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Measuring the educational impacts of a graduate course on sustainable development

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While university-level education is increasingly recognized as an important component of sustainable approaches to development, little empirical research has been done on the impact of sustainability education on student behavior. This study relies on an evidence-based research approach to better understand how graduate coursework on sustainable development can facilitate learning and transform the perceptions and reported behavior of class participants. Specifically, the authors use ecological footprint analysis in an interdisciplinary graduate-level course on sustainable development to make statistical conclusions about the degree to which education on sustainability influences students' daily consumption patterns. The results of this study suggest that graduate-level education can significantly increase the degree to which students behave in a sustainable manner as measured by their ecological footprints.

Introduction

Education and training within a university setting is increasingly being considered a critical component of sustainable approaches to development. Agenda 21, signed at the Rio Earth Summit in 1992, was one of the first major international agreements to emphasize the incorporation of sustainability into higher education. Since that time, several world summits and national declarations in the United States and other countries have further defined and clarified the need for educational programs that teach the principles of sustainability at the university level. While the broad concepts for integrating sustainable development into higher educational institutions have been identified and case studies have been written describing the implementation of sustainable development curriculums, little empirical research has been done on the impact of sustainable development education on student behavior.

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This study pursues an evidence-based research approach to better understand how coursework on sustainable development may facilitate learning and transform the perceptions and reported behavior of class participants. A pretest–posttest design with a nonequivalent control group enabled us to draw statistics-based conclusions about the degree to which education on sustainability affects the way students think and act. Specifically, we used ecological footprint analysis in an interdisciplinary graduate-level course on sustainable development taught at Texas A&M University to: (1) measure students' level of reported sustainable behavior at the beginning and end of the course; (2) measure the degree to which students' reported daily consumption patterns changed after three months of exposure to the topic of sustainable development; and (3) examine which course components contributed most to learning and behavioral change. The course employed a problem-based learning (PBL) approach where students actively participated in solving complex real-world problems associated with sustainability.

The following section briefly examines three areas of literature which formed the conceptual basis of our study: (1) the importance of education in attaining more sustainable levels of development; (2) the role of PBL in teaching issues associated with sustainability; and (3) the use of ecological footprint analysis to indicate individual levels of sustainability-related behaviors. Next, we describe the research methods used in the study, including sample selection, concept measurement and data analysis. Statistical results based on a pretest–posttest design with a nonequivalent control group indicate the degree to which course content impacts ecological footprints, environmental learning and behavior related to sustainability. Finally, we discuss the implications of our findings in terms of improving educational programs on sustainability and achieving more sustainability-focused behaviors at the societal level.

The importance of higher education in building a sustainable society

Over the last 30 years, the issue of education in achieving sustainable practices has become more prominent in both the international and national arenas. The seeds for incorporating aspects of sustainability into higher education were first planted with the signing of The Stockholm Declaration in 1972 (Calder & Clugston, 2003).[1] However, it was not until The Talloires Declaration in 1990 that 20 different university administrators signed an explicit statement of commitment to support sustainability efforts in institutions of higher learning (Wright, 2002). This 10-point voluntary action plan urged universities to 'engage in education, research, policy formation and information…to move toward a sustainable future' (University Leaders for a Sustainable Future, 1990, p.1). As of 2001, approximately 280 universities in over 40 countries had signed the Declaration indicating a global commitment to teaching the principles of sustainability.

The discussion on critical dimensions of sustainability in higher education has continued through the signing of multiple international declarations, the implementation of national programs, and specific initiatives within universities (Clugston & Calder, 2000; Wright, 2003). While all of these initiatives have their own nuances, one theme is prominent: institutions of higher education have a responsibility to develop curriculum, and teach and train students on the principles of sustainability. This reflects the deeper assumption that universities should impart the knowledge and skills that will enable graduates to create the changes required to achieve a more sustainable society.

While some of the broad principles of sustainability and higher education have been defined, systematic knowledge of the impact of existing initiatives and ways to effectively incorporate sustainability into university curriculums is limited. The descriptive and advocacy-oriented research pervading the literature has recently received considerable criticism from environmental education scholars (Palmer, 1999; Fien, 2002). For example, Fien (2002) notes the majority of studies on sustainability in higher education lack rigorous research designs in that they fail to report on data collection procedures, data analysis and issues of validity. The author suggests that the use of empirical–analytical approaches such as quasi-experimental pretest and posttest designs may be one of several research approaches to advance the state of knowledge on sustainability and higher education. Similarly, Corcoran *et al.* (2004) argue case-study research lacks a rigorous research design and discussion of methodology has failed to live up to its potential for improving the field of sustainability.[2] Based on an analysis of 54 journal articles on sustainability in higher education, the authors found that case studies (the predominant method of research on the topic) rarely included information on research methods and instead relied on stories of successes to support their argument.

The role of PBL in teaching issues associated with sustainability

While there are many ways to effectively teach sustainability at the university level, one approach called problem-based learning (PBL) has received recent attention in the environmental education literature (Jucker, 2002; Steinemann, 2003; Warburton, 2003). PBL emerged as a response to criticism that traditional classroom environments do not provide essential contextual features that enable students to understand and apply information (Schmidt, 1993). The approach is grounded in the notion that learning occurs when students are given problems and situations that represent genuine complexity (Brown *et al.*, 1989). While PBL has been used as an important learning framework in many disciplines (Gabbert *et al.*, 1986; Walton & Mathews, 1989; Peterson, 1997; Cockrell *et al.*, 2000; Wallace, 2001; Friedman & Deek, 2002), it can also prepare students to solve real-world, interdisciplinary problems associated with sustainability once they leave the classroom environment and become working professionals. Directing students to work through actual sustainable development scenarios (e.g. green building, site and community designs, simulated negotiation, etc.) builds their capacity to address the complex interaction of human decisions and the biophysical environment.

Foremost, PBL promotes the idea that nothing is ever learned to finality, that interdisciplinary learning coincides with solving the complex interrelated problems of sustainability, that there exists too much for any one person to learn and that tasks need to be shared among students.

Ecological footprint analysis as an indicator of sustainability

Ecological footprint analysis (EFA) is one method that may help evaluate the effectiveness of teaching sustainability at institutions of higher education. This technique offers a quantitative measure of sustainability that can be systematically tracked and compared across individuals, households, institutions and geographic areas. Rees and Wackernagel first introduced the ecological footprint (EF) concept in an effort to convert these broad principles into a measurable indicator of whether population demands remain within the confines of the earth's natural capital stocks (Wackernagel *et al.*, 1999b). An EF is measured as the total area of productive land and water required to continuously produce all resources consumed and to assimilate all wastes produced by a defined population in a specific location (Rees & Wackernagel, 1996).

The usefulness of EFA is that it aggregates and converts typically complex resource use patterns into a single number (Costanza, 2000). EF calculations are based on two basic assumptions: first, most consumption and much of the waste people generate can be accounted for; and second, the biologically productive areas appropriated for these consumption patterns and the assimilation of waste can be calculated (Wackernagel *et al.*, 1999a). Consumption categories include: food, housing, transportation, consumer goods, services and wastes. An EF is usually expressed in global acres (or hectares). Each global acre corresponds to one acre of biologically productive area based on the earth's average productivity.

EFA has been applied at various geographic scales, including global/national (e.g. Wackernagel *et al.*, 2002), municipal/institutional (e.g. Flint, 2001; Barrett & Scott, 2003) and individual levels (Crompton *et al.*, 2002). At the household scale, individual impact is often assessed through direct accounting or simplified questionnaires (Wackernagel & Yount, 2000). Simmons and Chambers (1998) devised an EF tool for households called 'EcoCal,' an easy-to-use computer-based questionnaire comprised of 45 questions. The authors used the tool to measure the EF of 42 households in the United Kingdom and found that the average household EF is almost 5 ha or 1.7 ha per occupant. The EF ranged from less than 0.5 hectares per household to several hundred hectares. A high EF score generally resulted from large families with energy-inefficient homes taking long-haul holidays abroad coupled with 'high impact' purchases (Simmons & Chambers, 1998). Crompton *et al.* (2002) introduced the EF concept into an undergraduate course at the Open University, United Kingdom, as a learning tool. Using the EcoCal program, students were required to calculate their EF and then consider how changes in their lifestyles could decrease their overall impact on natural resources. The average EF from 692 student samples was only 3.34 ha per household, or 1.33 hectares per person. Households without children (under 16 years) had a higher EF per person than households with children; rural households had a higher average transport EF than urban residents. On average, transportation and energy consumption accounted for nearly three-quarters of the total household per capita EF.

Methods

Sample selection and treatment

This study uses an untreated control group research design with a pretest and posttest to measure and explain the change in the EF of students enrolled in a course on sustainable development. The treatment or study group consisted of 22 graduate students enrolled in a sustainable development course taught at Texas A&M University in the spring of 2004. The class was comprised of both Masters and doctoral level students from one of the following three programs within the College of Architecture: Urban Planning, Architecture and Land Development. The control group consisted of 28 students enrolled in a general graduate-level market analysis for development course (with no emphasis on sustainability) taught within the College. In both courses, students had a variety of undergraduate educational backgrounds, ranging from the physical and natural sciences to policy and social sciences.

The design and content of the sustainability course was based on the PBL approach. This course covered a broad range of topics related to sustainable planning and development. Readings and discussions were organized by sociopolitical scale as opposed to media (air, water, waste, etc.) or subject matter (ecology, economics, social equity, etc.). Substantive class sessions were organized by the following seven spatial study units: Global/Biosphere, National, Institutional/Organizations, Community, Site, Building and Household/Individual. Within each unit a range of sub-topics was explored including social equity, economic development, ecology of place, urban form and sustainable enterprise (see Appendix 1 for an outline of the course).

The approach of the course was problem based, where students had the opportunity to apply the principles of sustainability to realistic problems, settings and solutions. In-class group exercises included: designing a sustainable community, addressing the adverse environmental impacts from a subdivision development and developing a concept design for a sustainable house based on specific site requirements. Place-based case studies were assigned as part of required readings and subsequently discussed in class. In general, the content of the course was meant to help prepare students to address the interdisciplinary, complex problems associated with sustainability in their work and everyday lives. The objectives of the sustainable development course were to:

(1) understand the principles of sustainable planning and development at and between a variety of scales and settings;
(2) critically examine the challenges and opportunities to build, plan for and direct sustainable communities;
(3) apply the principles of sustainable planning and development to real-world problem domains, working alone and in groups;
(4) develop individual and collective student expertise on a topic related to sustainability to enhance professional development and increase effectiveness in the workplace after graduation.

The course was reading intensive and discussion based. Students were expected to apply their own knowledge and specializations to solving specific sustainable planning and development problems from a variety of perspectives. Several problem papers were assigned asking students to apply the concepts presented throughout the course to real-world planning and development situations. A final project required students, either working alone or in groups, to identify, analyze and present to the class a place-based sustainability problem of their choice.

Concept measurement

We calculated each respondent's EF by administering the Ecological Footprint Quiz (EF Quiz) originally designed by a nongovernmental organization called Redefining Progress (www.rprogress.org).The survey, consisting of 16 questions, was given to each group at the beginning and end of the academic semester (see Appendix 2 for more detail). Consumption activities for each survey question were weighted by a 'footprint factor,' calculated by the amount of energy and land needed to support the given activity. Footprint factors were pre-calculated by Redefining Progress according to national levels of productivity. Multiplying each respondent's level of activity by its corresponding footprint factor yielded an equivalent impact in terms of acres of land/sea that can be compared across all nations (for more detail on individual EF calculation, refer to Merkel, 2003).

A composite EF score was calculated by aggregating four separate components: food, mobility, housing, and goods and services. The *food* component summed up land and marine areas that sequester carbon dioxide from the energy expended to grow, process and transport food. Survey questions included the types of food respondents regularly eat and where this food is produced. The *mobility* component was based on impacts from walking, cycling, driving cars and flying. Respondents were asked to provide information on their mobility habits including the mode, distance and relative energy efficiency of their daily travel or commute. The *housing* footprint component was based on yard area, energy and materials for constructing buildings. Specific questions included the size and type of shelter and the number of inhabitants. Finally, the *goods and services* component considered consumer behavior patterns such as use of appliances, electronics, computers and communications equipment. Specific questions also obtain information about utility use including water, sewer and trash disposal services. The composite EF was measured for each respondent and averaged over each group, creating a continuous scale.[3]

In addition to calculating the per capita EF for the study and control groups, a post-test measured which study unit was most effective for learning about sustainability and changing sustainable behavior of the treatment group. Each of the seven course topics (listed above) was measured using Likert scales from 1 to 7 (where a score of 1 is low and 7 is high). Respondents were asked to rank each unit based on how much it contributed to knowledge gained on sustainable development and also how much each unit contributed to changes in consumption behavior. Averaging and comparing responses indicated which aspects of the course were most effective in facilitating learning and affecting behavior related to sustainability.

Data analysis

The data were analyzed in two main stages. First, we used paired tests of means to assess the change in footprint scores between the pretest and the posttest for both the study and control groups. Second, we analyzed an ANCOVA model with the pretest scores as the covariate. Using the pretest in this way provides an adjustment for initial differences between the treatment and control groups. This method is considered more precise than an ANOVA when examining the effect of a treatment because the ANCOVA reduces the size of the error variance by including the pretest scores directly in the model (Cook & Campbell, 1979). We analyzed five separate ANCOVA models, one for each component and a composite footprint score. Several tests were conducted to ensure there were no violations of the assumptions for normality, linearity, homogeneity of regression slopes and reliability of the covariate.

Results

Based on the initial survey (pretest), the per capita EF of the class on sustainable development was 19.5 acres (Table 1). Of the class composite score, 26% came from the food component, 14% from mobility, 25% from shelter and 35% from goods and services. The control group had a very similar pretest EF score of 20.6 acres per

Table 1. Average pretest per capita EF for study and control groups

EF Component	Study (N = 22)	Control (N = 28)	USA (As of 2004)
Food	5.1	5.3	5.5
	26.2%	25.7%	23.4%
Shelter	5.0	5.4	5.1
	25.6%	26.2%	21.7%
Goods/Services	6.6	7.1	8.6
	33.8%	34.5%	36.6%
Mobility	2.8	2.8	4.3
	14.4%	13.6%	18.3%
(Car)	1.9	0.0	4.0
	(9.7%)	(0.0%)	(17.0%)
(Public transit)	0.1	2.1	0.1
	(0.5%)	(10.2%)	(0.4%)
(Air travel)	0.8	0.8	0.3
	(4.1%)	(3.9%)	(1.3%)
Average per cap. EF	**19.5**	**20.6**	**23.5**
	100%	**100%**	**100%**

(Units: Acres)

person. The component scores were also quite similar, where 26% of the composite EF was from the food component, 14% from mobility, 26% from shelter and 34% from goods and services. The composite EF for both the study and control groups was below the national per capita EF of 23.6 acres (and far above the global EF of approximately 4.5 acres). The component breakdown for the national footprint is similar to the groups in our study, except for mobility, which is substantially larger (18.3%) stemming from a greater dependence on car travel.

Comparing the means of the pretest and posttest scores for both the study and control groups provides an initial indication of the impact of education on individual levels of sustainability. Subsequent to the treatment, the sustainable development class's per capita composite EF decreased significantly to 16.8 acres ($p < .05$), while the control group's EF significantly increased to 23.1 acres (Table 2). While food and shelter EF components did not change significantly during the three-month study period, the study group showed marked reductions in both mobility and goods/services components ($p < .1$). For example, the mobility EF component decreased from 2.8 to 1.9 acres and the goods/services component dropped from 6.6 to 5.5 acres per person subsequent to treatment.

As shown in Table 3, a one-way between-groups analysis of covariance controlling for pretest EF scores indicates the treatment (sustainable development education) increases the degree to which students acquire sustainable behavior patterns. The composite EF score for the study group was significantly different from the control group, $F(1,47) = 11.26$, $p = .002$, with a large effect of almost 20% (partial eta squared = .193). The same ANCOVA test for each EF component supported the findings of the paired t-tests, where mobility ($F(1,47) = 8.37$, $p = .006$, partial eta

Table 2. The paired t-tests for study and control groups

	Variable	Pre-test (Mean)	Post-test (Mean)	t-value	p-value
Composite	**EF**				
Footprint	Study **(N = 22)**	19.5	16.8	2.39	0.026
	Control **(N = 28)**	20.6	23.1	−2.06	0.049
Component	**Food**				
Footprint	Study	5.1	4.8	1.42	0.170
	Control	5.3	5.1	1.13	0.269
	Mobility				
	Study	2.8	1.9	2.03	0.055
	Control	2.8	3.4	−1.59	0.123
	Shelter				
	Study	5.0	5.0	−0.07	0.949
	Control	5.4	6.2	−1.62	0.117
	Goods/Services				
	Study	6.6	5.5	1.98	0.061
	Control	7.1	8.3	−2.13	0.042

Table 3. One-way between-groups ANCOVA controlling for pretest EF scores

Dependent Var.	Source	F	Sig.	Partial Eta Squared
Composite EF	Study-Control	11.259	.002	.193
Food	Study-Control	.725	.399	.015
Mobility	Study-Control	8.374	.006	.151
Shelter	Study-Control	1.419	.240	.029
Goods/Services	Study-Control	10.658	.002	.185

squared = .15) and goods/services ($F(1,47) = 10.66$, $p = .002$, partial eta squared = .18) showed significant differences on posttest scores. Of the EF components, mobility had the largest effect, explaining approximately 18% of the variance on the dependent variable.

In terms of which study units in the course on sustainable development may have contributed most to increased learning and behavioral changes, respondents indicated materials on smaller spatial scales (community level and below) were most helpful. As shown in Table 4, individual or household scales were ranked the highest for both learning about sustainability and altering consumption patterns.

Discussion

The results of this study suggest that graduate-level education may significantly increase the degree to which students behave in a sustainable manner as measured by their reported ecological footprints. Findings support the effectiveness of PBL techniques in teaching the principles of sustainable development and the ability of a single course to change student consumptive patterns in a period of only three months. A significant decrease in the per capita EF is particularly encouraging given the fact that student footprints were well below the national average, primarily due to a general lack of student financial resources. Because students on average came to the course at a more sustainable level of activity (i.e. lower EFs), it could be assumed that it is more difficult for them to make easy improvements on their EF compared to other Americans. In other words, there is less room for improvement.

Table 4. Contribution of course study unit on learning about sustainability and behavioral change

Topics	A	B	C	D	E	F	G	Ave.
Learning about Sustainability	4.4	4.2	4.6	5.1	5.0	4.9	5.4	4.8
Behavioral Change	3.7	3.5	3.6	4.1	4.3	4.2	4.8	4.0

(Units: Average Ranking on a scale from 1–7.)
Notes:
A: Global/Biosphere B: National C: Institutional/Organizational
D: Community/Regional E. Site F. Building/Structure G. Individual/Household

Yet, not only did the study group significantly reduce its reported EF by the end of the course, it did so by improving in consumptive areas that were already below the national average (in contrast, the reported EF for the control group significantly increased, which may indicate the relative instability of reported EFs or further support the positive influence of education in increasing sustainable patterns of behavior). For example, mobility and goods/services components both decreased by approximately a full acre despite the fact that pretest scores were comparatively lower than US per capita averages. Graduate students at the university generally do not rely solely on automobiles to commute to campus or have the expendable income to purchase luxury items. We explain this result by the fact that, due to lifestyle preferences in the USA, consumption levels for transportation and service-oriented or entertainment items are overly inflated compared to other countries. Mobility and goods/services EF components thus represent 'low hanging fruit' in terms of improving sustainable behavior, particularly during a short time period. Substantially altering one's housing or diet, however, would presumably take much longer.

Focusing problem-based educational materials and programs on topics where easy gains can be made to reduce individual footprints may be the most efficient approach when using education to achieve the principles of sustainable development. According to the results of this study, readings, class exercises and simulated problem solving centered on the impacts of automobile dependency or the overproduction of household waste, among other issues, may expedite the reduction in per capita EFs. Such an approach may be particularly warranted for courses that last for only a semester or less.

Survey results also indicate that levels of sustainability can be improved if educational programs emphasize smaller geographic units when teaching the principles of sustainable development. In general, course content focusing on smaller spatial scales (community/region and below) facilitated both increased learning and behavioral changes as compared with larger geographic areas. For example, study units targeting the household level ranked considerably higher than the same subject taught at the global or national unit of analysis. This result can be explained by the way individuals learn by connecting concepts with personal experience. Students can relate to the principles of sustainability as applied to an individual or building more easily than the more abstract notion of a nation-state or biosphere. Household, structural or site level activities are tangible. Examples of sustainability at these micro-levels are more understandable and influential from a learning standpoint. Of course, it is important to teach sustainable development at all geographic units as well as the interactions between them. However, targeting PBL exercises and case studies at spatial scales students can best relate to may improve the effectiveness of teaching environmental sustainability at institutions of higher education.

Conclusion

Education at the university level has been internationally recognized as an important part of creating sustainable societies. While this study is based on reported sustainable behavior (as opposed to actual monitored behavior), it provides insights into the effectiveness of teaching sustainable development courses at institutions of higher education. We demonstrate that students may not only decrease their overall reported EF after taking a graduate course on sustainable development, but do so in specific areas. We also show that the spatial scales at which course content is aimed is critical for triggering learning and behavioral change related to sustainability.

While this study provides empirical evidence that may help the field of sustainability in higher education move forward, it should be considered only an initial step in understanding how graduate coursework can foster more sustainable patterns of behavior. Further quasi-experimental research is needed on several fronts. First, this study only controls for the pretest score of the study group. Additional control variables, such as proximity to the university, income, age, gender and existing environmental values, are needed to more thoroughly explain the variation of EF scores. Second, we surveyed only one study and control group during a single semester. Multiple classes surveyed at several points in time would increase the statistical validity and power of the findings. The relatively small size of graduate-level classes made our results vulnerable to outliers in the data. Third, our results are vulnerable to the threat of interaction between selection and history (sometimes called local history). Events other than the treatment could have affected the experimental group but not the control group, contributing to the observed decrease in EF scores. More effort is needed to account for history threats such as campus or departmental events or the subjects of other courses the students took during the same semester. Fourth, this study only tests EFs at the beginning and end of a semester and can make no conclusions whether education-induced behavioral changes are enduring. Additional research is needed to determine if graduate courses can produce permanent alterations in lifestyle or if they have only a short-lived effect. Finally, this study is limited by the fact that it only measured reported behavioral patterns contributing to an EF. The data could be biased based on individual perceptions of changed behavior or students' increased awareness of the correct responses to the survey. Future research should monitor actual behavioral changes of students over the course of a semester to make more robust empirical conclusions about the impact of higher education on sustainable lifestyles.

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Notes

1. For a more detailed description on the history of sustainability in higher education, see Wright (2002).
2. For a more detailed discussion on this topic, see *Environmental Education Research*, Special Issue, Volume 10, Number 1: Case-study research in environmental education.
3. The four footprint components were combined into a single variable. A Cronbach's alpha of 0.7 indicates that the composite variable is reliable and has good internal consistency.

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References

Barrett, J. & Scott, A. (2003) The application of the ecological footprint: a case of passenger transport in Merseyside, *Local Environment,* 8(2), 167–183.

Brown, J. S., Collins, A. & Duguid, P. (1989) Situated cognitions and the culture of learning, *Educational Researcher,* 18(1), 32–42.

Calder, W. & Clugston, R. M. (2003) Progress toward sustainability in higher education, *Environmental Law Reporter,* 33, 1003–1023.

Clugston, R. M. & Calder, W. (2000) Critical dimensions of sustainability in higher education, in: W. Leal Filho (Ed.) *Sustainability and university life* (2nd edn) (New York, Peter Lang), 31–46. Available online at: www.ulsf.org/pdf/Critical_dimensions_SHE.pdf (accessed 5 December 2004).

Cockrell, K. S., Caplow, J. A. & Donaldson, J. F. (2000) A context for learning: collaborative groups in the problem-based learning environment, *The Review of Higher Education,* 23(3), 347–363.

Cook, D. C. & Campbell, D. T. (1979) *Quasi-experimentation: design & analysis issues for field settings* (Boston, MA, Houghton Mifflin Company).

Corcoran, P. B., Walker, K. E. & Wals, A. E. J. (2004) Case studies, make-your-case studies, and case stories: a critique of case-study methodology in sustainability in higher education, *Environmental Education Research,* 10(1), 7–21.

Costanza, R. (2000) The dynamics of the ecological footprint concept, *Ecological Economics,* 32, 341–345.

Crompton, S., Roy, R. & Caird, S. (2002) Household ecological footprinting for active distance learning and challenge of personal lifestyles, *International Journal of Sustainability in Higher Education,* 3(4), 313–323.

Fien, J. (2002) Advancing sustainability in higher education: issues and opportunities for research, *International Journal of Sustainability in Higher Education,* 3(3), 243–253.

Flint, K. (2001) Institutional ecological footprint analysis: a case study of the University of Newcastle, Australia, *International Journal of Sustainability in Higher Education,* 2(1), 48–62.

Friedman, R. S. & Deek, F. P. (2002) Problem-based learning and problem-solving tools: synthesis and direction for distributed education environments, *Journal of Interactive Learning Research,* 13(3), 239–257.

Gabbert, B., Johnson, D. W. & Johnson, R. (1986) Cooperative learning, group-to-individual transfer, process gain, and the acquisition of cognitive reasoning strategies, *Journal of Psychology,* 120(3), 265–278.

Jucker, R. (2002) Sustainability? Never heard of it! Some basics we shouldn't ignore when engaging in education for sustainability, *International Journal of Sustainability in Higher Education,* 3(1), 8–18.

Merkel, J. (2003) *Radical simplicity: small footprints on a finite Earth* (Gabriola Island, New Society Publishers).

Palmer, J. A. (1999) Research matters: a call for the applications of empirical evidence to the task of improving the quality and impact of environmental education, *Cambridge Journal of Education,* 29(3), 379–395.

Peterson, M. (1997) Skills to enhance problem-based learning, *Medical Education Online,* 2(3). Available online at: www.med-ed-online.org/f0000009.htm#f0000009 (accessed 5 December 2004).

Rees, W. & Wackernagel, M. (1996) Urban ecological footprints: why cites cannot be sustainable—and why they are a key to sustainability, *Environmental Impact Assessment Review,* 16, 223–248.

Schmidt, H. G. (1993) Foundation of problem-based learning: some explanatory notes, *Medical Education,* 27(5), 422–432.

Simmons, C. & Chambers, N. (1998) Footprinting UK households: how big is your ecological garden?, *Local Environment,* 3(2), 355–362.

Steinemann, A. (2003) Implementing sustainable development through problem-based learning: pedagogy and practice, *Journal of Professional Issues in Engineering Education and Practice,* 129(4), 216–224.

University Leaders for a Sustainable Future (1990) *Report and declaration of the Presidents Conference* (Boston, Tufts University).

Wackernagel, M., Lewan, L. & Hansson, C. B. (1999a) Evaluation the use of natural capital with the ecological footprint: applications in Sweden and subregions, *AMBIO,* 28(7), 604–612.

Wackernagel, M., Lewan, L. & Hansson, C. B. (1999b) National natural capital accounting with the ecological footprint concept, *Ecological Economics,* 29, 375–390.

Wackernagel, M., Monfreda, C. & Deumling, D. (2002) *Ecological footprint of nations: how much nature do they use? How much nature do they have?* Available online at: http://redefining-progress.org/publications/ef1999.pdf (accessed 5 December 2004).

Wackernagel, M. & Yount, J. D. (2000) Footprints for sustainability: the next steps, *Environment, Development and Sustainability,* 2, 21–42.

Wallace, J. (2001) Introduction: Science teaching cases as learning opportunities, *Research in Science Education,* 31, 185–190.

Walton, H. J. & Mathews, M. B. (1989) Essentials of problem-based learning, *Medical Education,* 23, 542–558.

Warburton, K. (2003) Deep learning and education for sustainability, *International Journal of Sustainability in Higher Education,* 4(1), 44–56.

Wright, J. (2003) Introducing sustainability into the architecture curriculum in the United States, *International Journal of Sustainability in Higher Education,* 2, 100–105.

Wright, T. S. A. (2002) Definitions and frameworks for environmental sustainability in higher education, *International Journal of Sustainability in Higher Education,* 3(3), 203–220.

Appendix 1. Course outline

Department of Landscape Architecture & Urban Planning

Texas A&M University

LDEV-671: Sustainable Planning & Development Course Outline

INTRODUCTION AND OVERVIEW OF SUSTAINABLE PLANNING AND DEVELOPMENT

- Introduction to the Practice of Sustainable Development

UNIT 1: GLOBAL/BIOSPHERE

- A Brief History from Stockholm to Rio
- Summary of the World Summit on Sustainable Development
- Agenda 21 Declaration

UNIT 2: NATIONAL POLICY

- The State of the Nation's Ecosystems
- Stumbling Toward Sustainability in the U.S.
- The Ecology of Place

UNIT 3: INSTITUTIONS & ORGANIZATIONS

The Organization

- Ecologically Sustainable Organizations

Sustainable Enterprise

- The Ecology of Commerce
- Competitive Environmental Strategy: the Changing Business Landscape.
- Being Green and Competitive
- **Corporate Case Studies**
- Motivations for Resource-Based Industry to Participate in Collaborative Ecosystem Management Initiatives.

UNIT 4: COMMUNITIES AND REGIONS

The Vision

- Moving Towards Sustainable Communities

Urban Form

- Shaping the Way We Live

Natural Resources & the Environment

- The Practice of Sustainable Development
- The Ecology of Place

Economics

- Lost Landscapes and Failed Economies
- Sustainable Economic Development

Planning

- Are We Planning for Sustainable Development?

Social Dimensions

- Improving Equity
- Building Equitable Communities
- The Land That Could Be

UNIT 5: SITE PLANNING

- Sustainable Site Selection and Planning
- The Role of the LEED Program

UNIT 6: SUSTAINABLE BUILDING & GREEN ARCHITECTURE

- Green Building and the LEED Program
- U.S. Green Building Council

UNIT 7: HOUSEHOLD/INDIVIDUAL

- Ecological Footprints as an Indicator of Sustainability
- Reducing Solid Waste

COURSE SUMMARY/CONCLUSION

- Exploring the links between sociopolitical and spatial units

Appendix 2. Ecological footprint survey

Individual Ecological Footprint Analysis

'Ecological Footprint' is an indicator which shows how much humans depend on natural resources. This survey helps to provide a better understanding of how much the **LDEV664** students impact the Earth. Your answers will remain anonymous and your input will help to achieve an environmentally sound and sustainable society. ***Please***, answer ***ALL*** of the questions.

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Your Home Address:

____

Street # and name *City* *State* *Zipcode*

Food Footprint:

1. How often do you eat animal based products? (Beef, pork, chicken, fish, eggs, dairy products)
① Never (vegan)
② Infrequently (no meat, and eggs/dairy a few times a week) (strict vegetarian)
③ Occasionally (no meat or occasional meat, but eggs/dairy almost daily)
④ Often (meat once or twice a week)
⑤ Very often (meat daily)
⑥ Almost always (meat and eggs/dairy in almost every meal)

2. How much of the food that you eat is processed, packaged and not locally grown (from more than 200 miles away)?
① Most of the food I eat is processed, packaged, and from far away
② Three quarters
③ Half
④ One quarter
⑤ Very little. Most of the food I eat is unprocessed, unpackaged and locally grown.

Goods Footprint:

3. Compared to people in your neighborhood, how much waste do you generate (e.g., newspapers, packaging, cans, bottles, plastic containers, and motor oils, etc.)?
① Much less ② About the same ③ Much more

Shelter Footprint:

4. How many people live in your current household addressed above ('NOT in your hometown family')?
① 1 person ② 2 people ③ 3 people ④ 4 people
⑤ 5 people ⑥ 6 people ⑦ 7 people ⑧ or more people (_____ people)

5. What is the size of your home?
① 2500 square feet or larger ② 1900–2500 square feet
③ 1500–1900 square feet ④ 1000–1500 square feet
⑤ 500–1000 square feet ⑥ 500 square feet or smaller

6. Which housing type best describes your home?
① Free standing house without running water
② Free standing house with running water
③ Multi-story apartment building
④ Row house or building with 2–4 housing units
⑤ Green-design residence

7. Do you have electricity in your home?
① No ② Yes ③ Yes, with energy conservation and efficiency

Mobility Footprint:

8. On average, how far do you travel on public transportation each week (bus, train, and subway)?
① 200 miles or more ② 75–200 miles ③ 25–75 miles
④ 1–25 miles ⑤ 0 miles

9. On average, how far do you go by motorbike each week (as a driver or passenger)?
① 200 miles or more ② 75–200 miles ③ 25–75 miles
④ 1–25 miles ⑤ 0 miles

10. On average, how far do you go by car each week (as a driver or passenger)?
Note: The average car-driving American travels about 14,000 vehicle miles per year, or 270 miles per week.
① 400 miles or more ② 300–400 miles ③ 200–300 miles
④ 100–200 miles ⑤ 10–100 miles ⑥ 0–10 miles

11. Do you bicycle, walk, or use animal power to get around?
① Most of the time ② Sometimes ③ Seldom

12. Approximately how many hours do you spend flying each year?
Note: Every year, Americans fly an average of 4.7 hours per person on commercial airline. This is roughly equivalent to one round trip flight between Washington, DC and Chicago each year.

① 100 hours (approximately 1 coast-to-coast U.S. roundtrip *Each Month*)
② 25 hours (approximately 2–3 coast-to-coast U.S. roundtrip *Each Year*)
③ 10 hours (approximately 1 coast-to-coast U.S. roundtrip *per Year*)
④ 3 hours ⑤ Never fly

13. How many miles per gallon does your motorbike get?
Note: If you do not own a motorbike, do not answer this question.
① More than 80 miles per gallon ② 65–80 miles per gallon
③ 45–65 miles per gallon ④ 30–45 miles per gallon
⑤ less than 30 miles per gallon

14. How often do you ride your motorbike with someone else, rather than alone?
Note: If you do not own a motorbike, do not answer this question.
① Almost never ② Occasionally (about 25%) ③ Often (about 50%)
④ Very often (about 75%) ⑤ Almost always

15. How many miles per gallon does your car get?
Note: The average U.S. resident is '15–25 mpg'. If you do not own a car, estimate the average fuel efficiency of the cars you ride in.
①More than 50 miles per gallon ② 35–50 miles per gallon
③ 25–35 miles per gallon ④ 15–25 miles per gallon
⑤ Fewer than 15 miles per gallon

16. How often do you drive in a car with someone else, rather than alone?
① Almost never ② Occasionally (about 25%) ③ Often (about 50%)
④ Very often (about 75%) ⑤ Almost always

Environmental Value and Attitude:

Note: For each statement, please indicate whether you strongly agree, agree, disagree, strongly disagree, or have no opinion.

17. We are approaching the limit of the number of people that the Earth can support.
① Strongly agree ② Agree ③ Disagree
④ Strongly disagree ⑤ No opinion

18. The balance of nature is very delicate and easily upset.
① Strongly agree ② Agree ③ Disagree
④ Strongly disagree ⑤ No opinion

19. When humans interfere with nature, it often produces disastrous consequences.
① Strongly agree ② Agree ③ Disagree
④ Strongly disagree ⑤ No opinion

20. The earth is like a spaceship with only limited room and resource.
① Strongly agree ② Agree ③ Disagree
④ Strongly disagree ⑤ No opinion

21. There are limits on growth beyond which our industrialized society cannot expand.
① Strongly agree ② Agree ③ Disagree
④ Strongly disagree ⑤ No opinion

22. Mankind is severely abusing the environment.
① Strongly agree ② Agree ③ Disagree
④ Strongly disagree ⑤ No opinion

23. To maintain a healthy environment we will have to develop a steady-state economy where industrial growth is controlled.
① Strongly agree ② Agree ③ Disagree
④ Strongly disagree ⑤ No opinion

Background Information:

24. How would you describe the area where you live? Urban ______ Rural ______

25. How many years have you lived in your current residence? ______ Years _____ Months

26. Please indicate your:
a. Occupation: ____
b. Age: ______ Years **c. Gender:** Male ____ Female____
d. Ethnic/Racial identity:
① African American ② Caucasian ③ Hispanic
④ Asian/Pacific Islander ⑤ Other ( )

27. Please, indicate the number of people in each age category currently living with you in your current household ('Not in your hometown family'). Count the number ***including yourself***:
a. ___ : Under 6 years old **b**. ___ : Between 6 and 16 years old
c. ___ : Between 16 and 64 years old **d**. ___ : 65 years old and over

28. Total number of 'Male: ______' and 'Female: _____' in your current household (***including yourself***).

29. Your highest level of education:
① Less than high school ② High school/ GED ③ Some college/ vocational school
④ College graduate ⑤ Graduate/ professional school

30. Your marital status:
① Married ② Single (Never married) ③ Divorced ④ Widowed

31. *If you married*, are you and your spouse both working (a dual-income family)? Yes___ No___

32. What do you estimate the one-way distance, ***in miles***, from your home to your work? ____ Miles

33. On average, how many minutes does it take you to travel to work? _____ Minutes

34. Please, enter your 5 digit ***Workplace***'s zip code: __ __ __ __ __ and your spouse's zip code for workplace if he/she has: __ __ __ __ __ (Ex.: 77840)

35. ***Approximately,*** what do you estimate the one-way distance, ***in miles***, from your home to each of the followings that are ***most frequently*** used?

① Grocery Market: ____ miles	② Major Shopping Mall: ______ miles
③ Elementary School: ____ miles	④ Bank: ____ miles
⑤ Post Office: ____ miles	
⑥ Hospital: _____ miles	⑦ Nearest Park: ____ miles

36. Your yearly household income before taxes last year:
① Less than $14,000 ② $14,000 - $23,999 ③ $24,000 - $ 34,999
④ $35,000 - $ 49,999 ⑤ $50,000 - $ 69,999 ⑥ $70,000 - $ 100,000
⑦ Over $100,000

Supplementary Questions Associated with the LDEV671 Class:

Note: *For each statement, please indicate your opinion using '7 point' Likert scales.*

37. What was your level of knowledge on sustainable development prior to taking this course (1–7)? ______

38. Did the course increase your knowledge about sustainable development (1–7)? _____

39. Rank (1–7) the following course components based on how much they contributed to your knowledge about sustainable development:
a. Global/Biosphere ………………….. ________
b. National …………………………… ________

c. Institutional/Organizational ……… ________
d. Community/Regional …………….. ________
e. Site ……………………………….... ________
f. Building/Structure ………………… ________
g. Individual/Household …………….. ________

40. Did the course change your behavior related to sustainable practices in any way (1–7)? ______
If so, please find examples. For instance, have your general household patterns of travel changed in any way? Have your general household patterns of consumption of energy and materials changed in any way? Have your attitudes towards the environment changed?

41. Rank (1–7) the following course components based on how much they changed your behavior related to sustainable practices:
a. Global/Biosphere .... ________
b. National .... ________
c. Institutional/Organizational .... ________
d. Community/Regional .... ________
e. Site ……………………………….... ________
f. Building/Structure …………………. ________
g. Individual/Household …………….. ________

42. Do you think your ecological footprint changed in any way as a result of taking this course? Yes: ____ No: ____

43. Please, compare your 'EF account' (calculated from *http://myfootprint.org*) with your 'EF goal'. And describe what you are going to do to fill the gap in terms of your food, goods, shelter, and mobility footprint.

Thank you for your participation. Your answer will be treated confidentially. Please, return your completed questionnaire in the pre-addressed, postage-paid envelope provided.