	Sustainable Environmental Resource Mgmnt.
Cambridge University	Masters in Leadership for Sustainability
Univ of Tokyo	Grad Prgm in Sust Sci (GPSS)
University of Edinburgh	Masters Environmental Sustainability
Bond University (AUS)	Environmental Mgmnt. (Sustainable Developmnt)
Universidade de Brasilia	Grad Prgm in Sustainable Development
Saint Louis University	Master of Sustainability
Ramapo College	Master of Arts in Sustainability
Lipscomb University	Master of Arts
Harvard Extension	Master of Science
Keele University	Environ Sustainability & Green Technol
University of Strathclyde	Sustainability and Environmental Science
Blekinge Institute of Technology	Strategic Leadership towards Sustainability

Appendix III – Survey Raw Data

Existing Program Data

	A1	**A2**	**A3**	**A4**	**A5**
Systems Thinking	53.0	17.0	13.0	17.0	0.0
Natural Systems	36.0	50.0	14.0	0.0	0.0
Exponential Change	0.0	42.0	43.0	10.0	5.0
Inter/transdisciplinarity	10.0	52.0	23.0	10.0	5.0
Full Costs/Impacts Analysis	40.0	45.0	10.0	0.0	5.0
Equitable Perspective	30.0	30.0	30.0	0.0	10.0
Adaptive Capacity	5.0	25.0	35.0	25.0	10.0
Policymaking	55.0	20.0	10.0	5.0	10.0
Expertise/Technology	30.0	20.0	30.0	5.0	15.0
Uncertainty	10.0	55.0	30.0	0.0	5.0
Resource Efficiency	25.0	45.0	25.0	5.0	35.0
Globalism	15.0	65.0	20.0	0.0	0.0
Pricing	10.0	45.0	25.0	15.0	5.0
Personal Responsibility	10.0	40.0	45.0	0.0	5.0
Conflict/Risk Management	0.0	35.0	35.0	20.0	10.0

Opinion Program Data

	B1	B2	B3	B4	B5
Systems Thinking	70.0	22.0	4.0	4.0	0.0
Natural Systems	59.0	41.0	0.0	0.0	0.0
Exponential Change	24.0	48.0	29.0	0.0	0.0
Inter/transdisciplinarity	48.0	38.0	14.0	0.0	0.0
Full Costs/Impacts Analysis	58.0	42.0	0.0	0.0	0.0
Equitable Perspective	35.0	40.0	25.0	0.0	0.0
Adaptive Capacity	40.0	30.0	25.0	5.0	0.0
Policymaking	70.0	20.0	10.0	0.0	0.0
Expertise/Technology	20.0	40.0	35.0	5.0	0.0
Uncertainty	25.0	40.0	30.0	5.0	0.0
Resource Efficiency	25.0	45.0	20.0	10.0	0.0
Globalism	35.0	50.0	15.0	0.0	0.0
Pricing	30.0	50.0	10.0	5.0	0.0
Personal Responsibility	30.0	25.0	45.0	0.0	0.0
Conflict/Risk Management	5.0	35.0	55.0	5.0	0.0

NOTE: All data is expressed in terms of the percent of responses in that category for each element. Thus rows add up to 100%.

Appendix IV Sample Cited Scholars' SHE Elements/concepts

Scholar	***Cited SHE Important Elements***
Huckle, John, 2004, p 34	key concepts: integration of natural/social sciences and humanities, local knowledge, critical pedagogy, enlightened vision
Blewitt, John, 2004, p31	focus on natural resource limits, social and environmental justice, intergenerational responsibilities, policy-making and implementation or corporate liability
Paden, Mary, 2000, p4	5 components: future, design, NR, economics, globalization 3 main elements : 3 legged, interconnectedness, multi-perspective
Byrne, Jack, 2000, p39	knowledge components: systems, connections (interconnectedness, components, diversity), multiple perspectives skill components: analysis, communication, collaboration, decision-making/leadership, deep thinking, action-taking, conflict management, technology, planning, multiple perspective assessment
Sterling, S., 1996, p36	political education/ecology, natural history, environ science, ecology and biodiversity, systems theory/thinking, social relations, conflict resolution, equity/social justice…health…economics
Sherren, Kate, 2006, p402	four well-established concepts capture a large percentage of this agenda: liberal education, cosmopolitanism, inter-disciplinarity and civics
Jones, Paula, 2010, p 12	variety of disciplines: business, geography/earth/environ-mental sciences, nursing, law, dance/drama/music, engineering, media communications & cultural studies, theology, social work, built environment, economics, languages, teacher training

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