DEVELOPMENT OF SUSTAINABILITY WITHIN A UNIVERSITY CURRICULUM

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DEVELOPMENT OF SUSTAINABILITY WITHIN A UNIVERSITY CURRICULUM

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At the beginning of the 21st century, we are at a peak of human power, wealth and information... We need to look back at our wonderful natural and human heritage, and cherish and protect the abundant values to be found there. We need to look out to the sides and see other parts of the world that need our help and can provide good ideas to go forward... We need to look ahead to be certain that our actions of today will make the world a better and richer and more varied place for our grandchildren and their grandchildren.

Robert Bateman, online source

For William James Smith

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SUMMARY

There are currently many complex issues facing human society. There are a range of well-documented environmental problems that stem from past and current methods of human development. Declining ecosystems and species extinctions aside, many humans suffer and struggle within this mounting tide of environmental hardships as well as continuing struggles with access to education and equality within society. A large portion of these struggles arise from the disparity in wealth and the seemingly oppressive nature of economic systems for the 'have-nots' of the world. This quick overview of environmental, social, and economic conditions shows the interdependencies of the three aspects of sustainability or sustainable development.

As there are calls to action from the scientific community, government, and society to address these issues of sustainable development, there are a number of voices calling for general changes within the various levels of the education system and more specifically with connecting students to the subject of sustainability. This thesis makes the argument that the most effective step in addressing both these issues is an introductory course on sustainability. Although the issues of sustainability and education are framed under different context, they both can be reduced to the concept of more holistic thinkers in society and in the classroom. A review of more discipline-specific courses incorporating sustainability, faculty surveys, and alternative learning and teaching methods strengthened the course design process. The end result is an upper level undergraduate course that uses the topics of food, water, and energy to bring a new level of understanding to the student on sustainability and holistic thinking.

CHAPTER 1

RESEARCH OBJECTIVES

1.1. Study Overview

This research examines how the concepts of sustainability can be taught within the university system. The intention is to provide students with both theoretical and practical knowledge and application experience with these concepts. Given the author's background in engineering, some emphasis is placed on the rounding out of the engineers' world view, and thus the importance of a truly cross-disciplinary perspective. A major product of this study is the development of a 15-week course on sustainability that would have both technological and societal aspects.

This study has been informed by both the coursework and research that the author has undertaken while an undergraduate and a graduate student at Georgia Tech. The foundation of the study dates further back to the first reading of Bill McDonough and Michael Braungart's Cradle to Cradle and an interest in developing environmental education programs as a profession (McDonough and Braungart). This seminal work as well as Lester Brown's work at the Worldwatch Institute and casual conversations with people, who knew nothing of sustainability, provided the inspiration and motivation to pursue this research.

In order to understand the current state of sustainability education at Georgia Tech, an array of classes was identified across campus that dealt with sustainability in relation to a specific focus or field of study. This effort provided an understanding of the various current methods for contributing to students' knowledge of sustainability that could be obtained at the Georgia Institute of Technology. It also illustrated the strengths

and limitations of having classes focused solely on one aspect of sustainability. It is critical to have a deeper understanding of sustainability as it relates to a specific disciplinary area, but often these classes have been set up to introduce the basic concepts and then to draw linkages between these concepts and the subject area. In the author's view, each of these courses had limited presentation of the interrelations between systems (economic, environmental, and social) and the numerous impacts of human behavior within our society and on the natural world on which we depend. This strengthens the argument of the need for a general course on sustainability that would address these interdependencies and impacts on a deeper level and in a much more focused manner.

Equipped with this knowledge prior to engaging in higher levels of discipline-oriented sustainability courses and research tracts, students could really delve into the complex and multi-faceted problems that are facing society at this point in history. As the level of technology and societal sophistication has increased, so too has the difficulty of defining problems and developing solutions for them. It is no longer easy to compartmentalize and diagnose situations along traditional lines. There is a growing movement within the professional world to tackle issues with cross-disciplinary teams. Academia has recognized this trend, and there have been different levels of calling for this change and development of coursework to address it.

There is even discussion that the rigidness of disciplines is partially responsible for the weakening of the university from its' high ideals (M'Gonigle). The arrogance and presumptuousness that sometimes cast a shadow over individual disciplines, as well as the unnecessary competition amongst disciplines and devaluation of fields of study operating in similar areas must become a thing of the past. The problems that the world

faces are much too complex and interrelated for there not to be strong support for an understanding of all fields' importance. This applies at all levels of the work force.

Many universities in the world are taking the initiative to pursue a vision of sustainability. There is no formulaic process to achieving sustainability, and thus no repeatable steps or methods that provide a descriptive model. Each school has to be able to adapt the basic tenets of sustainability to the local settings and academic interests of the university. This thesis will focus on the development of coursework appropriate to the Georgia Institute of Technology (Georgia Tech).

1.2. Thesis Organization

Chapter 2 describes the current context of education on sustainability at the university, which provides the motivation for this research. Stretching beyond the university, a range of different issues is covered that shows a complex web of interdependencies in the today's society. The central question of this thesis is presented with the acknowledgement that a complete answer will not be provided in this work. The intention is instead to strengthen the argument and provide useful class materials for other instructors through the vehicle of an introductory course on sustainability.

The literature review in Chapter 3 serves more as a means of clarifying and supporting the central argument for the need of university students to gain perspective on the issues of sustainability. Although it is intended for a general audience, there is additional attention given to engineering students and the supported call for changes to how and what engineers are taught. This has typically focused on providing more social sciences courses in the engineering curriculum as well as questioning the pedagogy or

standard operating procedure for setting up and solving engineering problems in the classroom.

There is a paucity of information on sustainability courses or developing materials for curriculum. However, the American Association of Sustainability for Higher Education (AASHE) and the Center for Sustainable Engineering each provide listings of different university courses related to sustainability (Association, Center). Reviewing syllabi and other available materials for this study provided insight into the general nature of these courses and common elements. On the other hand, there has been much research on the evolution and history of the sustainability movement within and outside of an educational context, and this provided the input into the development of the basic tenets of sustainability upon which an introduction course could be based.

Chapter 4 develops the argument underlying the issues that need to be infused into the coursework. The importance of each issue will be discussed in direct relation to particular disciplines, but also from the perspective of connecting to other disciplines in order to show the necessity of looking beyond the obvious links to an individual's profession. Building upon this cross-disciplinary awareness, other dynamics essential to this course are the balance of global and local impacts and interests, the balance in the breadth and depth of course materials, and the balance of theoretical advances and practical applications. The findings and synopsis of a survey of faculty and staff at Georgia Tech will be presented in this chapter as well. Building off of the theories of Maslow's hierarchy of needs, there will be three main focuses on energy, water, and food.

Outlining the modules for these three main focuses will constitute the bulk of the work for the course development. The intention is to develop them in a way that they can act in concert with each other in this introductory course, but also be pulled out and used in separate courses that might have more specific focuses. An alternative model for course development, learning-based instead of content-based was used. Details of the process and the good-fit applicability to this subject matter are covered in this chapter. The emphasis of this model is on active learning that engages students not only in the present context, but also throughout their life. Guest lecturers from the university and surrounding business community would provide a broad range of expertise on the different facets of the course. As stated before, there will be three chief focuses, but the linkages and interdependencies among them will be illustrated through inter-module class discussions and focused writing assignments.

The final chapter will focus on future developments in education and sustainability. This thesis will hopefully raise the awareness about the importance of advocating for and taking action to incorporate themes of sustainability into all levels of education. This is not an original idea, but rather another means of trying to find the right message to communicate to the wide array of interest groups in the world. In the same way, many of the programs and efforts discussed in the thesis have taken hold in some communities and are the focus of actions by different organizations and people. The development of an introductory course for engineering students could be considered antithetical to the argument of making sustainable development an integrated part of the curriculum, but it is viewed in this thesis as a positive step in bridging the present gap in education.

CHAPTER 2

BACKGROUND

2.1. The Present Global Context and Paradigm

> The key to sustainable, self-reliant development is education- education that reaches out to all members of society through new modalities and new technologies in order to provide genuine lifelong learning opportunities for all . . We must be ready, in all countries, to reshape education so as to promote attitudes and behaviour conducive to a culture of sustainability.
>
> Federico Mayor,
> Director General of UNESCO

The above call to action from Federico Mayor was originally delivered to the United Nations General Assembly in 1997, but the sentiments still ring true today with the called for "readiness" replaced with immediate and effective action. Current global conditions can leave people with a sense of apathy, but there is hope to be found in shifting the development paradigm towards a more sustainable one. As an intersection of thought development and transference point for knowledge into society, the university is the logical nexus for bringing together a diverse group of ideas on sustainability and finding ways to integrate this new concept into the heart of the institution's fabric.

Climate change, corporate scandals, government corruption, poverty and a growing gap between the rich and poor are just some of the broader issues facing societies around the world. There is no equation for how these problems developed and certainly no algorithmic process for developing solutions. However, there are certain patterns of behavior and beliefs that lead to a degrading of both physical resources from the biosphere and moral responsibility from the minds and hearts of Man. Interpretations of the Creation story for a vast majority of Judeo-Christians center around the belief that "no item in the physical creation had any purpose save to serve man's purposes." (White

1205) Although all blame cannot be placed on the interpretation of this one religious passage, many Western social behaviors, economic thought and production systems that have come to dominate global society were incubated within regions where these belief systems held a considerable amount of wealth and power.

Thus according to this world view, the world operates on a system of perpetual growth and consumption, often ignoring the realistic limits that are inherent to a planet, which "is finite, nongrowing, closed (except for the constant input of solar energy), and constrained by the laws of thermodynamics." (Daly 102) Along with these patterns, the power of marketing and advertising has contributed to a pervasive materialistic attitude and an assumption that accumulating goods creates happiness. Although it is nearly 170 years old, Charles Mackay's observation of people's obsession with wealth still rings true today especially in light of the greed and ethical negligence that has fueled the present financial crisis.

> Money, again, has often been a cause of the delusion of multitudes. Sober nations have all at once become desperate gamblers, and risked almost their existence upon the turn of a piece of paper. To trace the history of the most prominent of these delusions is the object of the present pages. Men, it has been well said, think in herds; it will be seen that they go mad in herds, while they only recover their senses slowly, and one by one.
>
> (MacKay 7)

In Deep Economy, Bill McKibben covers a range of different studies that have shown declines in happiness and increased levels of depression and anxiety among Americans since the 1950s and then trends that show equal levels of life satisfaction for a collection of individuals from various socio-economic situations. He does not deny the fact that wealth accumulation that leads to the meeting of basic needs for the individual generally leads to greater levels of happiness, but this growth continues past meeting

basic needs and to the point that "a single-minded focus on increasing wealth has driven the planet's ecological systems to the brink of failure, without making us happier." (McKibben 42)

The current method of finding solutions for pressing issues is to create isolated fixes for specific problems, essentially band-aids to a problem that is often beyond public comprehension. Examples of this are the attempts by the United States administration and other industrialized nations to create a significant fuel supply from food crops such as corn, sugarcane, and a variety of plant-based oils. Even if these efforts are well intentioned to reduce greenhouse gas emissions, strengthen the agricultural economy and shift revenues away from insecure oil-producing regimes, they are still extremely shortsighted and ineffective. Farmers and corporations are switching over to exclusive production of these fuel crops as well as resorting to wide-scale deforestation in tropical areas to produce palm plantations and sugarcane fields to create biofuels. The market effects of the shift of crops to fuel production combined with already record-high prices of crude oil have caused staggering increases in the price of essential food products. (Kingsbury) There are multiple angles from which this situation can be diagnosed, but the most basic relates to the idea often attributed to Einstein, "the problems that exist in the world today cannot be solved by the level of thinking that created them." (Giga) Instead of trying to assess truly innovative ways to deal with petroleum dependence and illogical networks of transportation and product distribution, leaders have attempted to find a substitute for an element of a larger system that needs a complete overhaul.

Although by no means completely thorough, this discussion of the food-fuel controversy has highlighted one argument that is central to future work on sustainable

development that relates to Otto Neurath's classic analogy of pragmatism. In a condensed frame, the analogy is that humanity's base of knowledge is a ship confined to a life at sea, and over time weathered planks or incongruous thought patterns are replaced one by one to keep the ship sailing. (Norton 107) The present rate of incremental and piecemeal approaches towards sustainable development will ultimately not "keep Neurath's ship afloat". The magnitude of global threats and inertia intrinsic to the present paradigm leaves mankind with the choice of "jumping onto a new ship" or continuing on the present course as the water slowly continues to rise.

2.2. Shifts in Understanding and Worldview

Another interesting development in an Age of Information is the impact of non-traditional knowledge sources. One of the chief emphases of the United Nations' and other global agencies' efforts within the sustainability education movement is universal access to education. The first task is encouraging people around the world to pursue basic education and then to provide the knowledge and learning skills to further pursue the necessary information of how sustainability relates to their situation. The internet and digital materials are obviously transforming the way in which traditional research is done, and are the means of making large amounts of information available. Over 200 universities in the Open Course Ware Consortium (OCW) have begun to release their class materials into the public domain (Open Course Ware Consortium). If nothing else, those interested enough in a subject matter can follow up on less accountable sources with more proven materials.

In the same way that internet searches and "surfing the web" can key disenfranchised people into new information and ideas, there is another, alternative form

of bringing awareness to different environmental, social, and economic causes; growing numbers of popular celebrities and entertainers donating money and their personal endorsements to existing organizations or by establishing new foundations and programs in which they maintain a certain level of control. Although in some ways celebrity endorsements represent a fickleness of our society, they often motivate action on important issues. They reflect the evolution of global society and how the realm of influence and compassion of individuals continues to grow. The recent election of Barack Obama as president will have profound effects as well on the motivation and concerns of the population in relation to education and knowledge accumulation. When an African American with challenging childhood circumstances has been elected to the highest public office in the country, there can be no doubt that regardless of one's background with proper education and dedication any goal is possible.

Perhaps the greatest challenge in moving forward is transcending the use of all the derivations of the word sustainability, interpreted to one's own ends by different schools of thought. In a paper addressing the issue of sustainable development in relation to the planning profession, Scott Campbell discusses this semantic ambiguity as both a dilemma and benefit of the widespread use of this concept, which is "so malleable as to mean many things to many people without requiring commitment to any specific policies", but at the same time "the idea has become hegemonic, an accepted meta-narrative, a given" (Campbell). The dilution of the concept is well accepted, but the momentum behind the recognition and public awareness of the importance of change could be transferred to an interdisciplinary effort, looking to inculcate the basic concepts into the collective

consciousness outside the traditional frames of reference of academia, industry, and government that might prove to be the most effective solution.

2.3. The Role of the University

The university is one of the oldest continuously operating human systems in the world. Although there have been many significant changes, the basic tenant of a system of advanced education has been at the heart of the university for over 1000 years. Universities stand at the crux among industry, government, and the public good. They serve not only to provide students with the knowledge necessary for successful careers, but also with the critical thinking and qualitative problem-solving skills to use in their personal lives. It is as well a great social institution that gives many students their first experience of independence and allows them to begin to craft their own views of how the world works and what their place in the world looks like. Although attempting to be fiercely independent, most college age students are highly impressionable and involve themselves in different clubs that have political, social-justice, and environmental associations. Finally, the faculty can have lasting influences on the student's knowledge and personal development.

The university clearly has many different means of impacting students' learning, personal development, and behavior. However, the scope of this thesis is limited to the development of course materials for an introductory unit on sustainability and a brief survey of considerations of future efforts at the university and within the broader educational system. A specialized methodology is used to create the framework for the learning to take place in the course. This philosophy of course development is in line with the ideals of holistic and integrated thinking and problem-solving that are at the

heart of the intention behind this course. As much as it is a means of addressing sustainability issues and student familiarity with the concepts in the classroom of a university, it is equally a chance to use this open subject matter as a vehicle for how to institute new learning environments and opportunities for students. Due to the richness and integrated nature of sustainability and the systems perspective needed to meet the challenges of our global society, this work seeks to answer the central thesis question of how a university can better prepare its students to think holistically about these myriad interrelationships within their own lives and disciplines.

CHAPTER 3

LITERATURE REVIEW

This chapter presents a brief introduction to the concept and history of sustainability. Supporting arguments are then laid out for the defining characteristics of a course on sustainability, these being: cross-disciplinary, practical, and holistic. Theories related to change in engineering curriculum are next discussed. This includes more recent work in developing a broad base of knowledge for sustainability and better preparation for the multi-faceted issues of living in a global society. Most of the arguments presented in this literature review align with the methodology advocated by L. Dee Fink (Fink) for course development, which will be covered in the chapter covering the course design.

3.1. Perspectives on the Concept of Sustainability

Several studies have looked at sustainability in relation to historical civilizations. Jared Diamond's well-acclaimed *Collapse* studied failed civilizations and the different circumstances that factored into their downfall (Diamond). Donald W. Floyd brings a more specific perspective to the topic in his book*, Forest Sustainability: The History, the Challenge, the Promise* (Floyd). The mismanagement of forestlands led to the "un-sustainability" or collapse of many powerful cultures as humans formed settlements. He also postulates that the abundance that the forest provided and the sacredness with which they were held fueled Man's first efforts at intentional conservation of this resource by such great thinkers as Henry David Thoreau, Thomas Jefferson, Aldo Leopold, and John Muir. Although the issue of sustainability reaches far beyond purely environmental concerns, these initial movements and thought-leaders established the idea of thinking

beyond one's own immediate needs similar to the first abolitionists, civil rights leaders, and advocates of universal suffrage, health care, and education.

Many attribute the 1987 Brundtland Commision Report, *Our Common Future*, that arose out of the United Nations' World Commission on Environment and Development as the modern introduction of the concept of sustainable development to the world's governing bodies. The Report produced the following often-used definition of sustainable development: "to meet the needs of the present without compromising the ability of future generations to meet their own needs" (World 8). Furthermore, it laid out two very significant underlying concepts:

- "the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs"

(World 8)

Unfortunately much of the literature on sustainable development has not paid much attention to these important concepts.

3.2. Considerations and Principles of Sustainability Efforts in Education

The consideration of sustainable development in college education begins to parallel this main discussion. Appendix A provides a list of the different guiding principles or goals that different schools and authors have used in advocating for and developing university vision and curriculum for sustainability. It is not within the interest of this thesis to discuss the controversy over the plethora of definitions and interpretations as there has been significant coverage of this topic already (Shriberg, Reid and Petocz, Wright). It is instead understood that there are unique local interpretations of

the concept that incorporate overriding principles of justice and lengthy exploration of the consequences of decisions in relation to the environment, and the social and economic well-being of people.

One of the basic concepts for a course on sustainability is establishing an inter- or cross-disciplinary foundation for the presentation of material. It is important to establish the working definition of these two terms. Cross-disciplinary can be classified as multi-disciplinary or inter-disciplinary, but in both cases it means working across multiple disciplines. Inter-disciplinary is more specific in that it is a method by which "diverse theories and approaches are developed into a singular framework for inquiry." (Carey and Smith) In the context of this thesis, cross-disciplinary will be used in reference to the inclusion of all disciplines within the discussion, and inter-disciplinary will be used in reference to developing a means of finding a solution.

Within the literature, almost all reviews of specific university programs for curriculum revision, whether it be in relation to sustainability or not, have emphasized the strength that an interdisciplinary focus brings to student learning and teacher satisfaction (Clugston and Calder, Crofton, Wemmenhove and Groot). A growing number of universities are in fact bringing different disciplines together into 'centers' or 'institutes' so that direct student interaction and problem solving can occur amongst engineers, economists, and scientists (Deutsch). There are arguments for integrating sustainability across the curriculum, and this will be discussed in the last chapter of this thesis. However, there are also advocates of more generalized and introductory courses that introduce the concept of sustainability and systems theory to all disciplines (Vann et al., Clugston and Calder). This method establishes a common foundation of the basic tenets

and ideas with the students, and in the case of this course, an active, learning-based environment that cultivates a desire for lifelong learning. The strengths of this approach were further laid out in a review of Ball State University's development of an introductory course:

- Course designed with a specific focus on sustainability;
- Multiple aspects of sustainability integrated throughout the course;
- No need for cross-departmental coordination of section offerings
- Introduction is handled efficiently with one course rather than three;
- No prerequisites

(Van et al. 901)

Systems theory is a critical element behind the motivation and the crafting of a sustainability course. At Georgia Tech, it was in fact integrated into a required course for Civil/Environmental Engineering undergraduate students that also presented sustainable development issues as they relate to this field of engineering. Originally conceived as a mathematical expression for a general theory of unifying science by defining and solving problems of many different fields and disciplines, the theory has evolved into less rigid terms in some circles as discussed in Soft Systems Methodology In Action: A 30 Year Retrospective (Checkland). The split between 'hard' and 'soft' systems theory is basically how the 'system' is defined. The traditional 'hard' theorists saw the world similar to Herbert Simon's management science view of a number of interacting systems that can be engineered to meet specific objectives (Checkland). The 'soft' theorists, such as Checkland and his Soft Systems Methodolgy (SSM), argue that the world is complex and mysterious and that instead we must approach it with a systematic and organized process of learning and dealing with continually changing issues. This discussion of engineered systems meeting specific objectives with certain resources and constraints

certainly has some validity, but can a university be defined as such a system? Even more difficult would be the task of designing a curriculum or a unique course. Even for the most logic-based and rigid-routine problem-solving courses, there is a need for a deeper understanding that goes beyond rote-memorization. In a sense, the human brain and learning system might not be able to be engineered with maximum efficiency across the student body. There has to be a level of flexibility and adaptability to meet the student and instructor needs.

The most important piece of SSM is the balance and evolution of theory and practice within knowledge created as "the intention to allow the tentative ideas to inform the practice which then became the source of enriched ideas- and soon, round [*sic*] a learning cycle" (Checkland A4). A course will likely be more resilient and holistic that brings together both popular theories and direct applications or solutions that have been implemented in the real world as well as to pull from multiple disciplines to assure diversity of experience and ways of thinking. Multiple perspectives in class discussions and shared considerations on the topics of theory and how it takes form strengthens the way in which students are able to fully comprehend the subject.

> The process of learning by relating experience to ideas is always both rich and confusing. But as long as the interaction between the rhetoric and experienced 'reality' is the subject of conscious and continual reflection, there is a good chance of recognizing and pinning down the learning which has occurred.
>
> (Checkland A7)

Checkland also discusses how there is a difference in the validity of theories between the social sciences and the natural sciences due to subjective power of human intentions. This relates to discussions of sustainability as a balance of scientific observations combined with subjective reasoning and assertions of justice. It is also for

the most part constrained by a human-created system of economics, which often constrains the perspectives of some to market-focused concepts. This suggests a course that will change as world events, perceptions, and understandings change.

A combination of change strategies that focus both on provable and legitimate science as well as social pressure are key to sustainability strategies within the university curriculum. In an overview of organizational theory and change, Meyer asserts that an "empirical-rational" strategy occurs when people are provided proper and comprehensive knowledge about the interconnections of their decisions and the far-reaching consequences that they will act in a rational manner and accept necessary changes in lifestyle. Whereas a "normative re-educative" strategy requires a greater amount of participation from the stakeholders in the organization, in this case the university. The changes called for in this paper are more in line with this second change strategy as it is seen as an iterative process within an education institute, without a "purely technical fix" (Meyer 1978).

3.3. Changes within Education at the University

Avoiding a mindset of purely technological solutions and perspectives has been at the heart of many discussions of change in the engineering curriculum (American Society of Civil Engineers, Galloway, Ollis et al). Documentation of different changes in both the teaching style and where focus was placed within a discipline exists within the literature. Change efforts have been spurred by government agencies, industry, and accreditation organizations (Lucena, McCuen and Wallace). In fact, the standard for professional engineers, UK-Spec, in England has a requirement that all its engineers focus their efforts on projects in a sustainable manner (Fisk and Ahearn). As society

grows more aware of the diversity and complexity of globalization, mounting technological challenges due to resource constraints and environmental degradation, we need engineers that are better able to innovate and rethink traditional processes. It is critical to learn from past difficulties due to organizational inertia associated with changes within both universities and accreditation groups, as well as the diverse interests of government and industry that influence the subject emphasis in engineering education. Furthermore, if society does not better understand and acknowledge the interrelations that exist within a global society (i.e. current banking/credit/market collapses and terrorist breeding grounds in places where people feel marginalized and neglected), then these problems will continue to impact societal stability.

In response to the introduction of ethics and humanities within engineering education and the lack of truly connecting it to the actual profession, McCuen and Wallace wrote: "with respect to society, education should develop an awareness of social problems, of the origins of culture, and of the institutions in which we function. Finally, a profession functions within society and is subject to the constraints of that society" (p. 111). Additionally, the regulations that are required as part of such acts as the Americans with Disabilities Act (ADA) and from agencies such as the Environmental Protection Agency (EPA) are often seen as ceilings or as something to avoid in engineering. Granted, these regulations often do result in more cumbersome and lengthy processes, but they do ultimately serve to protect the safety and rights of those who might not have a voice. It is critical then to develop a real understanding of what these regulations do and why they have been put into law, as well as the real consequences of not following them because "someone who lacks an understanding of culture can view such unprofessional

conduct only from a behavior-punishment perspective; that is, it is wrong only when one gets caught and the risk of punishment determines whether or not the unacceptable action should be performed" (McCuen and Wallace 113).

Just as there have been efforts aimed at expanding the awareness of engineers beyond a traditional technical focus, there are several schools as well as authors that have instituted or begun the argument for including sustainability into the coursework or curriculum of undergraduate and graduate students, especially those in the field of engineering. The first of these efforts began after the signing of the Talloires Declaration in 1990. Following the Brundtland Report's call for sustainable development for members of the United Nations (U.N.), the signatories of this Declaration were university administrators who pledged to lead and support efforts on their campus and others towards the goal of sustainability within higher education (Wright 2002). Additionally, there have been multiple calls to action within the education systems of nations from conferences and summits of the U.N., such as Agenda 21 from the Rio de Janieiro conference, and the United Nations Educational, Scientific, and Cultural Organization (UNESCO), such as the Thessaloniki Declaration (Azapagic et al., Haigh, Reid and Petocz, Wright). The Thessaloniki Declaration in particular had a message of urgency for leaders by noting that efforts up till that point had had very little success at making Education for Sustainable Development (ESD) into a worldwide movement (Azapagic et al.). The governments of Australia and the United Kingdom have taken notable efforts in implementing ESD initiatives into the national school systems from elementary levels through higher education (Reid and Petocz, Department). In an effort to boost environmental education, the United States House of Representatives passed a bill in

September, 2008 that "would improve existing environmental education programs by providing states with resources to train teachers, develop research based programs and create environmental literacy plans to ensure that students understand the role of the environment as a natural resource" (U.S. House)

Government and upper administrative leadership and support certainly helps sustainability efforts on campus, but there are countless examples of more bottom-up approaches led by faculty, students, and individual departments. Georgia Tech's Civil Engineering curriculum went through major changes in the 1990s to bring the students' preparation in line with predicted professional demands and a more well-rounded understanding of the current unique issues and how they relate to civil engineers. Emphasis was placed on stakeholder engagement throughout the process in both the development and feedback processes with the new and redesigned courses. This was crucial to the initiative's success as "people must actively participate in the change process to become committed to its objectives" (Meyer 302).

The calls for change in pedagogy at the university are starting to be realized in different ways. A New York Times article highlighted the efforts at the Massachusetts Institute of Technology to recreate the learning experience for its Introductory Physics course. Shifting to smaller class sizes with more practical and hands-on approaches to conveying elementary principles, student enrollment and success has risen dramatically from the previous levels of the traditional format- a lecture hall with 300 students with dismal attendance rates and high failure rates. This more engaged interaction between professor and student is mostly aimed at the required sciences in which some students

have the most trouble gaining interest, personal connection, and motivation, and its advocates have noted its experimentation at other universities (Rimer 2009).

3.4. Implications of University Efforts

Universities that fully understand the significance of their place in molding their students as future leaders and decision-makers pursue the path of incorporating sustainability fully into both the operations of the campus as well as into the curriculum. There is consensus within the literature that the efforts must be aimed at vision, academics, operations, service, and research (Lang 1999, Shriberg). There have been efforts to report on these successes as well as challenges from both outside (Lang 1999, Wright 2002, Crofton 2000) and inside perspectives (Fisk 2005, Azapagic 2004, Vann 2006, Bremer 2006). Some of the benefits that could be expected from unilateral commitments to sustainability include improved reputation, student satisfaction, hire-ability, financial savings, reduced environmental impacts, and surrounding community enhancement.

Universities and faculty face many challenges in their quest to make more valuable learning experiences for the students on the topic of sustainability. There is acknowledgement that the rigid structure of specialized disciplines has an inertial effect on any movement towards widespread dissemination of sustainability through the curriculum (Haigh, Lucena, M'Gonigle, Orr). In order to create the necessary environment for change, leaders must identify institutional mechanisms that cause conformity and restrict innovation, or as David Orr puts it "remove impediments to learning that are often little more than habit, ego, and turf defense" (Orr 80).

CHAPTER 4

CONTENT AND TOPIC REASONING

4.1. Choice of and Support for Course Content

There are multiple ways of approaching the subject of sustainability. In one way, it is similar to many beliefs in that depending on context and location, there are many different interpretations and expectations of what the term means and the weight people place in it. One could postulate though that there are undeniable qualities and concerns with respect to sustainability when put through the lens of science and risk management: resource depletion, uncertainty within the complexity of life, and a basic moral call to action. There are of course counters to each of these concerns that could be raised to promote action towards sustainability. A similar parallel can be seen running through the past and current discussions of human-influenced climate change and the accompanying call for aggressive action from much of the scientific community. Although there is overwhelming evidence for man's influence on the climate and analogous support for curbing other forms of pollution associated with greenhouse gas emissions, multiple segments of society refuse to acknowledge responsibility and the need for concerted actions.

As mentioned in Chapter 1, the introductory prototype course on sustainability will have three main subject areas: water, energy, and food. Definitions and the history of sustainability will be discussed at the beginning of the course, and a discussion of progress indicators will wrap up the course. The three chief elements in the body of the course are ubiquitous throughout human society for existence. Other topics and concerns were considered, but they can all be drawn back and related to these central elements.

The choice of these elements as a base of discussion for sustainability and systems theory was strengthened by a look at the hierarchy of needs as laid out by Abraham Maslow (Maslow). The feedback from a questionnaire of Georgia Tech faculty and staff was also considered in the development of course direction and materials. Additionally, a review of other syllabi for introductory courses was integral to the course content.

As discussed in the literature review, there is a plethora of definitions of sustainability. Therefore the unraveling of this tangle of perspectives will serve as the point of departure for this course. This will allow students to understand their connection to the term and concept or to begin the development of their own personal understanding, all of which will take shape over the course of the semester.

Food, water, shelter, and energy are all essential elements of Man's ability to survive and thrive in the world. They are representative of the "Physiological Needs," which make up the foundation of Maslow's Hierarchy of Needs Pyramid (Maslow). Without these fundamental needs met, humans cannot seek to engage in more gregarious thought processes and actions, because they are so focused on the deficiencies of unmet needs. This requirement is referred to as pre-potency or "the appearance of one need usually rests on the prior satisfaction of another, pre-potent need" (Maslow 3). The developed world more often than not loses all recognition of this most basic struggle, but for many in the developing world, meeting these basic needs is the most important task of their day-to-day lives.

Another reason for the choice of these topics is how they each are so linked to both technical and behavioral fixes, and in many cases are concerns that are furthest from the everyday thoughts of typical students. No thought is given to the process of bringing

the hamburger to the school cafeteria for student consumption, or the consequences of leaving the light on in a dorm room all day, or how much material and energy is wasted in watching a faucet slowly drip in a laboratory over the course of a semester.

It is within this context that the general applications course on sustainability is set. The course will challenge students to see beyond meeting these basic needs and instead to see how they come into our lives and provide us with the conveniences of modern society. This leads to a discussion of the problems that arise from establishing the systems that develop and maintain this way of providing these simple ends through complex and interacting means.

4.2. Summary of Findings from Georgia Tech Faculty and Staff Survey

Although the content and learning objectives of the course were already defined, the survey of the faculty, staff, and researchers of Georgia Tech and Georgia Tech Research Institute provided critical outreach and input to the formulation of course ideas. It is central to the concept of sustainability that any policy or program has consensus or at least serious input from the community. This is to ensure that the community can feel that their concerns are being addressed and that appropriate measures are taken that address local needs instead of some standardized approach developed someplace else. The concepts, themes, and subjects that were consistent throughout the questionnaire are very much parallel with those that were already being considered for the course. The responses do not necessarily represent the full breadth of opinions at the University as the survey was targeted at people involved with the Brook Byers Institute for Sustainable Systems and other sustainability efforts on campus. However, feedback was gained from

a variety of different disciplines including management, engineering, public policy, and earth and atmospheric sciences. A sample questionnaire can be found in Appendix B.

The survey, which focused on this introductory course on sustainability, included opinion questions on what content should be covered, quantitative allocation of class time, importance of class projects and cross-disciplinary instruction, specific topics to be covered, and barriers or challenges to such a course at Georgia Tech. A brief summary of the responses will provide support for the topics and course materials.

The 'key concepts' question brought out many of the answers, which would be expected at a technical university such as Georgia Tech. Population, energy, and resource use and efficiency were the most common elements throughout the responses. Mirroring the arguments for a more holistic learning environment within this course, there were calls for 'long-term systems thinking', fleshing out the 'underlying physical linkages', and 'interconnectedness'. Furthermore, there was recognition of the need to have a balanced focus on both technological and behavioral solutions within the domains of policy, business, and industry. Another important shared concept was the importance of scale in solutions: the understanding of the relation between local and global concerns, as well as the differences and need for shared resources and practices between developing and developed countries. Many respondents brought up the need for the discussion of innovators and actual success stories in business and design. There were some specific replies that were aimed at getting ethics and economics brought into policy discussion, as well as how scientific modeling and the crafting of public strategies interlink.

With regard to time allocation, six choices were given with a request that the respondent assign a percentage to each. In addition two respondents suggested

consideration of the following two aspects separately: other engineering fundamentals and analysis (not just tools), and the role of behavior. After averaging the time percentages for each provided aspect, the following rankings were given to the class materials: practical application, role of technology, relevant analysis tools, relevant theories, broad societal context, and historical development of sustainability. Table 1 below shows the assigned percentages of the respondents and the bottom row is the average for each aspect. As one could predict given the technical focus at Georgia Tech, there is heavy emphasis on hard science application and analysis in response to sustainable development. These topics certainly have their place in providing students actual examples of strategies, programs, and technologies that are being implemented and used in the real world. In more discipline-specific courses, these topics would be even more appropriate as a deeper connection with a particular technology would likely exist within a specific field of study, such as innovative design in wind turbines with mechanical engineers.

Table 1. Survey Respondents' Percentages for Time Allocation in Curriculum

Field	Relevant Theories	Historical Development of Sustainability	Practical Applications	Relevant Analysis Tools	Role of Technology	Broad Societal Context	Other Engineering Fundamentals and analysis (not just tools)	Role of Behavior
CEE	20	10	15	20	15	20	0	0
GTRI	5	5	25	25	20	20	0	0
Admin	15	30	10	5	20	20	0	0
Admin	25	5	30	5	20	15	0	0
CEE	5	5	40	25	10	15	0	0
CEE	10	10	20	10	10	10	20	0
CP	10	10	10	10	25	10	0	25
ISYE	5	5	40	20	30	10	0	0
MGT	20	5	25	30	10	10	0	0
EAS	15	15	50	10	5	5	0	0
CEE	20	10	15	15	20	20	0	0
EAS	10	15	20	20	25	10	0	0
EAS	15	50	25	15	10	20	0	0
PuBP	20	10	30	10	15	15	0	0
CEE	20	10	20	20	15	5	0	0
average	14.33	10.67	25.00	16.00	16.67	14.33	1.33	1.67

A Lickert item format was used to gauge respondents' attitudes about class projects and co-teaching arrangements. Respondents were able to attribute a level of importance to these two questions, and several left additional remarks. Generally there was a more positive response about a project but with some noted indifference. This shows support for comprehensive learning and the incorporation of learning into projects. There were several supportive remarks for cross-disciplinary instruction, but more strongly worded remarks were against the idea. Table 2 and Table 3 below show the tally of the responses from the survey but don't fully illustrate the respondents' opinion as some of the written responses did not have accompanied marks on the Lickert item. However, it seems that bringing in guest lecturers and professors for specific discussion is supported by those on both sides of the issue.

Table 2. Responses From Survey for Student Projects

How important is a student project in a class such as this?				
Not Important At All	**Not Important**	**Neutral**	**Important**	**Very Important**
0	**0**	**5**	**3**	**6**

Table 3. Responses From Survey for Cross-disciplinary Co-instruction

How important is it to have such a course be co-taught by instructors from different programs?				
Not Important At All	**Not Important**	**Neutral**	**Important**	**Very Important**
0	**2**	**6**	**2**	**2**

The 'specific topics' section had quite a few repeated responses from the earlier 'key concepts' question and in general had very similar responses. In reality, this question does provide a challenge to the respondent in such an informal and short survey

as was pointed out by one of the respondents. However, there were some very strong responses: establishing a personal connection and public policy understanding of the concept, looking at global change issues beyond the oft-examined climate change, confronting viewpoints that believe sustainability is anti-growth with the challenge of innovation and development of new business models and technology. Paralleling the time allocation question, there was emphasis placed on actual practical examples, analysis tools such as life cycle analysis, and the understanding of sustainability's relation to the fundamentals of engineering.

Responses for the question of 'barriers or challenges' were polar in nature. Some respondents saw Georgia Tech as primed for the development and teaching of such a course. These replies pointed to current interdisciplinary efforts within Tech and with neighboring universities, and simply a sufficient amount of resources to make the course happen. Others had a harsher perspective on the school's support and encouragement of inter- or cross-disciplinary efforts. There were several mentions of finding a professor with the time and resources being the chief inhibitor to developing a new course such as this. Additionally, some pointed out institutional roadblocks with respect to class credit, 'team teaching', and committee approval of electives. Several responses pointed to more specific issues of attracting students critically interested and engaged in the material, having too much focus on technology, and not having a model for the crafting of a substantive course. Finally a concern about student involvement in class and hesitation for in-class responses would be addressed by the empowerment of students through the interactive and significant learning techniques which will be discussed in Chapter 5.

4.3. Review of Syllabi and Guidelines for Sustainability Courses

As discussed in the literature review, there are a growing number of universities that have courses on sustainability and organizations that have guidelines on what elements or topics should be included within curricula to promote sustainability in education. Several syllabi and frameworks were reviewed to see what relations and parallels could be drawn between the ideas for this course and other courses currently offered. However, it must be pointed out that there was no direct communication with the instructors of these courses about learning methods and projects that were used within the course. The means by which the content outlined in these syllabi is transferred to the students is critical to the students learning potential within the classroom and into their future development.

Through an email correspondence, Lindy Biggs, director of the Office for Sustainability at Auburn University, explained that Auburn is in the beginning stages of offering a minor in sustainability (Biggs). An Introduction to Sustainability course is the first requirement of this minor, and she was able to pass on a syllabus for it. The layout of the course has many similarities with the course that will be laid out in Chapter 5. There are several modules at the beginning of the semester devoted to history, definitions, global context, and discussions of changes to production and business models. Significant attention seems to be paid to climate change as it is one of the most publicized and galvanizing issues of the day. The bulk of the course is devoted to a problem/solution format on the issues of 'food', 'water', 'energy', 'transportation', 'consumption', and 'shelter.' There are closing discussions on sustainable business practices supported by a case study of the Interface model, a company widely saluted as

being a leader in sustainable business practices. There are several exams as well as a class project that provide the instructor with the means to assess the students' performance and level of understanding of the material.

Harvard University Office for Sustainability offers two different courses through the Harvard Extension School. Both pursue a specific focus rather than just an introductory base of knowledge (Harvard website). However, one of the courses, The Challenge of Changing Our Institutions (Change Management for Greening Organizations), does speak to the goal of developing empowered students who will think critically of the different scalar issues today. It concentrates specifically on opportunities and the ability to enact change towards environmental sustainability within students' academic, professional, and personal lives. As the course title indicates, there is emphasis on the operations and policies within organizations and what the effects of the decisions of these organizations can have on both a local and global level. Therefore, it can be seen that there is certainly validity given to the argument that behavior and psychology are critical elements to the discussion of sustainability within an introductory course. The other major issues, more technical in nature, discussed during the course are climate change, sustainable business practices, and the multi-faceted impacts of building decisions.

Ball State University's Land Design Institute and international contributors from the Department of Architecture at the Instituto Tecnologico y de Estudios Superiores in Monterey, Mexico developed a sample syllabus for an introductory course on sustainability (Vann et al). There are opening discussions on the linkages of sustainability to the areas of economics, environment, and society, but differing from the

course at Auburn there is an additional discussion on the characteristics and defining of systems. There is certainly an overarching emphasis on the environment and its connections to human society and consumption. A number of problem areas from population concerns to resource depletion are discussed, which definitely tends to create a sense that there is a bit of Malthusian worldview being expressed. Later in the course, there is class time devoted to temporal and scalar awareness of these issues in relation to society. Economics and innovation within technology and business are brought forward at the end of the semester, which lead to a final discussion of possible solutions.

The organization Second Nature advocates for sustainability within higher education. They have produced a framework for the themes that they feel should be incorporated into a general curriculum, cognizant of the fact that there will be different types of courses and a "unique teaching process" from each instructor (Second Nature). They are listed with bulleted examples that stretch out the key points of the following themes: scale, human connections to the physical and natural world, ethics and values, how natural systems function, technological and economic relationships to sustainability, motivating environmentally sustainable behavior, and pedagogical strategies for integrating sustainability. Balance is promoted across these themes through the examination of scale, human systems, natural systems, and their interactions. It should also be noted that the technical connection to sustainability is balanced with investigations of behavior, personal connection, and the influence of government and society. Finally, there is credence given to the importance of teaching strategies so that students can actually take something away from these lessons and establish a personal connection and lifelong interest.

Throughout this chapter, it was illustrated that there are many different perspectives on what and how to teach the subject of sustainability. However, there are similarities that emerge from these varied sources. In terms of content, there is certainly agreement on discussion of population and resource consumption, associated with these topics are those of scale and awareness of global and local issues. Additionally technology and behavior must both be examined for solutions to these issues. Since, humans are dependent on the environment as a life support system, it receives a greater amount of attention, but the economic and social implications of human existence must also be examined within these courses. A subtle importance is placed on empowering students to take a personal interest in these matters and what effects they can have through their own studies, personal and professional lives. The issues of equality, justice, and environmental and social health will be at the forefront of concerns for businesses and governments over the next several decades. The complexity and interrelationships of current and future problems require a higher level of critical thinking and use of the uniquely human qualities of compassion and understanding.

In a course on sustainability, it is hoped that students will find that there are many potential solutions currently being used in the areas of technology and policy. Surprisingly, there is relatively limited implementation despite the urgency expressed by scientists about environmental degradation and seen in the headlines through economic hardships, social upheaval and suffering. There is no clear reasoning for why this is, whether it be lack of political will, financial concerns, misinformation, or ignorance. It is beyond the scope of this thesis and the author's base of knowledge to understand the social implications for the level of apathy and lack of formidable action. However, it is

possible that through seeing practical examples of success and being challenged in the learning process to develop themselves and a lifelong interest in learning that students could be catalyzed by such a course.

CHAPTER 5

COURSE DEVELOPMENT

5.1. Overview of Course Design Methodology

The development of the course was going to be loosely created as a collection of topical discussions and writing assignments configured around a 15-week schedule with room for examinations to assess student performance. However, Lydia Soleil, Assistant Director of TA Programs and Graduate Student Development of the Center for the Enhancement of Teaching and Learning, suggested L. Dee Fink's 2003 work, Creating Significant Learning Experiences, as a guide to curriculum development. A brief scan of this book provided enough evidence that its central arguments were both consistent with and even enhanced the views and motivations for a more holistic learning style course. It is important to recognize that the content, learning goals and objectives will be established along these guidelines, but that an instructor's understanding of these principles and methodologies is critical to the students' success.

Fink based his guide on both recent developments within curriculum design as well as instructional design used in corporate training settings. Fink's book begins with coverage of both the current setting and challenges for education and learning as well as the motivation for change. He highlights several different studies that point out the chief problems with student performance as well as challenges that students identify: deficits in basic contextual understanding and general knowledge, rote memorization of content rather than critical understanding, lack of knowledge retention over time, focus on grades rather than learning, absence of teacher-student interaction, and an understanding of the connection among courses (Fink).

These factors build the argument for the remainder of the book, which focuses on the twelve step process of course design. These steps are broken down into three phases as illustrated in Table 4. The rest of this chapter will follow these outlined steps using support and guidance from both Fink's book, *Creating Significant Learning Experiences*, and his web-available document, "Self-Directed Guide to Designing Courses for Significant Learning." The book provides much insight on the context of course design and the reasoning and support for each step and sub-step. However, the web-available guide offers much more direct exercises and questions to consider in developing the course and was used more directly in the course development. Several of the steps in the initial and intermediate phases garner much more emphasis than others in the writing of this thesis, but each step will receive some amount of coverage.

Table 4. Interpretation of Dee Fink's Twelve Steps of Course Design

Design Phase	Step	Description
Initial	**1. Situational Factors**	**Analyze the existing situation for learning/teaching characteristics and context**
	2. Learning Goals	**Intentions for what students will gain from the course through a taxonomy of significant learning**
	3. Feedback and Assessment	**Educative assessment which provides basis for course grades but also enhances student learning**
	4. Teaching/Learning Activities	**Tools and methods for incorporating active learning or experiential and reflective learning**
	5. Integration	**Assuring that the work for the first four steps coalesces**
Intermediate	**6. Course Structure**	**Breaking up course topics and arranging them in a logical sequence**
	7. Instructional Strategy	**Arranging learning activities that build upon past lessons and connect to future lessons**
	8. Creating the Overall Scheme of the Learning Activities	**Pull together Steps 6 & 7 into a comprehensive plan of action for the course**
Final	**9. How Are You Going to Grade?**	**Determine the best approach for having the students work represented grade-wise**
	10. What Could Go Wrong?	**Give thought to constraints of students completing the work and fully engaging the material**
	11. Let Students Know What You Are Planning	**Construct the syllabus**
	12. How Will You Know How the Course Is Going? How It Went?	**What approaches will be used for gaining feedback from the students on the course, resources, and teaching style**

5.2. Situational Factors

Although this course is strictly hypothetical, the setting and circumstances of establishing the course at Georgia Tech were considered in laying out the situational factors. Fink lists a number of different factors and questions to consider in gaining awareness of what challenges and variables will be met in the implementation and execution of the course. Below are the summaries, which are in response to Fink's outline (Fink 69).

- *Specific context of teaching and learning situation:* Open to sophomores, juniors, and seniors in a 15 week format, the class would meet twice a week for 1.5 hours with approximately 20 students. Due to the advanced learning styles used within this course, it would be helpful to have some level of assurance that well-qualified, motivated, and interested students were being allowed into the class. However, the real challenge to a course such as this with such a broad range of course materials is what department or school it would be hosted by. In a school such as Georgia Tech, a course listing in the School of Engineering would provide the least amount of resistance for the greatest number of students. If it could then be cross-listed with other schools around campus, then an even greater number of students would have access without having to go to through a number of different registration requirements.
- *Expectations of external group:* There are no standards set by the university or professional societies on the topic of sustainability, however, it does align with the principles of the ethics requirement and the goals of sustainability that the

University puts forth, and groups like ASCE and ABET are looking for it in the curriculum (Body, ABET).

- *Nature of the subject:* This subject is convergent in the sense of seeing that there is a necessary change or paradigm shift for humans to sustain their existence on the planet, however, it is highly divergent in what pathways will lead us there both individually and as a society. There is emphasis on local solutions, but there is a need for coming together as a global society. This subject area is certainly in a rapidly changing context.
- *Characteristics of the learners:* Due to the size of the class and the specifics of the subject matter, the students would likely be of a high caliber and highly motivated to learn and expand upon any knowledge that they were previously exposed to on sustainability and systems theory. Due to the rigidity of Tech's engineering curriculum, many of the students will be very comfortable with content-based learning and will have to show some flexibility in having a much more open format style of class.
- *Characteristics of the teacher:* This is a brand new class and would thus be a learning experience for the teacher as well. The instructor would definitely depend upon other faculty and professionals brought in to highlight and provide deeper insight into certain topics over the course of the semester. In the same way that the students are adept at content-based learning and assessment, most teachers are locked into that same way of teaching and would have to adjust to this learning-based course. In addition to the difficulty of finding a proper school or department on campus to list this course in, there would also be difficulty in

finding an instructor or set of instructors that could commit to such an undertaking as this course. Due to the course content, and time and resources requirements, it would likely need to be a tenured faculty member. As stated in the survey of Georgia Tech faculty, there can be difficulty for junior faculty members in putting time into courses outside of their areas of expertise or outside of the core courses for their departments.

- *Special pedagogical challenge:* In reviewing the surveys from Georgia Tech faculty and staff, the biggest challenge is the magnitude of difference from typical courses at Georgia Tech both in the style of teaching and learning, and with various institutional barriers, such as time and resource constraints, class credit, 'team teaching', and committee approval of electives.

5.3. Formulate Significant Learning Goals

In establishing significant learning goals, there has to be consideration of how to develop the course in a way that reaches beyond purely content-based objectives. One aspect of this is how to get students fully engaged with the subject and the learning process. Truly, it should be a priority to have students walking away from the course with an understanding that their learning on the subject of sustainability and systems theory does not, in fact, end with the semester. There are indeed certain facts and figures that will be part of the course's central goals, but there will be more emphasis on developing analytical, empathetic, and integrative thought processes within the students.

Fink classifies these alternative means of instruction as significant learning. His taxonomy of significant learning has six interactive kinds of learning that can be broken down as follows: *foundational knowledge, application, integration, human dimensions,*

caring, and learning how to learn. It is not essential to use all of these kinds of learning within one course, but due to their interactivity including as many as possible strengthens the course, much like diversity strengthens ecosystems in nature. Goals will be laid out for each of these types of learning, but in a simple summary the introductory sustainability course's goal is:

> Students that become more aware of the subject matter and of complex, global issues, but also and more importantly eager to personally and professionally expand their knowledge and exert their influence in all facets of their life.

5.3.1. Foundational knowledge

Courses across all disciplines have traditionally placed a high level of emphasis on this type of learning. In many instances, it is well understood that a certain amount of memorization and simple acceptance of what is read or lectured about is justified. Historical dates, geographical locations, biological taxonomies, and simple engineering formulas are all examples of this. However, this is not to say that even these basic elements of understanding can not have deeper lessons associated with them and that there is not an element of critical thinking needed to fully comprehend them.

There are certain basic facts and ways of understanding the world that support the base of knowledge upon which sustainability sits. In consideration of thermodynamics, the Earth could be seen as a closed system other than the very necessary input of the Sun. Therefore it is energetically impossible to extract from the Earth and produce waste faster than the Earth can reprocess it for a sustained period of time. Within ecology, there is the concept of carrying capacity or that there is inherently a limit to the population of a species that an ecosystem can support, which if surpassed leads to the collapse of that

population. This brings forth the question that despite all the manipulation which humans have over the environment and the Earth, how many people can the planet really support. Then there is the concept of efficiency, which takes on several different definitions. Once again looking at principles of thermodynamics, it can be applied to how raw materials and resources are converted to usable products and energy. However, Michael Pollan writes about the comparison of "large-scale industrial" efficiency and "natural systems" efficiency in relation to agriculture (Pollan 214). The former makes use of vast networks of standardized procedures and simplified processes, which don't account for the externalities of the inputs and outputs such as pollution and soil degradation. The latter relies on complexity and symbiotic relationships; whereas, the concept of waste doesn't exist because it is, instead, a usable resource for another organism or process. Another concept that will be core to the course is biomimicry or "innovation inspired by nature," which is a philosophy that seeks to emulate these natural efficiencies that Pollan describes in the design and manufacture of products and services (Benyus 2).

5.3.2. Application

Problem-solving, evaluation, and analysis are all commonly seen through engineering, mathematics, and science curricula. However, students typically deal with them in a controlled context, or in a sense they are searching for answers that exist in a solutions manual. Counter to this, matters of policy and human behavior exist in a dimension where there are no 'correct' answers, but instead students must apply critical and creative thinking skills to assess the question and develop an equitable solution. The intention of this course is to provide students with an understanding of both of these skills and the knowledge and awareness that many of the complex issues today require a

marriage of technological and behavioral fixes. Additionally, a chief focus throughout the course will be enabling students to achieve a higher level of performance within their communication, both written and oral. A variety of writing assignments, journaling, and class discussions will place a demand on students to step outside of their areas of expertise and yet still be able to communicate their ideas and comprehension effectively.

5.3.3. Integration

Integration is essentially the basis of this entire course or rather having the students gain an understanding about all the interrelations in life and applying this integrative or holistic understanding to their personal, academic, and professional lives. There will certainly be efforts made to have clear connections among different topics within the course and to leave room for in and out of class discussion of these matters. Writing assignments and projects will be developed in way that students can draw out the connections from the concepts introduced in class and readings.

5.3.4. Human Dimension

Fink asserts that it is necessary for students to discover the human dimension of subject matter, by this he means to understand one's own place in relation to the material as well as other people's relation to the material and to oneself (Fink). Individuals at the college age have likely come to an understanding of themselves in terms of personal traits and preferences, but many still have much to learn about the power of their decisions (economically, politically, and socially). The power of consumers and voting citizens has far-reaching consequences that go beyond how much of one's income is spent on groceries or if there is an additional one cent sales tax on gasoline in their county. It is

indeed a core goal to empower students to have a fuller perspective of the outcomes of their behavioral choices.

Beyond this, it is equally important to see that some of these unforeseen consequences can have either very beneficial or harmful side-effects on other people in the world. A possible outcome for students in this course is to have a greater appreciation for fully informing themselves when they're deciding what toothpaste to buy, what choice they make in the voting booth, and what causes they choose to support. Additionally, students must be aware that the best solutions to our problems are not always going to arise from esteemed, educated sources, and that one must be able to reach out to a variety of communities to both seek and share proper answers.

5.3.5. Caring

The type of caring here is not just an extension of altruism for the arguments laid out in the human dimension section above. It is more of a response to the level of apathy and disinterest in students today. The course materials were chosen in a way that hopefully will spark the interest and excitement of the students. Opportunities for personal reflection and multiple avenues of class discussion could open up the minds of the students to different world-views and perspectives. Having subject materials that relate so closely to one's own life also could produce the benefit of extending the learning and quest for knowledge beyond the classroom.

5.3.6. Learning how to learn

Fink writes of three different levels of emphasis to consider when thinking of designing a course that challenges students to learn how to learn. Although attempts to

teach students about proper study, writing, and time-management skills are critical, the focus of learning is more expansive as it is broken down below.

Better student

A cross-disciplinary course would provide more of an open and dialectic format to class discussion and assignments. Integrating both convergent and logical formulations as well as free thought and argumentative research-based writing would bring a healthy dose of flavor to all types of students. Students within the engineering discipline would have the ability to stretch their minds and learning ability through creative and divergent thought processes. Students within non-engineering fields would be introduced to some scientific and technical concepts, which have bearing on their everyday lives and decisions. The challenges for both types of students would strengthen their ability to be competitive within their time in academia as well as when they move into their careers. It would also help students to communicate with other proficient students and instructors in disciplines other than their own.

Better grasp of material and engage in inquiry to construct knowledge

The intent of this course is to develop or further the ability of the student to see a problem from multiple perspectives and with an open-mind. There will be many facts laid out that are critical to the understanding of the different topics within the course, but the more important lesson is the awareness that these different statistics and numbers are constantly changing and as such there is not necessarily an exact solution. Rather these issues that often have both global and local implications in either their source or implementation phase have to be viewed as having resolutions. They are similar in nature to social policy and planning problems that Rittel and Webber in their 1973 paper,

Dilemmas in a General Theory of Planning, termed "wicked problems" in that there is no single answer, and thus these resolutions are attempts at bringing us closer to a solution. The central tenets for the definition of "wicked problems" are as follows:

1. There is no definitive-formulation of a wicked problem
2. Wicked problems have no stopping rule
3. Solutions to wicked problems are not true-or-false, but good-or-bad
4. There is no immediate and no ultimate test of a solution to a wicked problem
5. Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly
6. Wicked problems do not have enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that might be incorporated into the plan
7. Every wicked problem is essentially unique
8. Every wicked problem can be considered to be a symptom of another problem
9. The existence of discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution
10. The planner has no right to be wrong

(Rittel and Webber 161-166)

This last point is a rather sharp and subjective criterion, but as it stands with issues where not only human but the entire planet's well being is at stake, it is crucial for decision-makers at all levels to see and understand the diverse consequences of their actions.

Self-directed lifelong learner and how to go about it

This directive parallels the central question of the thesis: how to better prepare students to think holistically about the numerous interrelationships within their own personal, social, and work lives. Seeing that there is so much more complexity to life and all that surrounds us than is typically presented, students should feel encouraged and empowered to dive more deeply into their own learning of how things operate and what connections exist between their decisions and situations in the world. The avenues for discovering these connections and access to them should be more apparent to the students after navigating their way through the course. Several of the suggestions that Fink pulls

from the work of Phil Candy on self-directed learning apply directly to this course's intentions: "increasing questioning by the learners, develop their critical thinking capabilities, enhance their comprehensive monitoring (of their own learning)" (Fink 54).

5.4. Feedback and Assessment Procedures

In this section, there will be a distinction from the typical method of assessing students' progress with quizzes, midterms, and finals that focus on the content of the course material. Fink refers to this type of assessment as "audit-ive," and he makes the argument for an "educative" method that pushes students to learn from their assessments and gain something additionally from them rather than simply having a justified grade (Fink 82). The alternatives that are part of this educative assessment process are "forward-looking" assignments, clear and express "criteria and standards," self-evaluations, and instructor feedback that is comprehensible, direct, and recurrent.

There will be some amount of quantitative material in different assignments, but the majority of work will be in writing as well as discussion and presentation. The most significant piece of the assessment process for both the instructor and the student will be a journal kept throughout the semester. Students will be required to stay up to date with the journaling for reading assignments, in and out of class discussions, and reflecting on the significance of the class to their lives.

The class will have assignments that place a significant amount of responsibility on the students in both respect to time and themselves. The assorted reading materials, journal entries, and other writing assignments will challenge them to manage their time between this and other courses. Additionally, the students' journals will only receive a grade at the end of the semester but will be used as a catalyst for class discussions, and

thus the student will need to keep themselves from procrastinating and throwing together the journal at the end of the semester. However, the reading materials and assignments will be generated in a way that should keep the interest of the students peaked and intent on achieving a high level of performance in the course.

The issues pertaining to sustainable development, as mentioned before, have no clear answers. Therefore, students will be instructed to perform their writing assignments in a similar fashion to a familiar type of writing: technical lab reports. This is not to say that there will be sections of observations, methodology, and such, but the students will approach the assignment without a right or wrong answer to work toward. Instead, they must show through their writing that they can stand behind their argument and that they have references from solid resources to back up the claims.

The freedom within the direction of these assignments will be countered in some instances by the constraints of real-world situations. These assignments and guided journal entries will push students to consider how situations in future professions and their own personal lives would be different with consideration of sustainable choices. Class discussions will allow for students to gain feedback and synthesize ideas with other students about these challenges.

5.5. Teaching/Learning Activities

Fink focuses on three modes of learning in his writing on active learning. Active learning seeks to engage students in the learning process rather than a more passive approach of lectures and reading assignments. The modes of learning that should be integrated in this active form of learning are information and ideas, experience, and reflective dialogue (Fink). Information and ideas refers to the more traditional and

passive method of knowledge transfer through lectures and reading assignments. The incorporation of a term journal that feeds into class discussions and dialogue enhances this form of passive learning with a more active method of reflective dialogue. This method of journaling is intended to keep students interested and involved in the learning process. It will challenge them to reflect on how their views and interpretations of the subject matter change over the course of the semester and provide incentive to come to class with their thoughts on the page.

There will be experiential opportunities for students throughout the semester. Service opportunities within the community will be encouraged and will serve as a means of reflecting on real world experience in relation to lessons from class. Each module will present students with different ways of gaining a different perspective of how they live their day-to-day lives. Modeling exercises and basic methods of calculation will be used to put personal consumption into more understandable terms. There will also be chances for students to alter daily personal behaviors to experience empathy with how other people in the world live and what alternatives exist to the status quo. These experiences could lead to additional journal entries and help students develop a means of transferring this knowledge and experience to others within their circle of influence.

The final project will provide the opportunity for students to integrate all the concepts learned over the course of the semester into one cohesive undertaking. The development of sustainability indicators for the university campus challenges students to consider all the different facets of sustainability, what relation they have to the global society, and how they can be transferred to the context of a local, community level and

put into measurable objectives. Additionally, these measures are applied to the campus community of which they are an integral part.

5.6. Integration

The intention behind this step is to encourage oversight of the decisions within each step so far. The characteristics outlined in the situational factors must link up with the sought learning goals as well as the means used by the instructor to achieve them. The students must be fully informed through printed materials and class discussions of what responsibilities and requirements that they must meet in order to fulfill the outlaid goals. Additionally the instructor must have a pulse on how the students are connecting with the material and if their comprehension is adequately represented through their writing and class participation. One final consideration in the implementation of the course is for the instructor to make sure that the transitions between topics highlight their interdependencies. These integration efforts within the course are discussed in the following section.

5.7. Course Structure

The course is divided up into 5 segments: an introduction and history, food, water, energy, and business implications. Class days will be structured as follows; five days to the first section, six classes to each of the second, third, and fourth sections, and three days to the final section.

The introduction and history section will serve to set the tone for the class and how discussions arising from instructor queues will be the primary form of class instruction. Within this first section, there will separate readings and discussions for the

three chief focuses of sustainability (social, economic, and environmental). The food section will focus on the human food system as well as other related agricultural topics, and it will transition out of the environmental aspect discussion on sustainability. The conclusion of the food section will have topics that have interrelations with water issues and thus will lead into the third section of the course. At the end of the water section, there will be two classes that will allow students to gain a better feel for the objectives of the final project with a guest lecturer and a group workday. The energy section will begin after this group workday. The final section will summarize the place of sustainability in relation to corporations and business interest. The final two days of class will be scheduled for final project presentations on sustainability indicator systems at the university.

5.8. Instructional Strategy

Instructional strategies were developed for each of the five sections in the course. Each section has a sequence of learning activities that occur both in and out of class that build upon each other through escalating levels of complexity and critical thinking requirements in the following manner. Informal journaling and class discussions lead by the instructor are followed by a student-directed discussion and an assignment that pushes students to pull together different concepts and apply to different aspects of their lives. The complexity of the main assignments increases over the three modules, challenging the students to think beyond themselves. The interactive nature of class dialogue will allow for a high level of communication about a student's progress with the material and knowledge retention. The instructional strategies were all integrated into the complete course layout, which is covered in the following section.

5.9. Creating the Overall Scheme of Learning Activities

Fink advocates an illustrative technique to charting out in class and out of class activities over the course of the semester. This process works well in practice with open space and larger format sketch paper, but for the purposes of clarity and presentation, an outline format is used here to discuss the activities in class and the readings and assignments scheduled in between classes. There are several repeated class activities and assignments that will be introduced here and simply listed within the outline below within each module. There is a noticeable decline in reading and workload towards the end of the semester to provided adequate time for students to prepare their final projects.

1. Summary/Discussion Assignment- These are simple assignments two paragraphs in length. Students will need to find a current newspaper or magazine article dealing with the current class topic. They will spend time summarizing the article in one succinct paragraph. The second paragraph will be used to show awareness of interrelationships that exist within the story and outside of the story as preparation for a class Whiteboard discussion the following week.
2. Whiteboard discussion- Students will lead this discussion augmented with their completed assignments. The instructor will participate by means of charting notes on the whiteboard in a bubble chart format. This will provide an illustrative means of showing the interconnections within the articles and between various articles.
3. Module Assignment- A paper of two to three pages that will allow students to use the readings and class discussions as a means of exploring the subject and its relation to their personal lives and professions.

5.9.1. Introduction

Day 1

- Introduction, course overview, and syllabus distribution
- The assignments for the semester will be discussed, including expectations for the thoroughness and depth to which critical thinking is applied to all writing.
- An opening dialogue will allow both the instructor and students to express what their goals and expectations are for the semester

Readings

- A section from Ray Anderson's A Mid-Course Correction that first presents sustainability principles and system stipulations, and then it follows with the seemingly counter-intuitive conditions that the current industrial system functions within.
- Donella Meadows paper, "Leverage Points: Places to Intervene in a System," which lays down a basis for systems theory and how to most effectively instigate change within a system.

Assignments

- Each student will complete a personal Eco-footprint. A number of different organizations have these tools, and so there will be no recommendations made on which one to use in hopes that there will be some variety in the findings.

Day 2

- Review of the students' Eco-footprints assignments. The importance of this exercise is to show the limitations of such a tool in its accuracy, but that it

provides a valuable lesson in understanding the impact of people's behavior. It can also serve as a baseline for actions to decrease one's footprint and a common metric that can be compared by different individuals and groups.

- A dialogue on initial impressions of sustainability and systems theory that students had already developed or that were influenced by the assigned readings.
- A lecture on the history, basic principles, and major influences on the sustainability movement. The three-legged stool analogy will be presented for the three facets of sustainability (social, economic, and environmental). Two significant points will be the equal importance for actions and concerns on a local and global level. Additionally, the significance of solutions that deal with behavior as well as those that deal with technology will be highlighted.

Readings

- Rittel and Webber's policy piece, "Dilemmas in a General Theory of Planning," covers the difficulty of finding solutions to human problems that are outside the hard sciences of physics and mathematics. This will provide a good transition into the social aspect of the sustainability discussion

Assignments

- Initial journal entry with personal interpretation and review/summary of class discussion

Day 3

- Social aspects of sustainability will be covered including: poverty, social welfare and charitable efforts, varying forms of bigotry and discrimination, human

trafficking, child labor, human health, political will and government representation, and the moral fiber of society.

- There should be mention of a historical timeline of social causes over the past 100-150 years to put into perspective the progress and continued efforts that are needed within the sustainability movement.

Readings

- Herman Daly's "Economics in a Full World" provides an alternative way of interpreting the concepts of growth and development and a critique of the currently practiced form of capitalism.

Day 4

- The economic aspect of sustainability will include discussion of the concept of externalities, credit systems, inflated condition of wealth in world markets, the implications of direct marketing, and finally the idea at the root of capitalism of infinite growth. Some of these concepts such as direct marketing will have overlap with the discussion of social sustainability in terms of influence over people's consumer choices. The final discussion of infinite growth will lead into actual constraints that are placed on this economic system by the biosphere.
- There will be some room for historical discussions of the development of various economic theories.

Readings

- There is a piece on the International Fund for Agricultural Development's website, "Combating Environmental Degradation," that covers a range of current

environmental issues on the planet. It also provides an angle for social concerns on these matters.

Day 5

- The environmental aspect of sustainability is perhaps the easiest for students to comprehend. The human species is dependent on relatively clean air, water, and other basic resources for survival, and thus if those resources are no longer available, the collapse of many life forms would likely follow. Different historical moments in society and the environmental will be showcased such as Transcendentalist writing, the various environmental disasters that led to the development of the Environmental Protection Agency within the United States, and the current global situations that are confronting human society.
- Some basic principles of thermodynamics and ecology will be used within this section of the course in discussion of boundary conditions and system constraints.
- A transition towards the Food module will occur with the discussion of climate variability, the science surrounding it, and impact on human systems.

Readings

- A large section of Michael Pollan's The Omnivore's Dilemma will be used over the course of the following module. This covers many different facets of the discussion on the sustainability of the human food and agricultural system.

Assignments

- The initial introduction of the final project will result in the formation of four groups. The project will be the development of a sustainability indicator system for the university. Students will be provided with some guidance on where to

seek out resources on similar indicator systems (Harvard, New York University, Penn State, and Yale), but they will largely be responsible for the research and development of this system. A distinction that must be made between some of the referenced efforts and this project is that the others largely focus on environmental performance measures. Later in the semester, a school representative will speak to the students about what the official university stance is on sustainability. Along with this, students will look at the school's setting, the surrounding community, and the general make-up of campus to develop these indicators.

- Students will be asked to hold an initial meeting after this class to discuss the project with their group and write a group journal entry. This will be submitted to the instructor for review but not for a grade.

5.9.2. Food

Day 6

- Historical account of human connection to the food and agricultural systems
- Scientific and technological developments that have altered that connection.
- The implications of nutrition, pollution, and immigration on the current food system in both the developed and the developing world

Readings

- Continued reading from the section of Pollan's The Omnivore's Dilemma.

Day 7

- Initial student impressions of Pollan's writing.

- Seek to find their understanding of why it was chosen and its connection to the focus of the course.
- Discussion of different operating systems for food production within the United States and around the world.

Readings

- Continued reading from the section of Pollan's The Omnivore's Dilemma.

Assignments

- Journal entry on a personal connection with food. This could be some sort of connection to a farm, family style meals, or the experience of international traveling and eating.

Day 8

- Guest Speaker: An individual or a panel will discuss community and school gardens.

Assignments

- Summary/Discussion Assignment #1 on food or agriculture

Day 9

- Discussion of current and future issues such as effects of climate change, genetically modified organisms, food-fuel controversies, long distance shipping and transportation of food, government legislations and regulations
- Potential solutions for these issues will be discussed such as adaptive growing techniques at the Land Institute, increased levels of local production, reworking of tariffs and subsidies

Assignments

- Module Assignment #1 is on the symbiotic relationships discussed within the Pollan reading and how such relationships can be taken advantage of in one's own life and work.

Day 10

- Whiteboard discussion of Summary/Discussion Assignment #1

Readings

- A National Geographic article by Charles Mann discusses food production but with more emphasis on the importance of soil health to the process. This highlights an aspect of food production that students might be ignorant of.

Day 11

- There will be time for a brief reflection on Module Assignment #1. This will give the instructor and students time to raise any concerns or issues that were encountered in the completion of the assignment.
- A range of issues that connect with both food and water will wrap up this module. Pesticides, fertilizers, and top soil loss are examples of such issues. These three are, in fact, responsible for 'dead zones' within bodies of water around the world. These 'dead zones' are areas where environmental pollutants or contaminants limit the ability of some species to properly function and often leads to their extinction.

Readings

- United Nations Development Programme (UNDP) produced a report in 2006 that covers a range of different issues associated with water. Students will be asked to

look through the document and find a particular issue that they would like to discuss.

5.9.3. Water

Day 12

- The introduction to the water module will give students a review of the issues discussed at the end of the food module with greater emphasis placed on the impacts to water systems.
- A number of issues concerning the state of different water systems and the species which depend upon them will be discussed. Additionally, Man's connection and dependence upon water will be presented, as well as some of the recent developments in the move to privatize and market water.

Readings

- Additional time to read from the UNDP report and prepare for class discussion
- There is an article by Ben Block on how potential environmental liabilities, abandoned coal mines, are actually providing the means to an alternative economy of aquaculture.

Day 13

- Open discussion of issues within the UNDP report, which the students wish to talk about
- Discussion about the aquaculture article will lead to talks about the importance of rehabilitation efforts for water systems and the ecosystems in and around them.

Readings

- Paul Hawken, Amory and Hunter Lovins have made their book, Natural Capitalism, available online for free access. One of the chapters focuses on water, and although it is relatively brief, it covers a range of important topics and solutions.

Day 14

- Guest Speaker: A speaker will discuss the various water issues around the world. The talk will focus on the role of engineering in providing water to people and the policies that influence how water is distributed.

Assignments

- Summary/Discussion Assignment #2 on water issues

Day 15

- Follow-up with any questions remaining from the previous guest speaker.
- Examine the issues related with climate change such as rapid glacial deterioration, fluxes in oceanic water cycles, and droughts.

Assignments

- Module Assignment #2 is on the differences between water issues in the developing world and in the developed world. This will involve looking at historical developments treatment and sanitation in addition to present policies and environmental influences.

Day 16

- Whiteboard discussion of Summary/Discussion Assignment #2

Day 17

- A range of solutions will be presented for both the developing world and the developed world. Students will be able to add to the discussion with the research and work they put into their Module Assignment #2.
- These solutions cover a range of different technologies that have been shown to be successful when implemented. Some examples are groundwater pumps that function with the mechanical energy from a children's seesaw and other playground devices, grey and black water systems for water reuse, and cheaply distributed handheld filtration systems.

5.9.4. Final Project Work

Day 18

- Guest Speaker: Campus Sustainability Director or appropriate position for that particular university. It would be beneficial to have multiple perspectives on the topic of sustainability efforts at the university and what is the mission of the upper administration and other influential bodies. This will provide the students with some ideas of how to craft their final projects.

Day 19

- Brief review of message and talking points from previous class's guest speaker(s)
- Groups split up to discuss development of sustainability indicator system for final project

5.9.5. Energy

Day 20

- Historical perspectives on human energy use in both a pre- and post-industrial sense. This will link back to earlier readings, which discussed society's dependence on cheap, readily available, and high energy content fossil fuels.
- Expand this discussion to include all the associated issues that result from the use of fossil fuels. Relations can be made back to the water module through the presentation of events such as oil spills, toxic metal runoffs in streams in Appalachia from mountain top removal, and pollutants and greenhouse gases resulting from the combustion of various fossil fuels.

Readings

- Elizabeth Kolbert wrote an article about her visit to a Danish island where residents have made innovative and forward thinking decisions that have nearly eliminated their need for outside sources of energy. The article also includes discussion of the practicality of all of humanity reducing carbon emissions associated with their lifestyles.

Day 21

- The discussion of sustainable energy strategies covers a breadth of different fields and areas of interest. Students would likely be highly interested in various engineering applications that are in use or in development. The discussion must certainly include the business rationale for the development and implementation of these technologies. Government regulations and incentives can each have serious effects on how and when these technologies are released or become

commonly available and affordable. This discussion is intended to spark interest within the students in preparation for a later guest speaker that will provide more depth to this topic.

Day 22

- There will be a discussion of traditional means of energy production and what alternatives are and will be developed that could reduce their environmental impact. These can be focused on pollution prevention technologies, as well as improvements to performance and efficiency.
- The role of behavior and opportunities for education within schools and the community will also be in this class discussion.

Readings

- Sections from Plan B 3.0 by Lester Brown that cover a breadth of energy topics such as transportation and different emerging technologies.

Assignments

- Summary/Discussion Assignment #3 on energy

Day 23

- Guest Speaker: A speaker will lead a discussion on energy as it relates to the transportation sector. This will include topics such as alternative fuels, innovative vehicle designs, and the use of informational systems to reduce vehicle fuel use.

Assignments

- Module Assignment #3 will have students discuss how energy uses and sources have changed in their lifetime from their grand parents lifetime. They will then write about what changes they foresee happening in the next forty years due to

resource scarcity, environmental degradation, and governmental regulations. Special mention will be made about connection between energy, food production, and water management.

Day 24

- Whiteboard discussion of Summary/Discussion Assignment #3

Assignments

- Another group journaling effort on the progress of the final project. A meeting with the instructor will be scheduled the following week for any final concerns or questions by either party.

Day 25

- Guest Speaker: Speaker(s) will present on emerging technologies in the area of renewable energy and the difficulties or opportunities in making them accessible to a broad range of consumers.

Readings

- The introductory chapter from Natural Capitalism will serve as the reading to introduce students to the redefinition of business and industry in a more sustainable manner.

5.9.6. Business Implications

Day 26

- Natural capitalism as a concept and not just the title of the book will lead off this final section of the course.

- Other ideas and practices such as industrial ecology and triple-bottom line accounting will be introduced and followed up with practical examples from the real world.

Readings

- William McDonough and Michael Braungart's Cradle to Cradle is a seminal work in the field of sustainability and innovation. The entire book should be read, but the chapter used here will provide students with some perspective of how motivations behind design and within business are changing. However, some of these approaches might not be fully comprehended and need to be reconsidered.

Day 27

- Discussion of the previous reading will lead to providing students with the opportunity to comment on shortcomings or truly innovative ideas in their respective fields.
- Some videos from Interface Global, a carpet manufacturer and leader in corporate sustainability, will be shown. Some additional discussion will focus on the model of enterprise, which Interface has switched to over the past decade.

Assignments

- Students will be asked to write a journal entry about their thoughts on the re-engineering and re-designing of products and the re-thinking of business operations and practices.

Day 28

- There will be discussion of the public dilution of the concept of sustainability, organic, and green. These have all become highly marketable terms and as such

have lost some of the integrity, which their original application held. Loosening of regulations through government legislation also will be linked in relation to lower standards imposed on goods and services.

- A final dialogue will give students a chance to describe how their interpretations and attitudes changed over the course of the semester. The instructor could have some interesting feedback for the students as well about the evolution of their efforts shown in class and through their assignments that could be valuable to the students in future learning endeavors.

5.9.7. Final Presentations

Day 29

- Two student groups will have time to give their presentation on the sustainability indicator system at the university, which they developed over the course of the term. Each group will present for thirty minutes with ten minutes provided for questioning after each presentation.

Day 30

- The remaining two groups will give their presentations in the same format.

5.10. How Are You Going to Grade?

Communication, both written and oral, is at the heart of the core of competencies for this course. The very idea of sustainability requires for every voice and concern to be heard. Therefore, there is no excuse for students not to participate in discussions. Additionally, the complexity of situations that will be examined requires that the students' writing be clear and well-supported. The two major pieces for the course in

terms of grading will be the final project and the term journal, which factors in class participation as well. The full grading breakdown can be seen in the sample syllabus.

5.11. What Could Go Wrong?

This step is simply an attempt at troubleshooting before the course is implemented. It is critical to examine the course objectively and from the perspective of the students in the class. How much of a workload is being placed on the students with assignments and reading, and will they be able to effectively complete these requirements in addition to their other studies? What sort of constraints will students face in accessing the necessary materials for the class?

There are also other considerations with legality and institutional cooperation. Many of the readings in the course are sections pulled from a number of different books. It is not expected for students to purchase each of these books, and therefore the publishers must be contacted to allow for the legal use of their text in the class. Another challenge will be gaining support and approval from administrators and the necessary review boards for a class that stands outside of traditional curriculum. Additionally, it would serve the students well if they were to see that there was interest from the school community in the outcome of their final projects on sustainability indicators at the university.

5.12. Let Students Know What You Are Planning

A final syllabus will have obvious reliance on a number of variables related to how the course is ultimately implemented. However, a sample syllabus was crafted based upon the work completed in earlier steps with the course structure. There are

several notable elements missing with respect to instructor, office hours, Honor code, and assignment policies. The sample syllabus is in Appendix C in consideration of this documents legibility.

5.13. How Will You Know How the Course Is Going? How It Went?

Student participation in class discussions and committed effort to their journals will perhaps be the best indicators of how well the course and the teaching style were crafted. These two aspects will serve as a proper gauge of how much interest the students are taking in the subject matter and the learning process. If the course is successful, then there should be clear signs within their writings and thoughts that they are thinking about these issues in a more holistic way than at the beginning of the semester.

In a course such as this one, an open dialogue will be appropriate for gaining feedback from students on what they believe they are getting out of the course as it proceeds through the semester. Each module will have summary discussions that can serve to shed light on how well that module was taught and how it connects with the other parts of the course. Participation rates and specific feedback on standard end-of-semester surveys also provide valuable insight into the how well the course goals were achieved.

CHAPTER 6

CONCLUSIONS AND FUTURE CONSIDERATIONS

6.1. Concluding Remarks

This thesis has laid out the reasoning for a university adopting strategies to address sustainability, specifically through the development of an introductory course on sustainability and systems theory. The design of this course in the previous chapter exists as a resource to be implemented or to be selectively pulled from to strengthen other areas of a university's curriculum. In no way, is an introductory course a comprehensive step toward a sustainable world. Rather it is a positive step forward toward bringing holistic thinking and sustainable living to the world through a college campus. The university system provides the context for a major transition within most students' lives. They can be exposed to a broad range of lifestyles and influences and imparted with the knowledge of professional ethics, that will have lasting effects on the choices they make through their lives. Additionally, many universities have very extensive ties with government and industry, and through start-up companies and allied research institutes serve as incubators for research and development.

These factors combine to make the university perhaps the most significant cog in the machine known as society. Although there already are individual efforts at many universities to make campus operations, the curriculum, and research opportunities more geared toward sustainability, these efforts need to be pulled together, normalized, and focused into a resource base that can serve a greater number of schools. The issue then becomes how to best administer this resource library. Parallel to the earlier discussion of the multiplicity of views and definitions on sustainability, there exist many different

organizations and associations that are currently seeking to pull together these efforts at both national and international levels.

6.2. Organizations Focused on Sustainability in Education

The Earth Charter Initiative is one global organization that is seeking to promote sustainability within universities as well as other levels of education. Their efforts are centered around the principles of the Earth Charter and are based out of the Earth Charter Center for Education for Sustainable Development at the University of Peace in Costa Rica (Earth Charter Initiative Education). The Earth Charter is a document that was developed in response to calls for an approach to sustainable development as put forth in Our Common Future and the discussions at the United Nations Rio de Janeiro conference on the Environment and Development. It outlines principles and guidelines that speak to all facets of sustainable development by means of these four chief pillars: Respect and Care for the Community of Life, Ecological Integrity, Social and Economic Justice, and Democracy, Nonviolence, and Peace (Earth Charter Initiative About). It is now considered by many throughout the international community as an educational and policy framework for sustainable development.

Second Nature is an organization that was founded in 1993 by Dr. Anthony D. Cortese, Senator John Kerry, Teresa Heinz Kerry, Bruce Droste, and others with the purpose of promoting and advocating sustainability in the field of education (Second Nature's Beginnings). It offers consultations and workshops to institutions that are specifically tailored toward the present conditions at that particular university. The United States Partnership for the Decade of Education for Sustainable Development brought together a collection of leaders from government, industry, academic, and non-

profit areas to bring their resources and expertise together behind this cause. Their work is in line with that of the United Nations Decade of Education for Sustainable Development, and on the more national level they stand behind the "Recommendations for Education for a Sustainable and Secure Future, developed at the 3rd National Conference convened by the National Council for Science and the Environment (NCSE) in January, 2003." (About the Partnership)

The Association for the Advancement of Sustainability in Higher Education (AASHE) is an organization made up of universities in the United States and Canada that was formed in 2006. In addition to the university members, there is a staff that promotes the "mission to promote sustainability in all sectors of higher education – from governance and operations to curriculum and outreach – through education, communication, research and professional development" (Association). They host conferences, workshops, and an online resource directory that can aid individuals or institutions in efforts to promote and implement sustainability initiatives in and around the university campus. They advocate for universities to take a very high level of leadership in transforming society into a more sustainable civilization with a redefined paradigm of systemic and interdependent thinking for seeking solutions.

6.3. Expanded Approaches Within the Education System

Understanding that truly sustainable solutions must have a local focus, any developed general program and plan must have a level of adaptability and flexibility within it. An example of this hierarchical approach geared at both global and local issues is Agenda 21, which arose out of the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil in 1992. Its aim was the development of an action

plan to address human development interrelations and their impact on the environment. A distinguishing feature of it was the call for a "local Agenda 21" in Chapter 28, which explained the importance of the role for local authorities and organizations in establishing clear lines of communication and building consensus among the citizenry (UN Agenda 21).

Steps aimed at operational efficiencies within the university's facilities could largely be considered acontextual. These programs would be aimed at the "low-lying fruits" of reductions in resource use such as energy and water through a formulaic process for facility assessments and a continually updated guide to proper equipment investments and a procurement process. More contextual programs would be aimed at interactions with the local community, curriculum changes, and education for staff and faculty.

It is these three levels of instruction that individual universities should focus the most attention on. Visionary leaders exist within society-shaping fields such as engineering, architecture, economics, and marketing, but some lack the understanding that "designing a sustainable human future requires a paradigm shift toward a systematic perspective emphasizing collaboration and cooperation" (Cortese 16). Although a bottom-up approach used at Pennsylvania State University was able to gain widespread support throughout the university community, it required enormous levels of dedication and personal sacrifice on the part of Christopher Uhl and the Green Destiny Council (Uhl). Counter to that, heavy-handed top-down approaches seeking to implement sustainable initiatives across campus would face considerable pushback if they did not first engage stakeholders for input and try to build consensus around the project.

Successful campus sustainability requires a well-defined vision backed up by a combination of leadership and commitment from top administration, comprehensive understanding by faculty and staff, and a curriculum that informs the students on the scope of sustainability.

Wojciechowski writes of the efforts at Northland College in Wisconsin and offers the following guidance for a three pointed approached aimed at leadership in sustainability on campus: environmental coordinator, environmental council, and a linkage of student learning to sustainability efforts (Wojciechowski 70). Although the term 'environmental' is used, the responsibility extends beyond just ecological concerns and would, in fact, be more appropriate replaced with 'sustainability'. A fourth point should be added for a departmental position of each school on campus. Each of these four points is necessary in creating a robust campus effort toward sustainability. As with most matters concerning sustainability, there will be variation among different institutions in how exactly these points are addressed, but consistency with this theoretical framework would allow for better transfer of best practices among schools. It would be much more favorable for schools within a state system to follow a similar protocol as they are tied into the same agencies, board of regents, etc.

A growing number of university and community college campuses around the nation have launched their sustainability initiatives through a central figure. These coordinator, manager, or director positions work out of offices that carry titles such as energy services, environmental leadership, environmental sustainability, and even directly out of the president's office. Some positions have supporting staff to help

coordinate efforts on campus, but most have the Herculean task of harmonizing all facets of sustainability at the university.

Several of these coordinators and directors from well-established and successful programs participated in a roundtable discussion moderated by Matthew St. Clair for the publication, *Sustainability: The Journal of Record*. One of the overarching messages through the discussion was the importance of reporting and communicating in a language that is understood and on performance measures that can show success. At Yale University, the focus on operations and the 'greening' of the facilities provided the base upon which efforts could build toward pushing sustainability into academics and research (St. Clair et al. 101). Projects within the classroom at Rice have led to implementation of programs and commitments to more sustainable operations by the administration (St. Clair et al. 105).

All of these efforts must place emphasis on assuring an interdisciplinary approach and a non-exclusionary process to build a broad base of consensus within the university itself and the broader community. Bridging the various disciplines together and increasing the level of communication and interaction among them, the system is strengthened by this complexity parallel to the greater effectiveness of biodiversity in natural ecosystems (Jepson). Whether it be a politician's plan for tax reform or a new roadway project, the success of either measure is bound by the level of agreement held with the community accomplished through compromise, incentives, or other bargaining means. This also connects with Walker and Salt's discussion of resiliency, the ability of systems to absorb disturbances and still maintain form and function (Walker).

John Fien of Griffith University in Brisbane, Australia, wrote an insightful article about the place of research within a university's efforts toward sustainable development. He pulls from the research of Patricia Lather in describing four different paradigms of research, which can be described as follows;

1. to describe, control and predict – the empirical-analytical paradigm, involving positivist and postpositivist approaches;
2. to empathize and understand – the interpretive or hermeneutic paradigm;
3. to change – the critical paradigm; and
4. to deconstruct – the poststructural paradigm.

(Fein 246-247)

He uses these four models of research in a brief illustration for the study of two examples of sustainability efforts at a university: the campus catering service and the development of an engineering curriculum in line with the Earth Charter. This leads to a discussion of the equal importance of each paradigm of research. Fien (2002) highlights the perspective that as with issues of appropriate development, the appropriateness of research will vary based on the discipline, the university, and the geographical, political, and cultural influences.

Universities must extend their range of influence to include that of education at the K-12 level, community enrichment, and continuing education programs. Schools of education are of course a direct means for providing teachers with the proper training to positively influence children about sustainability. Another important step would be the promotion of service opportunities or volunteering for professionals to step into the classrooms of elementary, middle, and high schools or youth community centers. The extension schools and continuing education programs that are at many universities should also provide opportunities for professionals to engage in guided learning on the subject of sustainability. Individual universities will have differing strengths that will best be

adapted to promote and educate about a more holistic way of thinking and living outside the university.

6.4. Challenges

Funding shortfalls are placing all levels and types of government agencies under considerable strain to find ways to maintain their present operations, much less develop any sort of expanded or experimental programs. The public university system is not exempt from this and in some cases might even be hit harder especially during economic downturns. In 2001 and 2002, schools experienced one of the most dramatic challenges of the past thirty years as states brought in reduced revenues and thus school funding declines, and thus they had to find a way around this through staff cuts and other programs (Pratt). There are existing innovative programs that provide necessary funds to provide the capital for sustainability related projects. The University of British Columbia uses the money saved from efficiency improvements to provide funding for the office of sustainability and its general efforts around campus (M'Gonigle 107). On a different level, Harvard's Green Campus Loan Fund makes interest-free loans available to campus projects aimed at reducing greenhouse gas emissions, and there are plans to create Green Building Loan Fund, which would cover the offset in price for construction and renovation projects aimed at improving building performance (M'Gonigle 145). Regardless of how programs are rearranged or what new revenue streams are created, the necessity for leaders to understand the importance of the issue and find creative solutions can be found in a letter from Thomas Jefferson to George Wythe in 1786:

> I think by far the most important bill in our whole code, is that for the diffusion of knowledge among the people. No other sure foundation can be devised for the preservation of freedom and happiness... The tax which will be paid for this purpose is not more than the thousandth part of what will be paid to kings, priests and nobles who will rise up among us if we leave the people in ignorance.
>
> (Lipscomb 396)

Funding concerns aside, the more critical challenge to sustainability initiatives is gaining consensus and buy-in from the community. Changes in attitudes, ways of thinking, and lifestyles do not occur easily for anyone. There is no universally effective message for getting the population of the world to understand the severity of the issues we face and the necessity of change, but there are also many stories of success in overcoming these challenges that must be properly communicated. The university serves as a place where the findings of hard and soft scientific research can be synthesized to produce a plethora of communication strategies to help shift to a more sustainable paradigm. The effects of changes in education can take a long time to be noticed and effective, but the shortsightedness with which human society has based most of their decisions in recent times has led us to this tipping point. Perhaps crisis is the necessary catalyst for the next phase of human existence on this planet.

APPENDIX A

REVIEW OF GUIDELINES AND OBJECTIVES FOR CURRICULUM REDESIGN

Georgia Tech (Meyer and Jacobs)

1. The curriculum should provide depth and breadth of material
2. Science has been and will continue to be an important foundation for the curriculum
3. The curriculum should adapt a systems perspective on the planning, design, and impact assessment of engineered facilities
4. Social science requirements in the curriculum should be targeted toward an understanding of the social science context of engineering
5. An exposure to ethics should be incorporated throughout the curriculum
6. Computer-based analysis and design should be an important element in the curriculum

Technical University of Catalonia

1. Establishing the environmental knowledge the student should have acquired by the end of his studies in each degree course.
2. Establishing the optimal green syllabus: subjects that require greening (content), new subjects (if necessary).
3. Preparation of a short-term action plan to prepare the faculty for the teaching of these subjects.

Liverpool John Moores University (Clugston and Calder)

1. Developing a range of academic programs, from general environmental literacy to specific professional preparation.
2. Ensuring that appropriate environmental content is present throughout its academic programs.
3. The rationalizing and improvement of the physical and working environment and the effective, efficient and sustainable use of all resources.
4. Enabling all members of its community to develop healthy and ecologically sound lifestyles and to protect and improve the physical and social environment in which it is situated.

Delft University of Technology (Kamp, Linda)

Objectives for introductory course for engineers

- To understand natural and social systems that are present in our society;
- To understand the problems that humans have caused in these systems;
- To understand the role of technology in the creation of these problems;
- To understand the social and economic influences on technology, and the role of technology in reshaping society;
- To learn about general technological options that might contribute to sustainable development and barriers for the implementation of these options

Contents of Course Reader

1. Introduction to sustainable development;
2. Sustainability problems;
3. Innovation and sustainable technology, theory;
4. Innovation and sustainable technology, examples of solutions;

5. Sustainable development in enterprises;
6. Designing for sustainable development;
7. Case studies.

Common Principles of Sustainability in Policies and Declarations (Wright, T.S.A.)

- Moral Obligation
- Sustainable physical operations
- Encourage sustainable research
- Public outreach
- Inter-university cooperation
- Partnerships with government, NGOs and industry
- Develop inter-disciplinary curriculum
- Ecological literacy

Ball State Introductory course framework (Vann, J. et al.)

1. A system's perspective
2. Basic requirements for survival
    a. Food
    b. Water
    c. Land
    d. Health
    e. Atmosphere and climate
    f. Energy
    g. Materials flow systems
    h. Natural biological systems
    i. Social systems
    j. Economic systems

Linking obligations of engineers with ideals of sustainable development (Crofton, F.)

- Develop and maintain understanding of the meaning, goals and issues of sustainable development;
- Identify and account for individual and cumulative social, environmental and economic implications of a decision or process based on an understanding of the systemic nature of the world, the interconnectedness of natural and human systems, and a concern for fairness and equity;
- Identify short and long term consequences of decisions or plans in the context of both immediate priorities as well as long term concerns (anticipatory thinking extending to future generations);
- Identify and account for direct and indirect consequences for people and ecosystems based on an understanding of the global nature of the world and how local and regional issues are part of the whole;
- Assess alternative concepts, designs and methods in ways which reflect holistic thinking and integration;

- Develop an understanding of a variety of perspectives, the ways values and beliefs embedded in these perspectives may be divergent or convergent, and the ways decisions depend on both facts and values; and
- Develop communication, collaboration and related skills necessary for constructive involvement with other professionals, a range of stakeholders and the public in general.

University of British Columbia Civil Engineering Department course topics

1. The Problem (in keeping with engineers' professional self-identification as problem-solvers);
2. Sustainable Development: differing perspectives, goals, principles;
3. Systems: including systems theory, natural systems, human systems (including values, governance and economics), and systems interaction (including ecological footprint);
4. Formal and Informal Responses to Sustainable Development; full-cost accounting (triple bottom-line), roles and influence of multi-stakeholders, consensus decision-making
5. Engineering Means and Mechanisms (including student case studies): life-cycle analysis, decision-making, scenario-mapping, risk assessment, ethics; and
6. Sustainable Development and You: roles of engineers, expectations, codes, and guidelines.

APPENDIX B

SUSTAINABILITY QUESTIONNAIRE

I am a graduate student in C.E.E. under the advisement of Dr Michael Meyer, P.E. My thesis is entitled Education at the University: A Key Component of the Sustainability Movement. As part of this work, I am developing an illustrative structure for a 15-week introductory course on sustainability. In my time at Georgia Tech, I have taken a number of courses that have focused on sustainability in relation to a specific subject area or discipline. I am seeking to instead develop a more general course on sustainability that reaches beyond the typical subject areas covered within a students' standard curriculum.

You are part of a very small number of Georgia Tech instructors who I am contacting regarding this subject. I would appreciate you answering the following questions.

Classes Taught: _____

Areas of Research: _____

Areas of Additional Interest/Crossover Research Potential:

_____

In generating materials for this class, I wanted to reach out to those in the Georgia Tech community that have distinguished themselves as interested in contributing towards sustainable development.

1. What are the key concepts that you think should be covered in an introductory course on sustainability?

2. What would you recommend as the best allocation of class time among the following course material:

		Ex.
Relevant theories		15%
Historical development of sustainability		10%
Practical applications		30%
Relevant analysis tools		5%
Role of technology		20%
Broad societal context		20%

3. How important is a student project in a class such as this?

Not Important at all Not Important Neutral Important Very Important

4. How important is it to have such a course be co-taught by instructors from different programs?

Not Important at all Not Important Neutral Important Very Important

5. What specific topics do you think should be covered in such a course?

6. What are the barriers or challenges in teaching a course such as this at a school like Georgia Tech?

APPENDIX C

SAMPLE DESIGN COURSE SYLLABUS

Introduction to Sustainability and Systems Theory

This course is meant to serve as an introduction to the concepts and examples of sustainability and systems theory in a global context. There will be emphasis on both theory and practical example of applications in society. Due to the interdisciplinary nature of this course, there will be wide range of topics and various perspectives on a number of issues that tie into both personal and professional situations.

Course Goals

- Gain a solid and personal understanding of sustainability and how it relates to other popular perspectives.
- Be able to apply lessons from this course to one's own life or profession
- This includes the ability to understand the full scope of linkages between personal and societal activities and their repercussions
- Develop awareness of the implications and power of individual choices on one owns health and well-being, as well as the effects on other human beings
- Find a way of personally or professionally connecting with the subject matter and understanding its significance to one's life
- Gain insight into one's own learning process, the strengths and weaknesses, and how seeking knowledge and understanding of the world's complex issues must always be part of one's life

Performance Expectations

Future business leaders, directors of policy, and innovators of technology must have a solid comprehension of the complex issues currently facing the world and the countless number of problems that we have yet to identify or predict. Therefore, it is expected that students will be fully engaged in all aspects of this class. There will be heavy emphasis on writing and discussion within class and outside group work. No quizzes or exams are currently scheduled, as grades will be based on these other activities.

The subject of sustainability is one that is going through constant evolution. There are certain ideas and actions that can be declared unsustainable, and others that social or natural scientist currently view as sustainable. With this in mind, students should feel that their thoughts and feelings are fully justified and are thus encouraged to write and speak about them freely. Although, there are in some cases no right or wrong answers, all compositions and participation will be evaluated with expectations of supported arguments and documentation of findings.

Grade Breakdown

15% Summary/Discussion Assignments (3)
30% Module Assignments (3)
30% Journal and Class Participation
25% Final Project and Presentation

Assignments

Summary/Discussion Assignments: For these 2 paragraph assignments, students will need to find a current newspaper or magazine article dealing with the current class topic. They will spend time summarizing the article in one succinct paragraph. The second paragraph will be used to show awareness of interrelationships that exist within the story and outside of the story as preparation for a "whiteboard bubble chart" class discussion the following week.

Module Assignments: These assignments will be scheduled for the final 3 days of each module. They will be focused on incorporating elements of the current module along with broader lessons of the course. A 2-3 page paper with references will be expected for each of these assignments.

Journal/Class Participation: The journal will serve as both an input into class discussions and as a means of assessing a students' performance in the class. There will be guidance occasionally on what to put in the journal, but for the most part will be up to the student to decide what is appropriate. The journal should show comprehension of class discussions and readings, as well as personal insight from the student about the broader subject matter of sustainability and systems theory.

Final Project: This group project will result in the development of a **Sustainability Indicator System for the University**. Group work will take place throughout the semester, but the second half of the semester will be devoted to work towards research and development of this System.

Reading Materials – appear in the sequence that they will be read
* Denotes that these books are available in full online

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Class	Overview	Reading/Assignment
1	Introduction: Course expectations and discussion of assignments	Reading: Anderson (87-96) Meadows (all) Assignment: Complete a personal Eco-footprint
2	Review of Eco-footprint, Initial Impressions of sustainability and systems theory	Reading: Rittel & Webber (focus on 160-167) Assignment: Begin journal with personal interpretation and review/summary of class discussion
3	The 3-legged stool: The Social Aspect	Reading: Daly (102-107)
4	The Economic Aspect	Reading: International Fund for Agricultural Development
5	The Environmental Aspect	Reading: Pollan Assignment: Group Activity Discussion
6	Introduction to Food	Reading: Pollan
7	Impressions on Omnivore's Dilemma	Assignment: Journal entry on personal connection to food production
8	Guest Speaker: Community/School Gardens	Assignment: Summary/Discussion Assignment #1
9	Future Issues and Solutions	Module #1 Assignment
10	Whiteboard Discussion of Assignment #1	Reading: Mann
11	Reflection on Module #1 Assignment Food issues linked to Water	Reading: United Nations Development Programme (UNDP) Assignment: Module #1 Assignment Due
12	Introduction to Water	Reading: UNDP, Block
13	Water issues within the U.S.	Reading: Hawken (Ch. 11)
14	Guest Speaker: Global Water Issues	Assignment: Summary/Discussion Assignment #2
15	Continued Discussion of Global Water Issues	Assignment: Module #2 Assignment
16	Whiteboard Discussion of Assignment #2	---
17	Solutions	Assignment: Module #2 Assignment Due

18	**Guest Speaker: Sustainability Campus Coordinator**	**---**
19	**Group Activity Day**	**---**
20	**Introduction to Energy**	**Reading: Kolbert**
21	**Discussion of Sustainable Energy Strategies**	**---**
22	**Traditional Means with New Alternatives The Role of Behavior and Education**	**Reading: Brown (225-227, 243-257) Assignment: Summary/Discussion Assignment #3**
23	**Guest Speaker: Energy & Transportation**	**Assignment: Module #3 Assignment**
24	**Whiteboard Discussion of Assignment #3**	**Assignment: Group discussion and journal for final project**
25	**Guest Speaker: Emerging Energy Technologies and Market Access**	**Reading: Hawken (Ch. 1)**
26	**Business Implications: Natural Capitalism**	**Reading: McDonough (Ch. 2)**
27	**Cradle to Cradle Design and the Interface Model**	**Assignment: Guided Journal Entry on Re-engineering and Re-thinking how Business Operates**
28	**Wrap-up Discussion: Concept Dilution and Co-opting of Concept for Profit**	
29	**Final Presentations**	
30	**Final Presentations**	

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