US-China Education Review B 7 (2011) 960-974
Earlier title: US-China Education Review, ISSN 1548-6613

The Overlooked Dimension of Sustainable Education*

Ruth May, Vanessa Cox, Stan Kroder
University of Dallas, Dallas, USA

Geralyn Franklin
Stephen F. Austin State University, Nacogdoches, USA

While universities are increasingly focused on developing "green" practices on their campuses and integrating sustainability concepts into their curricula, few have considered the potential impact that their online learning programs may already be having on the environment. Online classes result in paper not printed, miles not driven and classrooms not lighted thereby reducing the carbon footprints of the sponsoring institutions. Yet, despite the growing enthusiasm of academic institutions to be recognized as "sustainable universities", most have overlooked the potential of their online learning operations to contribute to their long range goals for environmental stewardship. Consequently, the purpose of our paper is to present a proposed framework for measuring the sustainable impact of online learning which is currently being pilot tested at University of Dallas. We report results from the pilot data in the spring and summer semesters of 2009 and concludes with suggestions for establishing measurement models at other institutions where partnerships between university administrators, faculty and students hold promise for leveraging the sustainable impact of online learning.

Keywords: higher education, online, sustainable impact, measurement, carbon emissions

Introduction

More than 20 years after the World Commission on Environment and Development (1987) gathered to address the accelerating deterioration of human conditions and the environment, this group's definition has become the global standard in describing sustainable development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 8). Over the same period, consumers have excerpted greater pressures on companies to integrate sustainable practices into their businesses, and highly skilled individuals have increasingly avoided employment by firms that damage the environment in their production processes (Economist.com, 2009a). As a result, many organizations have begun to place the concept of sustainability at the center of their strategic thinking, recognizing that an affirmative stance on sustainable challenges holds the potential for generating strategic distinction in the marketplace (Porter & Kramer, 2006).

Although educational institutions have generally lagged the private sector in leveraging sustainability for competitive advantage, particularly in the US, recent progress by colleges and universities to close this gap

* **Acknowledgments:** The authors of the paper wish to thank the following individuals for their contributions to the design and execution of the pilot study: John Frey, Americas Sustainability Executive with Hewlett-Packard Company; Jeff Borden, Senior Director of Teaching and Learning for Pearson-eCollege; Anthony Hardy, Associate Director of Facilities at University of Dallas, Patrick Daly, Associate VP for Administration of Business Services at University of Dallas, and our Graduate Assistant in the COB at University of Dallas, Nestor Via.

Ruth May, professor, College of Business, University of Dallas.
Vanessa Cox, director of online learning, College of Business, University of Dallas.
Stan Kroder, Ph.D., associate professor, College of Business, University of Dallas.
Geralyn Franklin, Ph.D., associate dean, College of Business, Stephen F. Austin State University.

demonstrates a growing awareness of the potential benefits to be gained by making sustainability a centerpiece of higher education. Indeed, climate change may now be the primary focus of institutions of higher learning that wish to integrate sustainable concepts into their operations (Rappaport & Creighton, 2007).

Paralleling the increase in concern for the environment, Internet-based education has grown exponentially as illustrated in Figure 1. In the fall of 2002, 1.6 million students in higher education in the US took at least one online course, which accounted for approximately 11% of US college enrollments (Babson Survey Research Group, 2003). By the fall of 2008, the number of students in the US taking at least one online course had jumped to over 4.6 million, representing an increase in enrollment of 187% and more than 25% of US students in higher education (Babson Survey Research Group, 2009).

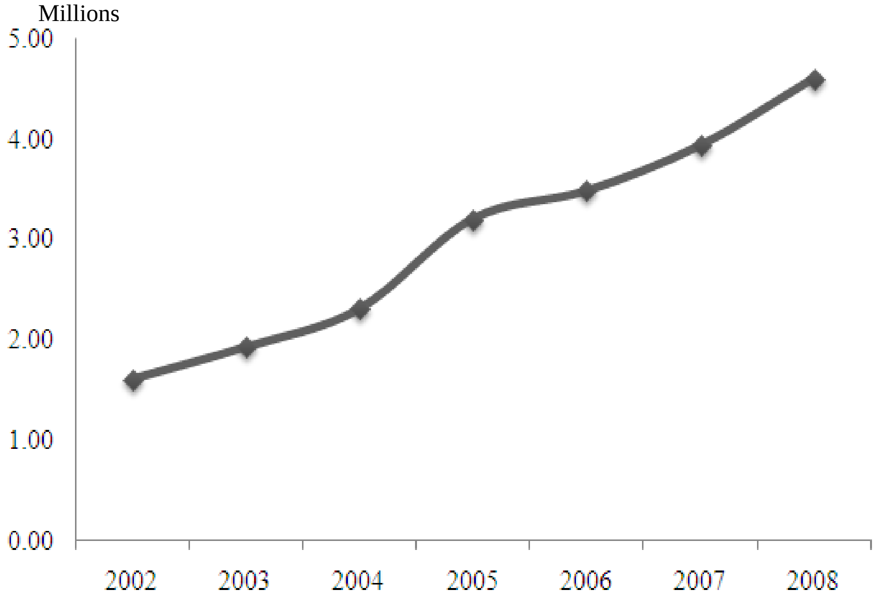

Figure 1. Growth in online students. Source: Babson Survey Research Group (2003; 2009).

In early 2009, as universities became increasingly pronounced in their "green" messaging, we began to wonder whether these same institutions had considered the possibility that their distance learning programs might be making a greater impact on the environment than many of their nascent green initiatives. More importantly, we wondered whether any aspiring champions of sustainability had attempted to measure the environmental outcomes which are associated with online learning. A thorough search of the literature revealed only one study, conducted at the UK-OU (UK Open University), which attempted to quantify the environmental effects of campus-based classes versus print-based and online courses (Roy, Potter, & Yarrow, 2008). While the UK-OU study represents the pioneering effort to document environmental consequences of distance learning, it is not without its limitations. As a result, we initiated a pilot study for the purpose of developing a measurement process to quantify the environmental impact of online learning in the COB (College of Business) at our university located in a large metropolitan area of the southwestern US. The measurement process was piloted in the spring and summer semesters of 2009 using archival and survey data. Consequently, the purpose of this paper is to provide an overview of the measurement process and report the findings from the spring and summer terms. More broadly, our goal is to generate discussion among scholars and administrators regarding the challenges and potential benefits of measuring the environmental consequences of online learning and encourage administrators, faculty and students to partner in leveraging the sustainable impact of online education.

Foundations of Green Education

The most common foray by colleges and universities into the realm of sustainability is to create a culture of environmental stewardship through the introduction of recycling, waste reduction and environmental awareness programs (Button, 2009). As "green" initiatives have increased across campuses, universities have simultaneously focused on integrating sustainability concepts into their for-credit curricula and not-for-credit continuing education offerings. At Harvard Business School, for instance, enrollment in non-credit courses focused on sustainability has surged by more than 70% since 2007 (Galbraith, 2009). COB, in particular, have stepped up efforts to integrate issues of social and environmental stewardship into their degree programs (Jabbour, 2010) in response to the needs of the corporate community as well as the urging of accrediting bodies, such as AACSB (The Association to Advance Colleges and Schools of Business) international. This premier accrediting body has increasingly promoted business school leadership in sustainability (Hart, 2009) by sponsoring speakers at various conferences and seminars as well as hosting its own sustainability conference (AACSB, 2009). Yet, despite of the growing interest in sustainability in academia, scholars (Graedel, 2002) have argued that if universities are going to legitimately call themselves "sustainable", they must first establish quantitative targets for their environmental initiatives which are clearly defined and defendable. In fact, some scholars (Nicolaides, 2006) have declared effective EMS (environmental management systems) for sustainable universities to be an ethical imperative.

In response to calls for greater "green" accountability, a number of researchers have formulated models for determining an institution's ecological footprint on various resource dimensions. For instance, a team at Rowan University (Riddell, Bhatia, Parisi, Foote, & Imperatore, 2009) assessed the consumption of all electricity, natural gas and oil on their campus for an entire year and found that emissions could be reduced by replacing on-campus steam production, which accounted for 57% of total campus emissions, with two cogeneration facilities. Similarly, a group at Yale University proposed an adaptable metric strategy for targets related to carbon emissions, energy use, recycling and water consumption which reflects the idea of sustainability as both local and global in scope (Rauch & Newman, 2009). Other institutions of higher learning have successfully developed measurement standards by partnering with industry and special interest groups. For example, the University of New Hampshire developed one of the first tools for documenting GHG (greenhouse gas) emissions in institutions of higher education through its partnership with CA-CP (clean air-cool planet). To date the jointly developed inventory tool has been adopted by more than 1,000 universities (Cleaves, Pasinella, Andrews, & Wake, 2009).

While efforts at the university level are to be applauded, the greatest potential for institutionalizing frameworks and protocols for sustainable measurement are through large scale consortia of universities that agree to cooperate in furthering a "green" agenda. Perhaps, the largest and most visible group of this kind is the ACUPCC (American College and University Presidents Climate Commitment), founded by nearly 400 charter institutions from December 2006 to September 2007 (White, 2009). This initiative, which had grown to 665 signatory colleges and universities by the end of 2009, requires that members commit to initiating two or more of seven tangible action options to reduce their GHG emissions within two years after a self-determined implementation start date (AASHE (Association for the Advancement of Sustainability in Higher Education), 2010). Interestingly, while all seven tangible action options in the ACUPCC are focused on physical and operating dimensions of the member institutions, none of them focus on the potential benefits to be gained by shifting the delivery of their primary product—education to the Internet.

More recently, the AASHE, which administers the reporting program for the seven action options for ACUPCC, created its own STARS (sustainability tracking, assessment and rating system). This new framework is a self-assessment benchmarking tool that can be used by higher education institutions to measure their progresses towards sustainability and achieve recognition for their efforts. Yet, despite of including 67 criteria on its sustainability checklist, spanning three categories—ER (education and research), OP (operations) and PAE (planning, administration and engagement), the STARS framework makes no mention of education delivery mechanisms as a means of achieving sustainable advantage. In fact, we found no evidence of any coalitions, colleges or universities in any country attempting to document the potential environmental benefits of online learning and save the one aforementioned study at UK-OU (Roy et al., 2008).

In the UK-OU project, Roy et al. (2008) compared 13 campus-based courses and seven print-based and online courses and concluded that distance learning as a delivery method consumed 87% less energy and emitted 85% less CO_2 than traditional brick and mortar classes. Ninety percent of the savings in carbon emissions were attributable to differences in fuel consumption among student groups and energy used to power campus facilities. In addition, the UK-OU researchers concluded that courses which are fully online offer only a minimal environmental advantage over mainly print-based distance learning classes in which hard copy materials were provided to the students, because the online classes required more energy for computing and paper for printing by students. Yet, we argued that the conclusions of the UK-OU study are premature and insufficiently substantiated for several reasons. First, one of the seven courses in the study’s sample classified as distance-based, three were not actually conducted online. Instead, they were primarily campus-based classes with an Internet-based companion tool, and thus, do not capture the true essence of pure virtual education. Second, only one of the seven courses in the sample categorized as distance-based was really conducted completely online, and this course was offered by another unnamed university, thus, raising questions about the ability of the authors to draw conclusions about fully online courses, particularly those offered outside the boundaries of their own institution. Third, data on students’ travel, paper consumption, printing and residential heating that were used as the basis for findings generalized to all distance learning across the UK (Roy et al., 2001) were collected from only 66 students in three classes in the UK-OU study, thus, raising concerns about sampling adequacy and the validity of the conclusions. While we recognized the UK-OU study as groundbreaking work, these limitations justify additional research on the sustainable impact of online learning. In the following section, we discuss the theoretical basis that underlies our measurement framework.

The Triple Bottom Line of Sustainability

One of the most common models of sustainability applied in a business context is Elkington’s (1994) TBL (triple bottom line). As depicted in Figure 2, Elkington’s (1994) central thesis is that managers have a fiduciary responsibility that is three dimensional rather than one dimensional. Consequently, they must act in the interest of their shareholders to maximize profits while simultaneously serving as responsible trustees of the people with whom and for whom they conduct business. In addition, they must serve as responsible fiduciaries of the planet that they exploit for resources and impact with the byproducts of their productions.

In applying Elkington’s (1994) theoretical framework to our study, we proposed that online learning provides an opportunity for institutions of higher learning to positively impact their financial bottom lines, while providing social benefits to students and faculty and environmental advantages to the planet. In other words, online learning is a means through which university administrators can attempt to fulfill their three-dimensional responsibilities to the TBL. While we focus on the impact of online delivery for all three dimensions of Elkington's (1994) TBL in our broader project, we limit our discussion here to the potential benefits for the planet, starting with the digital content, which is the core driver of the environmental benefits. Specifically, as the amount of digital content increases, costs associated with traditional paper and printing delivery decline for institutions, as does the carbon footprint generated by institutions. Furthermore, as courses are shifted from on campus to online delivery, students and instructors drive fewer miles to and from campus and turn on fewer lights in brick and mortar classrooms, thus, further reducing carbon emissions. In the sections, we will describe the design and implementation of our pilot study to quantify the environmental impact of paper not printed, miles not driven and classrooms not lighted. We follow with the carbon emissions results for each of these byproducts of online learning using data from the spring and summer semesters of 2009 and conclude with suggestions for universities interested in documenting the sustainable outcomes of their online learning programs.

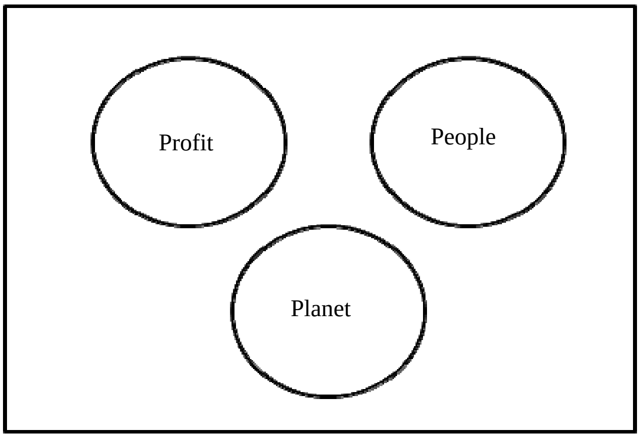

Figure 2. Elkington's triple bottom line. Source: Elkington (1994).

Archival Data Collection

The pilot study was initiated in January 2009 with the overarching goal of developing a measurement framework for quantifying the impact of all online MBA (Masters of Business Administration) courses in the COB. Given our proposition that the core driver of all environmental benefits of virtual learning is the digital content, we set two initial goals for the study: (1) to establish the definition of a virtual page; and (2) to create a rubric and audit protocols for counting virtual content.

We defined a virtual page as either actual pages in a paginated document or the equivalent number of pages in a Microsoft Word document for scrolling digital content. In addition, we classified virtual pages into three categories based on the likelihood that they would remain virtual, after students' printing habits were taken into account. The three categories of content included: (1) obvious printable downloads; (2) non-obvious printable digital content; and (3) non-printable digital content. Obvious printable downloads include items, such as syllabi, Powerpoint slides and case documents, which are intended to be downloaded and printed by students.

Non-obvious printable content includes items, such as chat sessions, interactive discussions, as well as directives to students. While there are no system tools which prevent students printing non-obvious printable content, these items are not necessarily intended for printing by the instructor. Non-printable digital content includes items, such as grade book scores and feedback, along with exam questions protected by plug-ins that prohibit the printing of designated content.

Once the total number of virtual pages in each online course was determined, we multiplied this figure by the number of students enrolled in each class to determine the total digital content provided in each online course. This approach is consistent with considering the sum of pages in all copies of a traditional textbook sold to every student purchaser versus assuming that a single copy of a textbook is sold and shared by all students in a class. Using a multi-user method to determine total pages per course provides a more accurate measure of the total amount of digital content provided by the institution across all courses in a single semester. To ensure accuracy and reduce the risk of double counting content items, specific counting protocols were established and applied by a single counter in both spring and summer semesters of 2009. External content located on other Web sites and eBooks were excluded from the count of virtual pages. Collectively, the sum of the pages in all three-page categories and all online courses represented the total number of virtual pages provided by the COB in a given semester.

Survey Data Collection

In addition to the primary archival data collection on virtual pages, we also surveyed students taking online MBA courses in order to acquire information on their printing habits and their physical locations. We also asked about their “would-be” commuting distances and specific vehicle data, if they were to drive to and from our central campus to take their classes rather than take them online. The students’ responses provided the means to estimate the number of virtual pages offered by our institution that ultimately remained virtual (i.e., were never printed). In addition, the survey data allowed us to calculate how many miles students did not drive to and from campus by taking their classes online, and in what type of vehicle. Collectively, the survey data, coupled with the archival data on digital content, provided the means to calculate estimates of the COB’s carbon footprint based on amount of paper not printed, miles not driven and classrooms not lighted for the pilot period. In order to establish a clear sampling boundary for the study, we audited only fully online courses delivered in an asynchronous delivery model in the MBA program in the COB. In spring of 2009, 48 online sections of MBA courses were offered, and in the summer term, 44 online sections were conducted. Thus, the course inventory used to compute total digital content for the COB consisted of 92 online course sections for spring and summer semesters of 2009 combined.

Sample

The student sample consisted of online MBA students enrolled in the spring and summer semesters of 2009. Students were invited to participate in the study via a notification message in the online course system one week prior to launching the survey. Participation was voluntary. Of 644 online students asked to participate in the spring semester term of 2009, 539 provided complete, useable data generating a response rate of 84%. In the summer of 2009, 621 students were enrolled and 500 provided useable responses for a response rate of 81%. Thus, the combined sample from both semesters was 1,039 students at an overall response rate of 82%. Across both semesters, the student sample ranged in age from 20 to 63 with an average age of 37. In the spring term

78% of respondents identified the metropolitan area where the university is located as their primary home base, while 75% of summer respondents reporting living within the metropolitan area. Thus, approximately one quarter of sample respondents lived outside the metropolitan area of the university, some within the US and some in other countries.

In order to offset the effects of individual printing on total virtual content offered by the COB, students were asked to approximate their percentage printing of obvious downloadable and non-obvious printable content. In both document categories, they were asked to select a percentage that they typically printed across all online courses from a drop down list ranging from 0% to 100% with 10% intervals. We elected to ask students about their printing behaviors in general rather than ask for a specific page count or rate for a specific class, because we believed that the probability of getting reliable responses about printing habits at such a level of specificity was relatively low and would likely reduce our response rate to the survey.

To calculate the number of miles not driven to campus by online students, we asked respondents to provide the number of miles they would have driven to and from our main campus, if they had taken a class at this location, and whether they would have driven their own vehicle, ridden with others, walked or taken public transportation. In order to derive the most conservative measure of overall student mileage, we only counted students who identified the university's metro area as their home base and indicated that they would have driven their own vehicle to campus, if they had not taken their classes online. These parameters resulted in a sub-sample of 420 local area students who provided mileage and vehicle data for the spring semesters and 367 students who provided data in the summer semester.

To derive the most conservative estimate of electricity saved by the number of brick and mortar classrooms that are not lighted, because online classes are held virtually, we asked every student to identify the number of classes they were taking online and whether they would have been willing to take these same class(es) on campus, given their geographic location, work/travel schedule or personal circumstances. Students responded on a continuum from zero (i.e., I am certain I would have still taken it) to ten (i.e., There is absolutely no way I would have taken it). In the spring semester of 2009, 182 students respondents, or 34% of the sample, indicated that they were at least 80% sure that they would not have taken their classes on ground, if they had not been offered online. In fact, 132 of these 182 students were 100% positive and they would have dropped their classes rather than move to campus. In summer semesters, 183, or 37% of the 500 students indicated they would not have taken their classes on campus, if the classes had not been available online. In sum, approximately 35% of online students in both semesters would have forgone their classes entirely rather than move to a campus location. This figure was important for us to know in order to estimate the number of classrooms that would have been needed, and classroom hours of electricity usage that would have been generated, if all online students who were willing to come to campus to take their classes had been accommodated physically rather than served virtually.

Results

Based on the results from the digital content rubric, the COB provided 1,526,412 pages of digital content or an average of 16,591 virtual pages per online class for the spring and summer terms of 2009 combined. Yet, the number of virtual pages that remained in digital format (i.e., were not printed by students) could only be derived by applying data captured on student printing behaviors. Results from the surveys indicated that students in the summer semesters of 2009 printed an average of 53% of obvious downloadable pages and 30%

of non-obvious printable content. Students in the summer semesters of 2009 printed an average of 49% and 32% in the same categories, respectively. The net results were that 543,275 pages remained virtual in the spring semester and 320,028 pages remaining virtual in the summer semesters. Thus, a total of 863,303 pages of the more than 1.5 million pages of digital content provided by the institution remained in digital format, with their corresponding economic and environmental consequences, even after student printing behaviors were taken into account for both semesters.

To quantify the environmental impact of the digital content, we relied on the HP (Hewlett-Packard) carbon footprint calculator, which is designed to assess printer energy consumption and associated carbon output as well as quantity of paper used and related monetary costs using inputs of number of employees, types of printers and number of pages printed.

Table 1 provides the gross institutional savings generated in pounds of paper, kilowatts, US dollars and tonnes of CO_2 emissions across all online courses in spring and summer of 2009. While the gross savings are real from an institutional viewpoint, the printing habits of students must be taken into account in order to determine the net real environmental benefits of the digital content. To compute our adjusted results, we entered the total number of online seats (i.e., the sum of the number of online classes taken per student) in each term along with students' responses for types of printers they used and the number of pages they did not print in each term. After accounting for printing habits and types of printers used by students, the net results for the planet remained positive as illustrated in Table 1. It is important to note that in reviewing the adjusted savings, the net environmental benefits are nonlinear relative to the gross environmental savings. In summary, for the first eight months of 2009, after adjusting for student printing behaviors, the delivery of all digital content in online MBA classes in the COB resulted in 9,509 pounds of paper not consumed, 65,487 kilowatts of energy not used, $37,341 dollars saved by the university and 47.05 tonnes of CO_2 not emitted into the atmosphere.

Table 1

Environmental Impact of Digital Content

Savings in	Gross savings			Adjusted savings for student printing		
	Spring 2009	Summer 2009	Year to date	Spring 2009	Summer 2009	Year to date
Paper (lb)	10,462	6,327	16,789	5,978	3,531	9,509
Energy(kWh)	154,991	143,654	298,645	33,538	31,949	65,487
Energy and paper (USD)	$20,243	$17,098	$37,341	$20,243	$17,098	$37,341
Carbon emissions-CO_2 (tonnes)[a]	103.16	93.31	196.47	24.85	22.2	47.05

Note. [a] A tonne or MTCE (metric tonne carbon equivalent) is a mass equal to 1,000 kg or 2,204.622262 lbs.

To determine the environmental impact of miles not driven to campus, we entered the mileage and vehicle information provided by students into the carbon emissions estimator at Website, Carbonfootprint.com (2009). This tool uses conversion factors sourced from the US EPA (Environmental Protection Agency), the Green House Office in Australia, the VCA (Vehicle Certification Agency) in the UK and the CSA (Canadian Standards Association) GHG registries in Canada. As shown in Table 2, results from data collected only from the students in the local metropolitan area who would have driven their own vehicles indicate that in the spring semester of 2009, 123,882 miles were not driven to campus by students and 131,679 miles were not driven from campus to students' regular overnight locations. In summer semesters of 2009, the same numbers were 92,671 miles not driven to campus and 108,110 miles not driven from campus, respectively. Cumulatively, online students drove 456,342 fewer miles in the first eight months of 2009 as a result of taking their classes online versus on campus. We estimated the miles not driven by instructors by taking the average number of miles not driven per student in each semester, 608 miles in spring and 547 miles in summer and multiplied the average mileage by number of instructors in each term. As shown in Table 2, the figure was 53,860 total miles not driven by online faculty for the two semesters. In summary, the 510,202 miles not driven by students and faculty in the first eight months of 2009 saved 213.77 tonnes of CO_2 which otherwise would have been emitted into the atmosphere of the metropolitan area in which the university is located.

Table 2

Environmental Impact of Miles Not Driven

Savings in	Spring 2009	Summer 2009	Year to date
# of students who drive in metro area	420	367	787
Student miles not driven to campus	123,882	92,671	216,553
Student miles not driven from campus	131,679	108,110	239,789
Total student miles not driven	255,561	200,781	456,342
Total instructor miles not driven	29,792	24,068	53,860
All miles not driven	285,353	224,849	510,202
Carbon emissions-CO_2 (tonnes)[b]	119.3	94.47	213.77
Adjusted CO_2[c]	63.72	49.3	113.02

Notes. [a] Total instructor miles driven = Average total miles driven per student × number of instructors; [b] A metric tonne carbon equivalent (MTCE) is a mass equal to 1,000 kg or 2,204.622262 lbs; [c] Adjusted carbon emissions = Only miles driven from campus.

Some would argue that even though the university requires students to drive to and from campus to attend classes that most of these individuals would still have driven somewhere in late afternoon leaving their places of work, and thus, would not have saved all of the emissions which we attributed to miles driven to campus. In keeping with our approach to err on the side of being conservative in our measurement framework, we adjusted our total year to date emissions reported in the COB carbon footprint based just on the "would be" miles reported as driven from campus to overnight locations. With this adjustment applied, the CO_2 savings recorded for the two terms in the pilot study was 113.02 tonnes of emissions. It is also important to remember when considering this environmental savings that these results represent the miles not driven only by students living in the local metro area of the university. Thus, the miles that may not have been driven by the remaining 25% of online students who live outside the metropolitan area have not been accounted for in our measurement model.

Finally, we considered the US dollars and CO_2 emissions saved by the number of brick and mortar classrooms not lighted during the first eight months of 2009 as a result of a portion of our MBA classes being offered totally online. The 92 online courses offered in the spring and summer semesters of 2009 were evaluated for the total number of seats in each section. The online delivery method did not require a physical seat limit and the total number of actual seats in an online classroom could exceed the physical classroom seat capacity. Therefore, the 92 online courses would require 105 physical classroom sections to accommodate the average on-campus seat capacity. As it can be seen in Table 3, if all online courses had been shifted outright to campus in spring and summer semesters, this would have required 105 additional classroom spaces on campus. Given the number of hours that each of these class sections would have met, this shift of online classes to campus would have generated 4,123 additional hours of classroom lighting that is currently not required, because all of these course sections are taught totally online. Using historical data on energy usage and costs provided by the university's associate director of facilities and our director of business services, we estimated a cost of one hour of classroom lighting for COB classroom space at $5.02 per hour. Thus, as shown in Table 3, the gross institutional savings in US dollars year to date for the 4,123 hours of classroom lighting currently not required is $20,695. The corresponding gross savings for the environment is 107.11 tonnes of CO_2. Yet again, we took a more conservative approach to measurement and adjusted classroom hours of lighting to reflect the availability of additional seats in existing classes already held on campus and students' willingness to transfer from online classes to brick and mortar classrooms.

Table 3

Environmental Impact of Brick and Mortar Classrooms Not Lighted

Savings in	Gross savings			Adjusted savings for existing capacity and probable student drops		
	Spring 2009	Summer 2009	Year to date	Spring 2009	Summer 2009	Year to date
Online class sections not on campus	56	49	105	50	41	91
Hours of classroom lighting not required	2,210	1,913	4,123	1,946	1,577	3,523
Energy savings (USD)	$11,092	$9,603	$20,695	$9,766	$7,917	$17,683
Carbon emissions-CO_2 (tonnes)[a]	57.41	49.7	107.11	50.55	40.97	91.52

Note. [a] A tonne or MTCE is a mass equal to 1,000 kg or 2,204.622262 lbs.

The survey data indicated that approximately 35% of online students would not transfer to campus-based classes, if their classes were not offered online. Thus, we assumed a worse-case scenario that across all online sections, the hypothetical shift from online to campus would result in one-third of existing online students dropping their classes. Then, we compared the remaining number of students in each online class to the minimum headcount required to offer a graduate level class at our university, which is ten students. Next, if ten or more students remained in each online section, after the hypothetical loss of one third of the class enrollment, we checked to see if there were enough spare seats in existing sections of these same courses on campus to accommodate the remaining students. If there were spare seats on campus, and this dropped the headcount of the online class below ten, then, we assumed the online class would be cancelled and not shifted outright to campus. However, if there were not sufficient spare seats in existing course sections on campus to accommodate the online students willing to shift, or if the same courses offered online were not even available on ground in a particular semester, then the online class remained in our adjusted count of online courses that we would have shifted to campus, thus, creating additional demand for lighting. The final results in Table 3 show that even after adjusting for spare seat capacity and probable student drops, if 91 online sections in spring and in summer terms of 2009 had been conducted on campus instead of online, these classes would have required an additional 3,523 hours of classroom lighting at a cost to the university of $17,683. However, by not turning on the lights for these hours, the online courses for spring and summer in the COB prevented 91.52 tonnes of CO_2 from being emitted into the atmosphere.

The overall summary of CO_2 savings for the full pilot period of January through August 2009 is presented in Table 4. As indicated, the gross savings, before the aforementioned adjustments, was 517.35 tonnes of carbon emissions. After adjusting for student printing of virtual content and applying a more conservative measurement approach to miles not driven and classrooms not lighted, the net environmental impact as illustrated in Figure 3 was a combined savings of 251.59 tonnes of CO_2, with the greatest environmental impact attributable to the miles not driven by online students and faculty.

Table 4

Carbon Emissions Savings Summary for the Planet

Savings in	Gross savings			Adjusted savings		
	Spring 2009	Summer 2009	Year to date	Spring 2009	Summer 2009	Year to date
Digital content: paper not printed	103.16	93.31	196.47	24.85	22.2	47.05
Gasoline: miles not driven	119.3	94.47	213.77	63.72	49.3	113.02
Electricity: classrooms not lighted	57.41	49.7	107.11	50.55	40.97	91.52
Total carbon emissions-CO2 (tonnes)[a]	279.87	237.48	517.35	139.12	112.47	251.59

Note. [a] A tonne or MTCE is a mass equal to 1,000 kg or 2,204.622262 lbs.

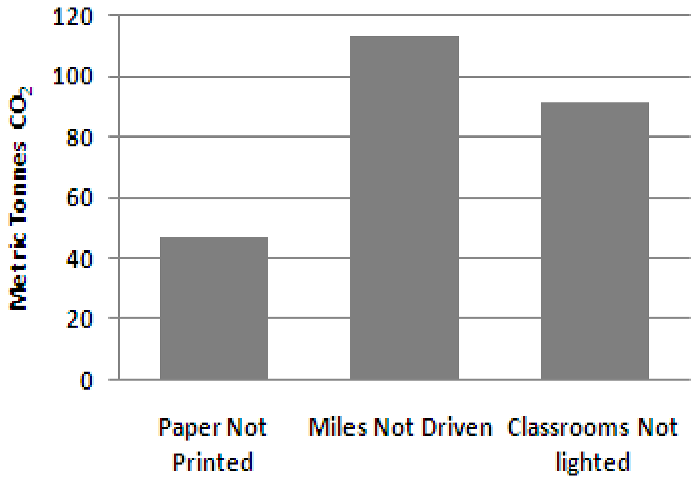

Figure 3. Breakdown of 251.59 carbon emissions savings for planet.

Discussion and Conclusions

This paper reported on the results from the first eight months of 2009 in a pilot study currently underway in the COB at a university located in a metropolitan area of the Southwestern US. The purpose of the pilot study is to develop a framework for measuring the environmental impact of online learning, particularly the impact of digital content delivery on CO_2 emissions through paper not printed, miles not driven and classrooms not lighted. Although many universities have stepped up efforts to integrate sustainability concepts into their curricula and their campus operations, we know only one other study at the UK-OU (Roy et al., 2008) that has attempted to quantify the environmental effects of online learning.

Using primary data from an audit of virtual content along with survey data from 1,039 online MBA students in the spring and summer semesters of 2009, we documented positive economic and environmental benefits from online course operations. After adjusting for the printing behaviors of online students, which represents a more conservative measurement approach, the offering of virtual content produced environmental benefits totaling 9,509 pounds of paper not printed and 47.05 tonnes of CO_2 not emitted. The online course offerings in our MBA program also resulted in a total of 456,342 student miles not driven to and from campus in the spring and summer semesters of 2009, with only local area students who drive their own vehicles accounted for. Once the 53,860 miles were added for the 93 instructors who taught in the same period, the resulting mileage savings topped half a million miles for the first eight months of the year, generating a CO_2 emissions savings of 213.77 tonnes. When only the miles driven from campus to overnight locations were considered, the CO_2 savings was still 113.02 tonnes.

Finally, offering 105 MBA course fully online in the spring and summer semesters of 2009 resulted in over 4,000 hours of classroom lighting not required at the university's physical campus. Even when we considered that approximately one-third of online students would drop their classes, if asked to move to campus, and that there were only a limited number of spare seats available in existing brick and mortar course sections, we were left with an adjusted figure of 91 online sections that would require an additional 3,523 hours of classroom lighting, if they were moved back to brick and mortar facilities. This hypothetical increase in electricity usage would cost the university nearly $18,000 and would generate 91 tonnes of CO_2 which are currently not going into the atmosphere, because these classes were offered entirely online in an asynchronous format during spring and summer semesters of 2009. In the case of our institution, which is operating near maximum seating capacity on campus, this shift would also result in additional costs for renting space, so as not to lose the online students entirely. While these are very real cost considerations for the university, they extend beyond the scope of this particular paper.

In summary, the total adjusted environmental impact from online operations during the spring and summer semesters of 2009 was a savings of 251.59 tonnes of CO_2. Notably, the area of highest impact on the carbon footprint of the institution was in miles not driven to campus, while the institution's emissions savings linked to digital content was most directly affected by students' decisions related to printing. Overall, the total savings in carbon emissions can be visualized as approximately 63 round trip flights from New York to Los Angeles not taken (Dunn, 2009) or 48 average American passenger vehicles not driven for one year (EPA, 2009).

While the measurement process described here makes an incremental contribution to the dearth of literature on the sustainable impact of online course delivery, it is not without its limitations. First, the pilot study is located at a university in a large, widely dispersed metropolitan area, and thus, the results may not generalize to other institutions or geographic settings. Second, while the survey response rate from our sample of graduate students was excellent, the same level of interest or participation may not be replicated with an undergraduate population, as evidenced in the significant variations in responses across student levels in the UK-OU project (Roy et al., 2008). Third, we did not attempt to account for the additional energy consumed by students when using their computers for online coursework. While some have pointed to the additional energy consumption attributable to computers as an offset to sustainability efforts, and the negative environmental consequences of their production and disposal (Economist.com, 2009b; Smith, 2004), we suspect that even if students and faculty were not using their computers for a certain number of hours directly attributable to online coursework, they would likely still be using their computers for alternative work or leisure activities. Moreover, many individuals leave their computers active 24 hours a day, seven days a week, so the hours required of online courses in our MBA program are less consequential from the standpoint of energy consumption. Nonetheless, we acknowledge that CO_2 emission from additional computer usage remains a valid concern and represents an opportunity for subsequent research on how to measure the offsetting effects against savings in CO_2. Finally, the measurement boundaries for our pilot program do not reflect all aspects of digital content delivery in our COB, because hybrid classes and Web companion tools used in campus classes were not included, so technically, the results are understated. Yet, the narrower unit of analysis provided us with a cleaner sampling boundary, which is important in developing a measurement process. Despite of these limitations, the results of the pilot program demonstrate the potential value of considering the environmental consequences of digital content delivery. Moreover, while the process we have described, starting with the number of virtual pages, is only one component in a broader framework for measuring the sustainable impact of online learning, and our intention was to provide an initial blueprint for other educational institutions to follow in determining: (1) the volume of digital content they provide; (2) the offsetting effects of student printing behaviors on the institution's digital content delivery strategy; and (3) the economic and environmental benefits that can be derived from a reduction in miles driven by students and faculty and in brick and mortar classrooms lighted.

More broadly, the study illustrated the importance of considering the combined effects of institutional and stakeholder choices on the environment. To this end, we would argue that university administrators, faculty and students have a unique opportunity to positively influence the profits and planet dimensions of the TBL via online learning. Specifically, administrators can be more proactive in increasing online offerings in various academic units and mandating the continuous tracking of benefits and costs associated with digital delivery in ways similar to how they are already tracking other "green" initiatives. Administrators can also consider establishing "stretch goals" for their online operations in both gross and per capita terms. At the COB level, deans can encourage faculty members to engage in more action research in sustainability in order to become a part of the phenomenon that they are teaching rather than focusing solely on publishing in peer-reviewed journals using secondary data (Hart, 2009).

Students have a role in determining how much of an institution's digital content remains virtual as a result of their printing activities. Therefore, it is important to involve students in discussions of the potential environmental consequences of e-learning. Students need to understand the power that they have to positively impact the institution's carbon footprint simply by becoming more aware of how much they print and how their print decisions have direct environmental consequences. In general, today's students are more likely to be environmentally conscious than their predecessors, according to a recent study conducted by the HERI (Higher Education Research Institute) (Pryor et al., 2008). While the level of social concern demonstrated by American Gen Y individuals is encouraging, these young people cannot make a meaningful contribution to the solution to a problem, if they are not made fully aware of their potential to influence its outcome.

Instructors also have a unique opportunity to contribute to the sustainable efforts of their institutions by rethinking their design of course content in keeping with the "less is more" proposition. For instance, instructors should consider the effectiveness of pure text content and how is it likely to be perceived by students, particularly those in the Gen Y demographic. Recent studies show that Gen Y individuals prefer learning through multi-media and multi-task designs rather than traditional text delivery (Dede, 2005; 2009). With this in mind, online instructors should consider including more effective pedagogical options in their courses relative to text for increasing students' engagement and reducing the temptation to print. These options might include relevant videos and student-directed "scavenger hunts" based around a central theme or problem which prompts students to focus on collecting and analyzing virtual content as opposed to printing and memorizing basic text.

In conclusion, we encourage future research that considers other aspects of the sustainable impact of online learning. At the same time, researchers must account for the offsetting effects of the behaviors of students, instructors and other institutional stakeholders, since they ultimately determine the net results of institutional decisions on the environment. We hope that our initial efforts to develop a measurement framework will prompt greater discussion of the potential benefits of online content delivery and the corresponding challenges involved in measuring these benefits among scholars and administrators in the wider educational community.

References

AACSB. (2009). *B-school facilities resource center*. Retrieved February, 2010, from http://www.aacsb.edu/resource_centers/facilities/buildinggreen.asp

AASHE (Association for the Advancement of Sustainability in Higher Education). (2010). *ACUPCC reporting system: Tangible action statistic*s. Retrieved January, 2010, from http://acupcc.aashe.org/ statistics-tangible.php

Babson Survey Research Group. (2003). *Sizing the opportunity: The quality and extent of online education in the United States, 2002 and 2003*. Retrieved January, 2010, from http://www.sloanconsortium.org/publications/survey/index.asp

Babson Survey Research Group. (2009). *Staying the course: Online education in the United States*. Retrieved January, 2010, from http://www.sloanconsortium.org

Button, C. E. (2009). Towards carbon neutrality and environmental sustainability at CCSU. *International Journal of Sustainability in Higher Education, 10*(3), 279-286.

Carbonfootprint.com. (2009). *Carbon footprint calculators*. Retrieved December, 2009, from http://www.carbonfootprint.com

Cleaves, S. M., Pasinella, B., Andrews, J., & Wake, C. (2009). Climate action planning at the University of New Hampshire. *International Journal of Sustainability in Higher Education, 10*(3), 250-265.

Dede, C. (2005). Planning for neomillennial learning styles: Shifts in students' learning style will prompt a shift to active construction of knowledge through mediated immersion. *Educause Quarterly, 28*(1), 7-12.

Dede, C. (2009). Immersion in learning: Augmented realities for middle school math and language arts. Paper presented at *the Second Annual Ubiquitous Learning: An International Conference*. Boston, M. A.. December 5, 2009.

Dunn. C. (2009). *Reduce your carbon footprint by half in three steps: Plant green*. Retrieved February, 2010, from http://www.plantgreen.discovery.com

Economist.com. (2009a). *Consumers and employees have made a strong business case for firms to adopt sustainability*. Retrieved February, 2010, from http://www.economist.com/businessfinance/management/displaystory.cfm?story_id=E1_TQPDTQSQ

Economist.com. (2009b). *Computing climate change*. Retrieved February, 2010, from http://www.economist.com/world/international/displaystory.cfm?story_id=E1_TQNJSDPG

Environmental Defense Fund. (2009). *How your pollution is calculated—Fight global warming*. Retrieved December, 2009, from http://www.fightglobalwarming.com

EPA. (2009). *Emission facts: Greenhouse gas emissions from a typical passenger vehicle*. Retrieved December, 2009, from http://www.epa.gov/OMS/climate/420f05004.htm

Elkington, J. (1994). Towards the sustainable corporation: Win-win-win business strategies for sustainable development. *California Management Review, 36*(2), 90-100.

Galbraith, K. (2009). Sustainability field booms on campus. *New York Times*. Retrieved February, 2010, from http://www.nytimes.com/2009/08/20/education/20GREEN.html?_r=3andref=nationalspecial2

Graedel, T. E. (2002). Quantitative sustainability in a college or university setting. *International Journal of Sustainability in Higher Education, 3*(4), 346-358.

Hart, S. L. (2009). Converging on green. *BizEd*, 24-28. AACSB International Magazine in July/August archives. Retrieved from http://www.aacsb.edu/publications/Archives/julyaug09-toc.asp

Hewlett Packard (2009), *Global citizenship report: Environmental sustainability*. Retrieved December, 2009, from http://www.hp.com/hpinfo/globalcitizenship/gcreport/envsustainability.html

Jabbour, C. J. C. (2010). Greening of business schools: A systematic view. *International Journal of Sustainability in Higher Education, 11*(1), 49-60.

Nicolaides, A. (2006). The implementation of environmental management towards sustainable universities and education for sustainable development as an ethical imperative. *International Journal of Sustainability in Higher Education, 7*(4), 414-424.

Porter, M., & Kramer, M. (2006). Strategy and society: The link between competitive advantage and corporate social responsibility. *Harvard Business Review*, December, 1-14.

Pryor, J., Hurtado, S., Sharkness, J., Korn, W., DeAngelo, L., Romero, L., & Tran, S. (2008). Political engagement among college freshmen hits 40-year high. *Higher Education Research Institute (HERI): The American freshman: National norms fall 2008.* Los Angeles: UCLA Graduate School of Education and Information Studies, Retrieved January, 2010, from http://www.gseis.ucla.edu/heri/index.php

Rappaport, A., & Creighton, S. H. (2007). *Degrees that matter: Climate change and the university*. Cambridge, M. A.: MIT Press.

Rauch, J. N., & Newman, J. (2009). Defining sustainability metric targets in an institutional setting. *International Journal of Sustainability in Higher Education, 10*(2), 107-117.

Riddell, W., Bhatia, K. K., Parisi, M., Foote, J., & Imperatore, J. (2009). Assessing carbon dioxide emissions from energy use at a university. *International Journal of Sustainability in Higher Education, 10*(3), 266-278.

Roy, R., Potter, S., & Smith, M. T. (2001). Exploring ways to reach sustainability in transport, housing and higher education. Proceedings of *Greening of Industry Network Ninth International Conference, Sustainability at the Millennium: Globalization, Competitiveness and the Public Trust*. Bangkok, Thailand, January (CD-ROM).

Roy, R., Potter, S., & Yarrow, K. (2008). Designing low carbon higher education systems: Environmental impacts of campus and distance learning systems. *International Journal of Sustainability in Higher Education, 9*(2), 116-130.

Smith, G. R. (2004). How green is technology? The paradox of online sustainable education. *International Journal of Sustainable Development and World Ecology, 11*(3), 262-270.

White, S. S. (2009). Early participation in the American College and University Presidents' Climate Commitment. *International Journal of Sustainability in Higher Education, 10*(3), 215-227.

World Commission on Environment and Development. (1987). *Our common future*. England, Oxford: Oxford University Press.