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# University leadership in energy and environmental design: How postsecondary institutions use the LEED® green building rating system

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# UNIVERSITY LEADERSHIP
# IN ENERGY AND ENVIRONMENTAL DESIGN:
# HOW POSTSECONDARY INSTITUTIONS USE THE
# LEED® GREEN BUILDING RATING SYSTEM

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by
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## DEDICATION

This book is dedicated to Dave Chance – the wind beneath my wings – and Cynthia Mara, Wayne Ringer, and Tony Brown who, like Dave, are my models of intellectual curiosity, perseverance, and craft.

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UNIVERSITY LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN: HOW POSTSECONDARY INSTITUTIONS USE THE LEED® GREEN BUILDING RATING SYSTEM

ABSTRACT

This descriptive, exploratory study focused on how institutions of higher education have used the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED®) Green Building Rating system. It employed statistical methods to assess which types of universities have used LEED, what ratings they earned, and what credit categories most influenced their success.

Results generated from studying 181 LEED-rated buildings indicate that of the six LEED categories, Energy and Atmosphere (EA) had the most influence over LEED rating. Analysis of all 446 postsecondary buildings certified under LEED-NCv2 prior to December 9, 2009 indicates clear evolution of the system. It reveals patterns that will influence future use of LEED and its categories.

Patterns in the data indicate effective planning and organizational learning. Over time, universities have achieved higher ratings. The LEED system has been integrating feedback and improving its measures. Applicants have been learning how to succeed in green building. LEED relies on organizational leadership and it appears to support a range of institutional goals. It also provides a tool for strategic planning that has demonstrated improvement in areas defined by the USGBC.

Findings regarding the use of various LEED categories can help leaders formulate green building strategy. The MANOVA tests conducted in this study

indicated that within the sample group, Energy and Atmosphere (EA) shared 47% of its variance rating. Water Efficiency (WE) shared 31%, Indoor Environmental Quality (IEQ) 30%, Sustainable Sites (SS) 25%, Innovative Design (ID) 20%, and Materials and Resources (MR) 9%. A multiple regression was calculated to determine how the categories operate cumulatively. Using a stepwise model, Energy and Atmosphere predicted the most about the sample's ratings. After EA, Sustainable Sites added the most new and unique information to the prediction model. The overall order of loading to achieve the optimal predictions was EA, SS, IEQ, ID, MR, and WE.

The sample used to generate these results over represented early applicants (those certified under LEED v2.0). Ratings have been increasing under v2.1 and v2.2. Because high ratings are associated with active use of EA, the population is likely to have earned more credits in EA than the sample group did. Within the sample, SS and IEQ contributed most to increases in ratings under v2.2. The USGBC recently instituted new policies that encourage higher achievement in energy, site, and water conservation. It more than doubled the number of points available in EA and WE, and it increased the points available in SS by 186%. The organization's newest version (LEED v3) also requires applicants to reach higher thresholds to earn each rating. This will undoubtedly shift the way applicants achieve certification and will likely raise the predictive capacity of EA, SS, and WE.

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PROGRAM IN EDUCATIONAL POLICY, PLANNING AND LEADERSHIP

THE COLLEGE OF WILLIAM AND MARY IN VIRGINIA

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# Chapter 1: Introduction

## Introduction

Universities throughout the United States are going green. The Carnegie Foundation for the Advancement of Teaching (2005) has classified a total of 4391 institutions of higher learning in the nation. Of these, 41.3% (or 1814) are two-year Associates colleges, 17.5% (or 767) are Baccalaureate, 14.5% (or 636) are Masters level, 6.4% (or 283) are Doctoral or Research-Intensive, and 20.3% (or 891) are special focus institutions. Scores of these institutions have adopted environmental sustainability as a central, motivating force (Second Nature, 2009).

More than 19% of four-year and graduate institutions and 10% of Associates colleges have, for instance, joined the Association for the Advancement of Sustainability in Higher Education [AASHE] (2009a). Hundreds of institutions have earned Leadership in Energy and Environmental Design (LEED®) Green Building Ratings through a program operated by the United States Green Building Council (USGBC). This study investigates how universities contribute to the green movement by using LEED.

Today, leaders of postsecondary institutions are rethinking and restructuring the way they operate in order to protect the environment. Many institutions have appointed collaborative, interdisciplinary teams to coordinate their sustainability efforts. Some have hired directors or staffed entire offices dedicated to environmental issues (AASHE, 2009b). Institutions that have embraced sustainability as a core operating principle are using it to unite people, fuse values, and elicit action. They see environmental sustainability as a cause that can dissolve administrative silos and disciplinary barriers. They use it to unleash collective creativity (Lauer, 2006; Steffen, 2008).

Environmental initiatives at universities involve conscious shifts in values and behavior. They are altering the way academic institutions plan and conduct business, operate facilities, conceptualize and teach environmental issues, and provide service. They can transform the way institutions conduct research as well, so that universities successfully apply knowledge to address pressing social needs in the tradition of the Wisconsin Idea and the American land grant (Kerr, 1995; Levin, 2003; Rhodes, 2001).

Innovative institutions are already finding ways to apply research, develop new technologies, and share what they learn about sustainability (Oberlin College, 2007a). They generate and disseminate environmental knowledge to students, professional and scholarly audiences, and the larger public (United States Department of Energy, 2009). Postsecondary institutions have assumed a visible role in the development and implementation of environmentally sustainable practice in the United States (AASHE, 2009b; Association of University Leaders for a Sustainable Future, 1990; Cortese, 2005). This role frequently involves green building systems and technologies (Orr, 1999, 2007; President and Fellows of Harvard College; 2009).

**Greening the campus.** Today, 500 four-year and 190 two-year institutions in the United States are sharing information and pooling resources through the Association for the Advancement of Sustainability in Higher Education (AASHE, 2009a). The organization's annual digest provides a framework for understanding trends in higher education (AASHE, 2009b). The digest describes environmental activities involving academics, operations, administration, and research.

AASHE (2009b) celebrates operational initiatives in the areas of: building, climate, dining services, energy, grounds, purchasing, transportation, and waste management. Green administrative and finance issues involve: ratings and assessments; access, diversity, and affordability; funding for environmental projects; human resources; investments; planning; legislation and policy; institutionalization of sustainability; sustainability staffing; trademark licensing; and media coverage of campus sustainability.

Sustainable construction is one critical component of college and university efforts to go green. American universities own roughly 240,000 buildings (United States Green Building Council [USGBC], (n.d.). These buildings (and their users) consume high levels of energy and other resources. Universities are implementing green construction as a way to conserve resources, improve building performance, save money, and serve the greater good.

"Being 'green,' and making decisions based on how your actions affect the environment is not as hard as it may seem (and it can also save you money!)" exclaims Furman University's *Green Guide* (2009, ¶ 1). "It will, however, require a new way of thinking, acting, and living" (¶ 2). Furman reflects the belief that environmental sustainability is an emerging and ongoing process that requires enthusiastic social engagement. It requires a new – collectively proactive – way of thinking and behaving (Orr, 2007; Palmer, 1998). Universities' active engagement in sustainability, and their enthusiastic participation in green rating programs, reflect a growing sense of optimism, collaboration, and shared responsibility for stewardship of the planet (Steffen, 2008).

**Opportunities for change.** Planning experts advocate proactive, non-linear approaches to change (Birnbaum, 1988; Cohen, Marsh, & Olsen, 1972; Rowley, Lujan, & Dolence, 1997). American universities are implementing such approaches in the realm of environmental sustainability. They are identifying and aligning opportunities in new and innovative ways.

Nature is providing valuable future-oriented metaphors of growth and evolution. Chaffee (1985) says such metaphors are essential to successful planning. In keeping with this idea, Cutright (2001) uses the metaphor of chaos theory to illustrate how sympathetic forces can align and act synergistically. Planners today see that crumbling buildings and decaying infrastructures present opportunities. The past tendency to delay maintenance on campuses means the situation is ripe for green improvements. Today, rising enrollments in college – coupled with aging physical plants – necessitate action (Ehrenberg, 2002; Leslie & Fretwell, 1996). Green construction helps solve immediate problems while saving money and protecting human and environmental health. Institutions that embrace change and proactively harness emerging opportunities like these, Rowley et al. (1997) insist, will reap the greatest economic and social benefits.

Today, the general population is beginning to see and understand environmental issues. Due to the scale and physicality of buildings, green construction is highly visible. It is also fairly easy to describe and justify. Images of green buildings can be found in thousands of campus web pages and publications (AASHE, 2009b). Universities use photos of buildings to illustrate their leadership in the green movement (President and Fellows of Harvard College, 2009). Hundreds of academic buildings have earned accolades under programs like Energy Star and LEED. These systems provide handy mechanisms that encourage participation and facilitate change.

The LEED Green Building Rating system provides one way for higher education to respond to growing calls for public accountability (Ehrenberg, 2002). Universities are now able to earn public recognition when they construct, renovate, operate, and/or maintain buildings in an environmentally responsible way (Goleman, 2009). Through LEED, institutions can demonstrate fiscal prudence and social responsibility (see Figure 1). They can show that they are harnessing innovation, operating efficiently, measuring and tracking performance, and providing leadership and service to society in ways recommended by Kerr (1995), Levin (2003), and Rhodes (2001).

Figure 1: *A digram from LEED's website about "What LEED Delivers."*

Source: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1990

**Growing momentum through LEED.** Postsecondary institutions have earned LEED certification for almost 500 projects since LEED's inception in 1998, and the number is quickly rising. Exponential growth is evident at Harvard University, where 24 projects have earned LEED ratings over the past decade. Harvard has registered 40 more of its building projects to become LEED-certified following construction. Universities use a range of LEED programs to earn certification, including programs tailored for new construction and major renovation (LEED-NC), core and shell construction (LEED-CS), neighborhood design and campus planning (LEED-ND), and the sustainable operation of existing buildings (LEED-EB).

Harvard uses LEED as a benchmark for assessing its relationship to peer institutions. Its accumulation of LEED ratings exceeds "all other Ivy League schools combined" according to Andrea Trimble, the university's manager of green building services (President and Fellows of Harvard College, 2010, ¶ 8). Harvard also uses the program to substantiate its position as a leader in green building. "We've found that meeting LEED standards doesn't add significant cost to the project, provided you start early," Trimble advises other LEED users. "I think the biggest lesson is to set environmental and sustainability goals early on in the process" (¶ 10).

**How LEED Works.** LEED is a voluntary program. It was designed on principles of encouragement, which many environmental advocates assert are more effective than mandatory regulations (McDonough & Braungart, 2002). Regulatory codes in the US are geared toward minimum compliance, while incentive programs can help society explore issues at a higher level. The LEED Green Building Rating system was developed to encourage exploration and foster evolution.

The LEED program allows building owners to earn public recognition. By obtaining certification, building owners are able to demonstrate that they care about the environment and have taken substantial measures to protect it. Primary incentives of using LEED appear to be: energy savings, environmental protection, improved health and productivity for building occupants, social prestige, and moral responsibility.

As new techniques are developed, tested, and improved, they become increasingly affordable. Once they become economically viable for a wider spectrum of building owners, they can be adopted into standard practice. When the process is approached holistically, the initial costs for construction are often comparable to conventional buildings – and operating expenses can be significantly lower (McDonough & Braungart, 2002; USGBC 2007, 2009a). Although some green systems may cost more to install than conventional ones, the savings they accrue can counterbalance the initial expense. An example is using shading devices and light shelves. Although there is a cost to manufacture and install them, they help distribute free light and block unwanted heat. Daylighting strategies allow for fewer light fixtures and less cooling equipment (Brown & DeKay, 2001; Schiler, 2004; USGBC, 2007). In many locations energy savings can quickly pay back any added cost of green technologies (Steffen, 2008; Wood, 2004).

Verifying financial savings is critical to the green buildings movement's evolution. Vakili-Ardebili (2007) has developed theoretical models to assess tangible and intangible benefits of sustainable design. His models measure a building's social, ecological, and economic value over time. They show that green practices can increase a building's value during operation and can extend the length of its useful life.

By September 2009, at least 39 institutions of higher education and 17 public school jurisdictions had mandated their own use of LEED for future projects (USGBC, 2009b). As the LEED program has gained momentum and demonstrated effectiveness, governments at all levels have started incorporating its metrics into their own regulations (Gowri, 2004). Policies requiring LEED have been enacted by 34 state governments and by 13 federal departments and agencies. State regulations directly influence construction at public universities (DuBose, Bosch, & Pearce, 2007).

Many individual municipalities (194 of them, across 45 states) have made LEED certification mandatory for new civic buildings and this frequently affects public and private institutions alike (USGBC, 2009b). For instance, Boston's city ordinances now require that all buildings larger than 50,000 square feet be certified at LEED Silver, Gold, or Platinum (Tonkovich, 2009). This applies to construction on university campuses within Boston and academic leaders in the city seem happy to comply (Freeman, 2008; President and Fellows of Harvard College, 2009). Their enthusiastic participation in LEED may have even spurred the legislation.

At Boston College, the Director of Sustainability and Energy Management insists green buildings are "a worthwhile investment" (cited in Tonkovich, 2009, ¶ 5). This is particularly true, Deirdre Manning says, because all of the buildings on campus are owned and operated by the College. She indicates that building green saves money and that LEED is a good way to address student pressure to go green.

Green academic buildings appear to have many different types of value to the public. Many universities benefit from the social perception that green buildings reflect value. Fund-raising experts identify sustainability as a motivator in financial giving (Valentine & Vargas, 2007). Universities can use environmental sustainability to encourage giving, especially among venture philanthropists and other niche donors (Boverini, 2006). The Green Building Learning Network provides resources for doing this (Valentine & Vargas).

***LEED registration and certification.*** A primary goal of owners who apply for LEED certification is to achieve the highest rating they can afford (Dudley, 2009). LEED offers four different ratings: basic Certification, Silver, Gold, and Platinum (UGSBC, 2007a). Individuals and organizations wishing to earn LEED certification can do so for new construction, major renovations, or for the way they operate and maintain a new or existing building. Building owners are active participants throughout the LEED process.

The USGBC (2007) and experienced LEED users recommend that applicants commit to LEED at the outset of design. This allows the owner to assemble a development team with expertise in green design and to utilize green strategies at all stages of the process. Owners who register early also have two separate opportunities for credit review: (1) during the design phase and (2) during construction (USGBC, 2007). During the first review, assessment is made as to whether the applicant is likely to earn credit based on the information provided. Final determination and award of credit is made at the construction review. It occurs when the building is almost ready for occupancy.

***LEED credit categories.*** The LEED program addresses targeted environmental issues. LEED-NC version 2 awards credits in the categories of Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), Indoor Environmental Quality (IEQ), and Innovation in Design (ID). LEED-NC v3 (unveiled in April 2009) uses the same structure but introduces a new category called Regional Priority (RP).

Version 3 also integrates feedback from nine years of using version 2 and two years of the pilot program (LEED v1). The new version adjusts the weighting of various credit categories based on past experience. Appendix A provides the title and point value of each credit. It also shows how point offerings have changed.

This project studies buildings that were certified under LEED v2, because v3 is so new that few (if any) university buildings have been certified under it to date. The *LEED* *for new construction reference guide, Version 2.2* (USGBC, 2007) represents the most comprehensive source of information on v2 programs. It explains the criteria for defining and measuring achievement under LEED v2. It provides detailed descriptions and examples, as well as references to other sources.

**Demonstrating leadership.** Observing how early applicants use this program, and witnessing the public recognition and prestige that LEED certification brings, encourages others to participate. Although people and organizations typically resist change, providing a viable and vibrant vision for the future helps garner widespread buy-in (Fullan, 2001). It helps organizations institutionalize new programs (Allison & Kaye, 2005; Holcomb, 2001). This is LEED's approach. The USGBC aims to build capacity across the construction industry and to spur market change through LEED (USGBC, 2009a). The size, scale, and status of the system lend an air of stability. Hannan and Silver (2000) insist that such stability is essential to precipitate change at a national level.

DuBose et al. (2007) say leadership is an essential component of green construction. They identify critical enablers for green building on campuses: people who champion the cause, stakeholder support, and power levers that leaders can use to prompt participation. Inhibitors to green building include: general resistance to change, opposition to LEED, and the presumed cost associated with using new technologies.

Leadership expert Daniel Goleman (2009) says LEED is "revealing the hidden costs to a building's owners and users of the old way of doing business in the construction world." LEED programs create "a virtuous cycle by offering ready market alternatives" (p. 136). They are fostering the new sort of organizational transparency that Goleman asserts is essential to good leadership and to a properly functioning society.

Universities employ LEED as a visible way to exhibit leadership in environmental sustainability. Harvard University, for instance, described the "certification of its 20th building" as a physical demonstration of its "phenomenal green building leadership." In this, the university exceeded "any higher education institution in the world" (President and Fellows of Harvard College, 2009, ¶ 1). Its close competitors also tout the benefits of LEED (Duke University, n.d.; University of Florida, 2007).

To prompt the necessary level of engagement throughout society, Second Nature (2009) argues, universities must take the lead. They must integrate environmental issues throughout all their programs and activities (Cortese, 2005). They must model responsible decision-making and proactive behavior for people on, and beyond, campus. LEED is just one mechanism universities use to achieve these goals, but it is highly visible and it has tremendous implications for long-term resource consumption.

Universities have been leaders in greening the nation – they actually helped initiate the green building movement in the United States. Oberlin College (2007a) helped catalyze the movement through the design and construction of the Adam Joseph Lewis Environmental Studies Center. Oberlin's activity placed academia center stage in transforming the way buildings are conceptualized, constructed, and operated (Orr, 2007). Although this facility predates LEED, it propelled the green building movement forward and set a high bar for other universities.

***Forms of leadership.*** An overarching assumption has been that participation in LEED constitutes a form of environmental leadership. By naming its program "Leadership in Energy and Environmental Design," the USGBC highlights *leadership* as a driving force. Building owners who earn LEED ratings are heralded as champions of green building and environmental sustainability. The USGBC (2009a) asserts that investing effort in this system represents a significant form of leadership. It means enabling product development and growth of green industries. Members of the USGBC, building owners who earn LEED certification, LEED Accredited Professionals, and others who facilitate green construction, provide such leadership. They represent early applicants who help push green technologies and practices forward.

Today, USGBC requires increasing commitment to data collection, knowledge sharing, and ongoing professional development. One of LEED's primary goals has always been to transform the construction industry through the active participation of diverse members (USGBC, 2009a). Participation in LEED fosters innovation, generates momentum, builds know-how, and grows capacity to generate green power and produce green building components. It contributes to shifting the way structures are imagined and produced. It is transforming the way owners, designers, and contractors work together (Bilec & Ries, 2007; Mazza, 2007; USGBC, 2009a).

The USGBC's claim that participation in LEED constitutes *Leadership* in Energy and Environmental Design is consistent with Fullan's (2001) leadership model. Fullan insists leaders must project a sense of hope, energy, and enthusiasm. In doing so they should also seek to: (1) generate knowledge and share it, (2) work with moral purpose, (3) build relationships, (4) construct meaning, and (5) understand change. The USGBC incorporates all these aspects into LEED.

Fullan (2001) also emphasizes the need for leaders to build commitment among internal and external stakeholders. USGBC (2009a) seeks commitment of all stakeholders to precipitate change. It uses LEED to build active enthusiastic involvement of diverse stakeholders in the construction process.

Paralleling Fullan's (2001) leadership model, LEED users seek to: (1) foster innovation and apply emerging research, (2) act with environmental integrity, (3) work collaboratively to achieve shared goals by specifically renegotiating the working relationships between owners, designers, and builders, and (4) shift the meaning of building today, and (5) spur change through a system that people can understand (Bilec & Ries, 2007; Mazza, 2007; USGBC, 2007). The system attempts to translate abstract concepts into measurable units and to celebrate success in a highly visible way. Each of these issues will be investigated in Chapter Two.

***Avenues for enhanced leadership and learning.*** By participating in LEED, universities contribute time, money, effort, and know-how to the collective cause. This study, for instance, helps extend understanding of green building on campus. It explores ways leadership is made manifest through LEED ratings, investigates the use of LEED by universities, and identifies additional paths for leadership. These paths include ongoing *program outcomes* and *building performance assessment*, *knowledge creation* through basic and design-related research, and *transfer of knowledge* from theory to practice through *applied research.*

Tracking the outcomes of investments made in LEED represents an opportunity for postsecondary institutions to: (1) tweak the performance of their own buildings, (2) generate knowledge to improve the LEED system, and (3) provide leadership in society's shift to environmental sustainability. *Participation* in LEED does not, however, ensure that universities' investments will have all the implied benefits. Ongoing analysis of outcomes is required to obtain maximum benefit from this, or any, planning program (Allison & Kaye, 2005; Holcomb, 2001; Wilson, 1997).

Kerr (1995), Levin (2003), and Rhodes (2001) highlight the importance of using university research to address environmental problems. They all discuss ways to generate and transfer knowledge, apply research, and promote better ways of living. It appears that universities can become increasingly effective environmental leaders by conscientiously integrating the various research and dissemination techniques they have crafted over the centuries.

**Structure of Dissertation**

This chapter explains how LEED operates and suggests how existing data may be used to study universities' achievements with regard to LEED. The literature review (Chapter Two) defines environmental sustainability and describes a range of related university activities. It discusses how fostering innovation, generating and applying new knowledge, and transferring knowledge from theory to practice constitute leadership in environmental sustainability. It also describes the purpose and history of LEED and discusses how universities implement the LEED system. Chapter Three describes the methods used for empirical analysis. Chapter Four reports results of the study. Chapter Five discusses findings and their implications for policy, practice, and research.

**Problem Statement**

Pro-active universities are working to foster an ethic of environmental responsibility among students and the larger public (Cortese, 2005; Oberlin College, 2007b; Second Nature, 2009; Sharp, 2009; Smith, 1999). These institutions promote activity that sustains – rather than drains – the natural environment. They seek to generate and share new knowledge about the environment.

Hundreds of universities now employ the LEED Green Building Rating system. LEED helps higher education create facilities that are healthier for the natural environment and for human inhabitants. LEED participation bolsters the green movement and fosters capacity within the construction industry. LEED provides a clear framework for applicants to develop and implement new strategies. Applicants can even earn Innovative Design credit for developing transferrable techniques.

Figure 1: *A digram from LEED's website about "What LEED Delivers"* (p. 5) identifies innovation, energy savings, corporate (i.e., organizational) responsibility, and decreased carbon footprint as intended outcomes of LEED. A number of studies are underway to assess how well LEED measures energy and carbon emissions. This study seeks to explore issues that have not yet received analysis. It proposes a way to assess innovation and corporate responsibility. The study associates *responsibility* with the degree of leadership an organization provides in the green building movement. It defines *innovation* as: (a) generating new knowledge, (b) applying existing knowledge in new ways, and (c) communicating how such applications are transferrable to other situations.

Because research has not been published in this area (innovation and corporate responsibility outcomes of LEED), this study employs descriptive and exploratory methods. A goal of this study is to assess if LEED is yielding the benefits USGBC advertises. This study aims to help improve LEED system and the way universities use it. Assessing outcomes – of campus sustainability programs and institutions' use of green rating systems – is critically important to the evolution of such programs.

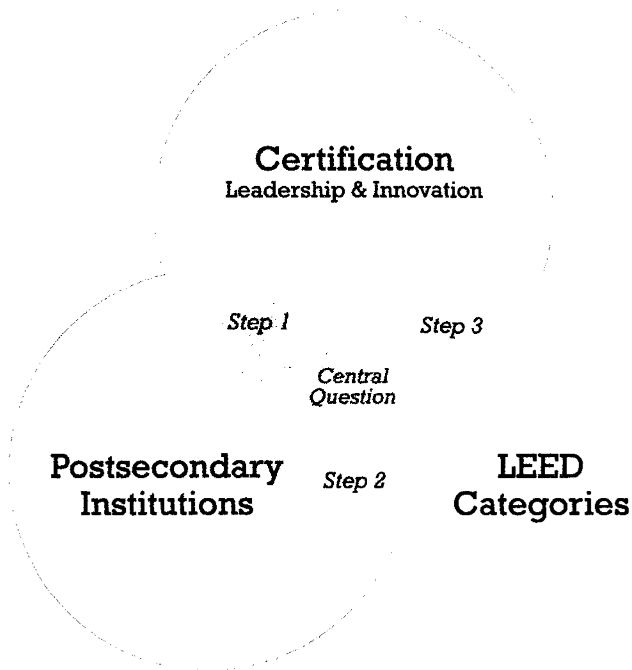
This dissertation seeks to understand if and how colleges provide environmental leadership, how they facilitate innovation, and how they integrate research into the design and construction of buildings. A related purpose of the study is to utilize existing data to enhance practice. It compares data about (1) the types of universities that use LEED, (2) the categories they use to earn green building ratings, and (3) the LEED ratings they have earned to date. Types of universities are described by: (a) region of accreditation, (b) source of control (public or private), and (c) type of institution, as well as (d) student enrollment, and (e) endowment per student. These characteristics are defined and reported through the federal government's Integrated Post-Secondary Educational Data System (IPEDS). The study utilizes IPEDS data and nine year's worth of data on LEED ratings and credit earnings.

This study serves to uncover patterns that can improve the LEED system and enhance the way colleges and universities use LEED. It aims to help academic leaders, architects and builders, and USGBC members become increasingly intentional and purposeful in the design and implementation of LEED programs. The study specifically assesses the degree to which institutions use ID credits in an effort to promote the application and transfer of knowledge though the category of Innovative Design.

**Research Questions**

The study involves three major spheres of investigation (see Figure 2). It explores: (a) the type of postsecondary institutions that have used LEED, (b) the LEED credit categories they used, and (c) the LEED ratings they earned. The study utilizes data collected by LEED and IPEDS in an attempt to ascertain (1) what LEED ratings institutions typically obtain, (2) how they employ the six LEED credit categories, and (3) how they foster innovation, generate knowledge, and/or apply knowledge in new, replicable ways as they earn LEED certification.

Figure 2: *Spheres of investigation for this study.*




Exploring each of these topics, individually, constituted a step toward answering the central overarching question of this study. Taken alone, the central question appears unwieldy. As such, a sequence of questions was developed for addressing the central question in a systematic way. Since the central question can be seen as resting at the overlap of three issues, the overlaps between individual issues were identified as critical (see Figure 2). Investigating each overlap, one at a time, represents a way to build holistic understanding. The overlaps were explored through a literature review and then through data collection and analysis. Statistical analysis involved four major steps, each directly associated with an overlap. The central question is: *To what degree have institutions of higher education used LEED® to earn certification, provide leadership, and foster innovation in environmental sustainability?*

*Step 1: Assess ratings earned by institutions.*

1a) What types of postsecondary institutions use LEED and what leadership ratings do they earn?

1b) What is the relationship between institutional characteristics (region, control, type, enrollment, and endowment) and rating?

*Step 2: Assess how institutions use LEED credit categories.*

2a) What categories do institutions typically use to achieve certification?

2b) What is the relationship between use of the six categories and overall rating?

2c) What is the relationship between institutional characteristics and use of categories?

*Step 3: Assess how institutions use LEED categories to foster innovation.*

3a) How frequently do postsecondary institutions earn Innovative Design (ID) credits?

3b) What is the relationship between the rating earned and use of ID credits?

3c) What is the relationship between institutional characteristics and use of ID?

*Step 4: Assess generalizability.*

4a) To what degree has LEED use changed over time, based on the version of LEED employed?

4b) To what degree has LEED use changed over time, based on inclusion in USGBC's credit tally?

4b) How does the sample compare to the population of postsecondary LEED users?

**Conceptual Framework**

Postsecondary institutions apply for LEED credits in order to earn certification. This process is illustrated in Figure 3. In earning LEED certification, institutions contribute momentum to the larger sustainability effort. Many of them generate new approaches for sustainable construction and earn Innovative Design credits.

Figure 3: *Basic process for earning LEED certification.*

Associated outcomes of certification are innovation and leadership. A major premise is that building owners who earn high ratings have contributed the most *leadership* in energy and environmental design. Their *innovations* contribute at the level of the building as well as the system and society at large.

The USGBC asserts that active participation enhances the overall green building movement. It claims that USGBC members and LEED earners are leaders in *innovating* and *transforming* the building industry. Even the system's most vocal critics agree that LEED has been incredibly successful at raising public awareness of green building practices and of the need for them (Gifford, n.d.; Malin, 2009).

LEED certification garners a building's owner recognition as well as the right to mount a plaque on the building, advertize the building as "LEED certified," and announce its rating: Certification, Silver, Gold, or Platinum. The designation and plaque are permanent and not currently subject to ongoing performance review.

Figure 4: *How the certification process relates to the spheres of study.*

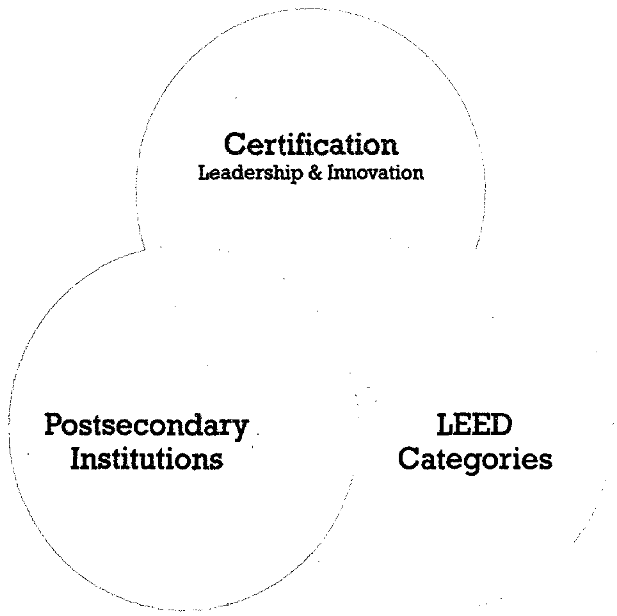
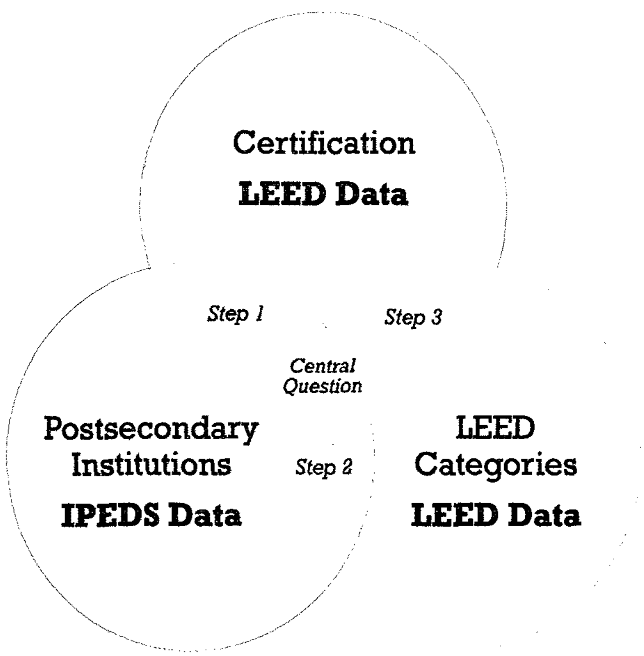
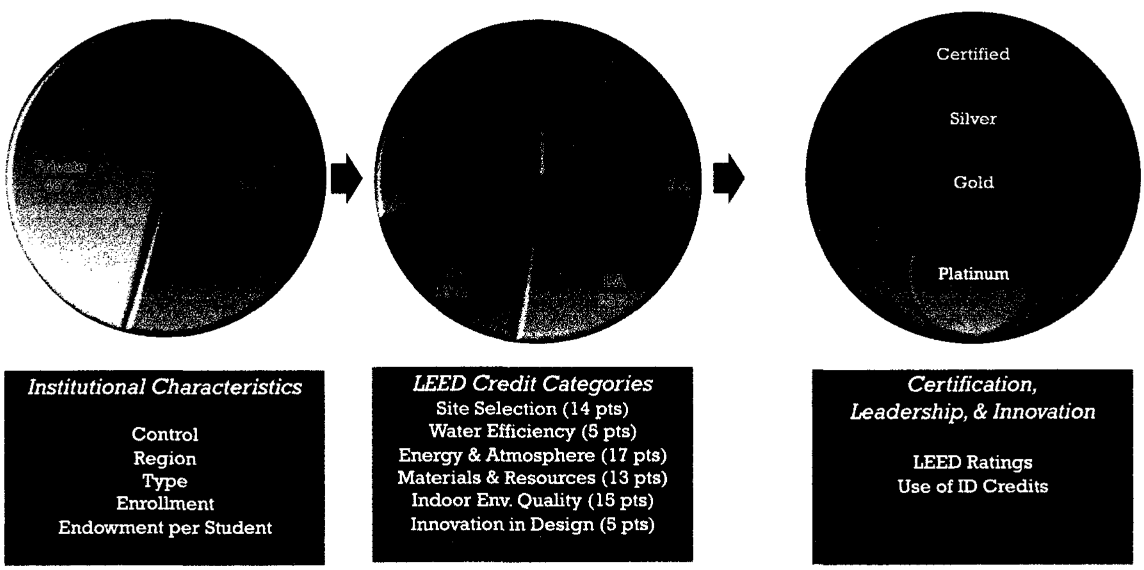



Figure 5: *Linking existing datasets to specific research questions.*



Each step in the LEED certification process corresponds to a specific sphere of investigation of this study, as shown in Figure 4. The sources of data for this study are identified in Figure 5. Data regarding institutional characteristics were obtained using the National Center for Education Statistics (NCES) Integrated Postsecondary Educational Data System (IPEDS). Data regarding LEED ratings and use of categories were obtained from the United States Green Building Council (USGBC). These data describe: (a) what types of postsecondary institutions use the LEED system, (b) what categories of LEED credits they use, and (c) what LEED ratings they earn.

Figure 6: *Corresponding spheres, depicting specific variables.*




## Constitutive Definitions

This section provides constitutive definitions that help explain the intention and scope of this study. Detailed, operational definitions are provided in Chapter Three. Each of the spheres of investigation corresponds with specific data collected by IPEDS and LEED (see Figure 5). These datasets can facilitate quantitative comparison through the sequence of steps described earlier. Some of the questions in this sequence compare LEED data with IPEDS data, while others investigate patterns within the LEED data.

Figure 6 shows what the LEED process looks like when specific variables are introduced. The first circle illustrates the source of control among institutions included in this study. Additional institutional characteristics, or variables, are listed below each circle. The middle circle represents the distribution of the 69 LEED points available through LEED v2. The credits are grouped into six categories (which are listed in the box below the circle). Each applicant is free to choose which of the 69 credits to employ in the design and construction of a new building.

The final circle in Figure 6 illustrates the four possible LEED ratings (Certification, Silver, Gold, and Platinum). Ratings are one variable related to certification and leadership. Applicants' use of Innovative Design (ID) credits is a reflection of innovation. Each circle in Figure 6 represents a sphere of knowledge involved in this study. Each of these spheres will be discussed following a brief summary of the methods used to conduct the study.

**Synopsis of methods.** As indicated earlier, each step of analysis in this study investigated relationships between specific sets of variables (as per Figure 5). Step 1 assessed how institutions obtain formal recognition of leadership using LEED. Individual sub-questions looked for existing relationships between (a) LEED ratings earned by institutions and (b) these institutions' specific characteristics. Selected characteristics included region of accreditation, source of control, type, enrollment, and endowment.

The unit of analysis for this study was the individual building that had earned LEED certification. More than 470 postsecondary buildings had secured LEED ratings at the time of study. The population for this specific study included all buildings (a) owned by accredited postsecondary institutions that were (b) certified before December 7, 2009 using LEED for New Construction and Major Renovations (LEED-NC versions 2.0, 2.1, and 2.2). Most of the 470 LEED-rated postsecondary buildings used this particular LEED program. A population of 446 buildings was found to meet all criteria listed above.

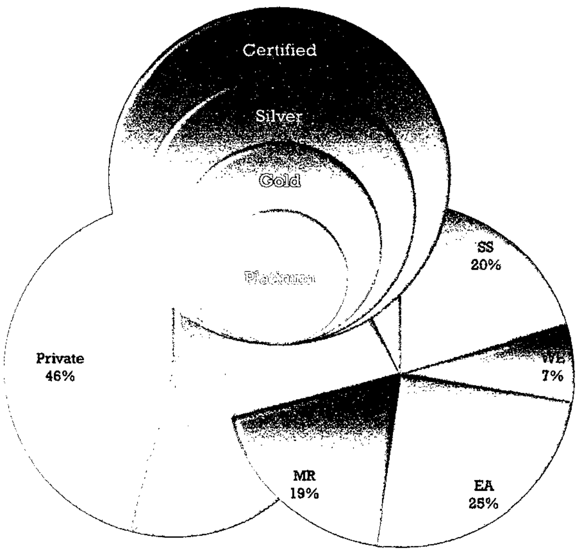
Although the initial intention was to study this population, not all data were available for the entire group. Data on credit earnings were obtained for a sample of 181 buildings, located on 121 different campuses. Necessary credit data were included in the USGBC credit tally spreadsheets last updated on July 30, 2009 (Tom Dietsche, personal communication, January 12, 2010). Credit tally data were not available for the other 265 projects. It was therefore impossible to study which particular credits these institutions had used to achieve certification.

In this study, the 181 institutions with credit tally data constituted a convenience sample. This group was composed primarily of early applicants (institutions that had been in the system longest). The other 265 made up the balance of the population. A number of comparisons were made between the sample and the balance of the population in order to gauge the representativeness of findings.

The study employed operational definitions (for LEED ratings and categories) that had been developed by the United States Green Building Council. It compared these variables with institutional characteristics, using definitions and measures provided by the National Center for Educational Statistics' IPED System. Chapter Three provides operational definitions for each variable. Figure 7 shows how variables might overlap, based on the conceptual framework. Procedures were implemented to identify significant relationships within the sample's data.

**The postsecondary institution sphere.** The lower left-hand circle in Figure 7 represents one variable in the postsecondary institution sphere. It shows the initially estimated proportions of postsecondary LEED earners classified as public and private. These designations have to do with the level of financial support the institutions in this sample receive from state government. This study used current information that is accessible to anyone using the online IPED System. All institutions that receive any sort of financial support from the federal government (such as through research grants or student financial aid) are required to report certain information to NCES for public use.

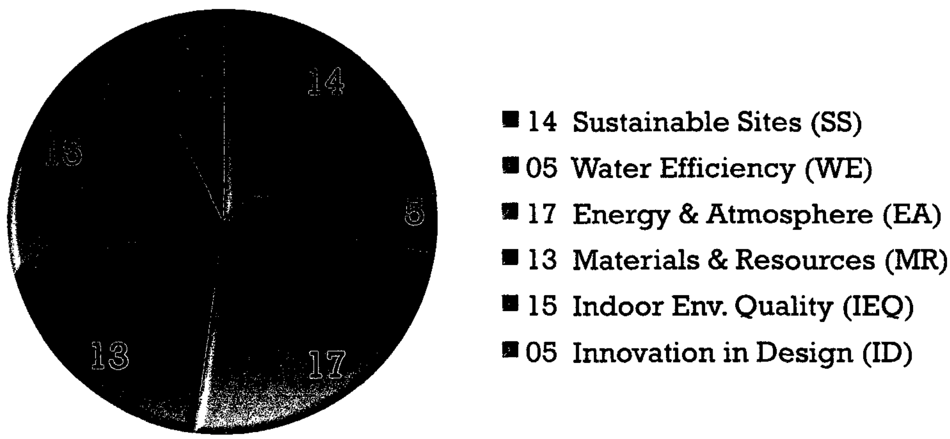
Figure 7: *Overlapping variables.*




Institutional control is just one characteristic that the federal government tracks. Using multiple variables provides a more complete understanding of the institutions that use LEED. This study incorporated the following variables, most available through IPEDS: region of accreditation, control, type of institution (derived from the Carnegie Classification system), student enrollment, and endowment per student.

**The LEED credit sphere.** LEED v2 programs offer the possibility to earn up to 69 credits. A building must meet eight pre-requisites (see Appendix A) and then earn at least 26 credits to become certified. Credits are grouped into six major categories, as shown in Figure 8. It is possible to earn up to 14 points in Sustainable Sites (SS), 5 points in Water Efficiency (WE), 17 points in Energy and Atmosphere (EA), 13 points in Materials and Resources (MR), 15 points in Indoor Environmental Quality (IEQ), and 5 points in Innovative Design (ID).

Figure 8: *Relative weights of the credit categories that define LEED-NC v2.*




Adapted from: USGBC (2001, 2002, 2007).

**The certification, leadership, and innovation sphere.** The top-most sphere in Figure 7 (p. 24) includes three facets of environmental achievement: certification, leadership rating, and innovation. Rating is the most visible aspect of LEED today. The impetus for this study was to find out if institutions were, in fact, using LEED to provide leadership, spur innovation, and generate knowledge in environmental sustainability. Unfortunately, leadership, innovation, and knowledge generation are difficult constructs to measure.

***Measuring certification and leadership.*** Table 1 shows the number of points necessary to achieve each leadership rating under LEED v2. The USGBC asserts that participation in LEED constitutes leadership. It uses the terms "leadership" and "rating" interchangeably. In this study, LEED rating was used as the primary indicator of leadership and of an applicant's contribution to the green building movement.

Table 1: *Relative weights of the credit categories that define LEED-NC v2.*

| **LEED Ratings** | **Points** |
|---|---|
| Certified | 26-32 |
| Silver | 33-38 |
| Gold | 39-51 |
| Platinum | 52-69 |

Adapted from: USGBC (2007).

The USGBC also claims that participation promotes development of green building techniques and technologies. It builds the knowledge base and market capacity of the environmental movement. Those building owners who implement the highest degree of innovation are seen to be pushing the boundaries of existing technologies the farthest, expanding the capacity of the green building industry the most, and leading the way for others to follow. A higher building rating means a higher level of engagement with these technologies and, by LEED's definition, a higher level of leadership in the areas of environmental design and energy conservation. Chapter Five will investigate if these are accurate assumptions, based on the results of this study.

***Measuring innovation and knowledge-generation.*** The major indicator of innovation and knowledge generation employed in this study was the applicants' use of Innovative Design credits. The ways to earn credit in this category are carefully defined by the USGBC and have been carefully measured for each applicant.

The ID category promotes development of new techniques and new applications. This reflects an institutionalized approach to innovation and knowledge sharing. To warrant ID credit, the proposed technique *must* be new and it *must* be transferable. Credit is only awarded for techniques that can be implemented by others in the future. Each application for ID credit provides a summary of techniques and methods that can be used for other projects.

An applicant may earn up to five credits in the category of Innovation in Design. One of these five ID credits is awarded simply for helping build capacity of LEED and the green movement by including a LEED Accredited Professional (LEED-AP) on the applicant's design team. Each of the other four credits can be earned in two different ways: Exemplary Performance (EP) or Innovative Design (ID). EP can be awarded when the applicant has far exceeded the base requirements for a given credit. Not all credits carry this possibility, and earning EP credit generally requires meeting a standard twice as high as the base criteria. While EP credits reflect high-level commitment, they do not require the applicant to develop new techniques or generate new knowledge.

Innovative Design (ID) credits, on the other hand, encourage applicants to develop and implement new methods (USGBC, 2009c). These are awarded only for techniques that are not specifically addressed by the existing rating system. The USGBC's (2008a) trained evaluators rigorously assess each ID credit application. To earn ID credit, the proposed strategy must be comprehensive and widely applicable, and the applicant must demonstrate that it will have measurable environmental and/or human health benefits. The application for an ID credit undergoes even more rigorous review than other, more standardized, credits.

Applications for Innovative Design credit must include:

1) Title of proposed credit
2) A narrative describing its intent
3) A list of requirements for the achieving credit
4) A description of the applicant's own approach
5) Drawings relevant to the proposed technique

One higher education applicant earned ID credit by conducting a semester-long university course in sustainable building that required students to conduct detailed case studies (USGBC, 2004, 2008a). Other previously accepted ID credits include: an Educational Outreach Program, Green Housekeeping, High Volume Fly Ash, Low-Emitting Furniture and Furnishings, and an Organic Landscaping/Integrated Pest Management Program.

At the time of this study, the USGBC had not harvested all data from digital applications. As such, it was not possible to distinguish credits earned in *Innovative Design* from those earned for *Exemplary Performance*. Data were not available regarding the titles and content of ID credits that had been approved through LEED. It was not possible to conducted detailed analysis of the use of Innovative Design. For the purposes of this study, all three types of ID credits were viewed as helping innovate the system. (Of the 181 certified buildings in the sample, all but one earned the AP credit.) In this study, AP, EP, and ID were given equal weight.

Because earning ID credits requires an applicant to develop new approaches and/or new ways to apply technologies, this study views these credits as a means for knowledge generation. This is consistent with Boyer's (1990) assertion that knowledge generation requires a transfer of knowledge from (a) observation into (b) a form that others can reference. ID credits reflect the features of scholarship identified by Boyer: discovery (of new knowledge), integration (of information into various contexts), application (of knowledge to solve problems), and teaching (students and society).

This study respects Boyer's (1990) recommendations to employ "a more inclusive view of what [scholarship means and] a recognition that knowledge is acquired through research, through synthesis, through practice, and through teaching" (p. 24). All LEED applicants (and their design teams) synthesize emerging research into the practice of design and construction. Use of ID credits requires knowledge sharing and transfer of practices from one context to another. Boyer would classify this as scholarship, which he measures "by the ability to think, communicate, and learn" (p. 15).

LEED ratings and use of the Innovative Design category were employed as the best available measures of leadership and innovation. This was done in the hope that analysis might contribute to greater understanding of what universities contribute to society through green building and LEED.

**Significance of the Problem**

The lack of existing knowledge about LEED's achievements over time represents a substantial problem that warrants study. It is important to assess how well LEED buildings are performing (although this is beyond the scope of this study). It is also important to investigate how well the overall LEED system is performing and how different types of applicant groups use the LEED system (issues pertinent to this study).

This study was conducted to assess how postsecondary institutions use the LEED program. It was intended to foster evolution of the green building movement. It was designed help feed information back into the system and to demonstrate ways to do so. It was conducted with the intention of improving LEED through iterative, rational analysis.

**Substantiating results.** Because very little research exists on this particular topic, a descriptive and exploratory design was appropriate (Creswell, 1994). In this case, a great deal of information had been collected and archived in quantitative form. This rendered quantitative analysis reasonable as a first step in the exploration.

Postsecondary institutions and LEED both face pressure to harness existing data and use it to understand current practices and operate more effectively. Postsecondary institutions and LEED both use quantitative data to define, track, and report achievements in a concise manner (Ehrenberg, 2002; Lauer, 2006; United States Department of Education, 2006). This quantitative format does not convey the whole picture, but it does provide a way to quickly compare patterns and to determine what warrants further study. Quantitative information is widely understood by the general public, so universities and LEED both use it to facilitate comparisons and gauge success (Goleman, 2009). According to Hoy (2010), quantitative research emphasizes "control and quantified measures of performance" (p. 1). This is true of the LEED system.

"Measurement and statistics," Hoy (2010) asserts, "are the connections between empirical observation and mathematical expressions of relations" (p. 1). Quantitative research is appropriate "when the audience consists of individuals or journals with a positivist orientation" (Creswell, 1994, p. 22). This is the case with many architects and LEED users who rely on numerical standards and data. Like quantitative research, LEED represents "scientific investigation" and uses "systematic methods" to measure performance (Hoy, p.1).

LEED provides universities with an easy-to-understand measure of success. It summarizes complex relationships, using straightforward scores and rankings that facilitate rational comparison. The simple nature of LEED and its checklist format are its strength as well as its weakness (Malin, 2003). The system helps make invisible environmental factors visible, but some of its measures may be too simplistic to accurately predict performance (Gifford, n.d.; Scheuer & Keoleian, 2002; Stanisstreet & Boyes, 1997; Malin, 2009; Udall & Schendler, 2005). A benefit of the existing system is that it carefully defines and measures a wide range of factors. This is a truly ambitious undertaking, and one where glitches are inevitable (Goleman, 2009). Additional research can help identify and address false assumptions. It can also help USGBC become more purposeful in its policies, procedures, and credit offerings.

The LEED system yields a vast quantity of numeric data. These data can help owners compare actual performance with projections included in their LEED applications. They can use existing definitions and benchmark calculations to evaluate building performance over time. This – in and of itself – helps address concerns inherent to strategic and long-range planning. Defining goals clearly enough to measure them has been an ongoing problem in educational planning (Barnetson, 2001; Cutright, 2001).

Without defining clear measures, organizations have a difficult time tracking performance outcomes. LEED is a tool that is widely used in building planning. It can be used to assess outcomes in more ways than it has been to date. Presley and Leslie (1999) say the results of most plans actually go unknown. This has been the case for LEED over much of the past ten years. It has not gone unstudied, but it has clearly not received the depth of performance assessment it deserves. Although many types of plans that postsecondary institutions implement are difficult to measure, LEED readily supports quantitative assessment. Existing data provide fodder for trend studies and comparisons among applicant groups. New data requirements will facilitate analysis of building performance.

Planning experts agree that organizations should track performance as plans are implemented and adjust course in light of analysis (Allison & Kaye, 2005; Holcomb, 2001; Wilson, 1997). Tracking performance and responding in proactive ways can help avoid major pitfalls of strategic planning. Presley and Leslie (1999) identify faulty assumptions, blind adherence, and failure to assess outcomes as impediments to effective planning. Few organizations have bothered to conduct analysis or report findings; Presley and Leslie suggest that the practice of planning may actually waste time and money. LEED benchmarks readily support performance assessment. Measures are clearly defined (though they warrant tweaking), benchmarks have been established, and the ongoing operation of buildings already requires oversight and coordination by knowledgeable staff. In this context, collecting performance data and systematically analyzing it are not difficult tasks.

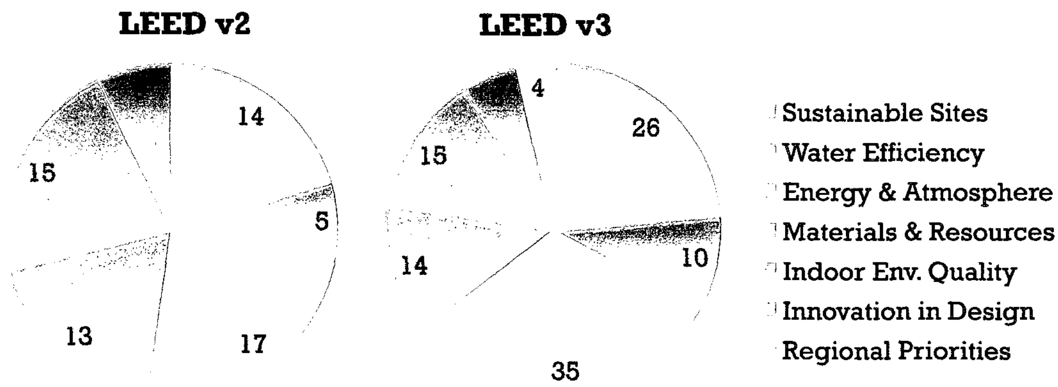
**Addressing criticisms.** Research is also needed to address direct criticisms of LEED. Certified buildings may be underperforming (Gifford, n.d.; Scheuer & Keoleian, 2002; Udall & Schendler, 2005). A study by Turner and Frankel (2008), which was sponsored by the USGBC, identified shortfalls in the category of Energy and Atmosphere. The USGBC has taken a number of recent steps to address energy performance (Environmental Protection, 2009; Stephens, 2008; USGBC, 2009d, 2009e).

Critics also claim LEED helps perpetuate ineffective technologies and that, by neglecting more viable methods, using LEED wastes resources in the long run (Gifford, n.d.; Malin, 2009). Presley and Leslie (1999) have identified this as a standard problem in educational planning. Institutions sometimes shift focus and resources away from worthy pursuits without accruing significant benefit. It is important to investigate the benefits of LEED planning and study how the system integrates feedback over time.

Future study should also investigate outcomes regarding innovation. Applications for Innovative Design credits include a wealth of information. This data holds the potential to transform the construction industry. Collecting data about innovative new solutions is an important aspect of the LEED program. However, it is currently not being utilized. USGBC's Tom Dietsche (personal communication, November 20, 2009) indicates that record-keeping software does not yet allow easy collection of data in the Innovative Design category. Those data must be harvested manually, and no one has had time to do so. Dietsche explains that this capability should soon be in place. Lacking this capacity, however, a decade's worth of ID applications have gone un-studied.

The mechanisms for fostering productive evolution of LEED are not entirely obvious. They have not been clearly defined (USGBC, 2009c). Changes are underway, however, and many professional publications have recently endorsed the progress made (Cheatham, 2009a, 2009b; Environmental Protection, 2009; Stephens, 2008). In response to findings of poor energy performance, the USGBC recently upgraded its energy requirements. It also introduced a new version that drastically increases the proportion of credits available in the energy category (see Figure 9). While v2 offered 17 of 69 credits in Energy and Atmosphere, v3 expands EA's share of the pie significantly. Now an applicant can earn up to 35 of the 110 possible points in Energy and Atmosphere.

Figure 9: *Graphic comparison of version 2 and version 3 credit allotments.*




Compiled from: USGBC (2001, 2002, 2008b, 2009a)

USGBC notes that some previously certified buildings would no longer meet LEED certification criteria (Navarro, 2009). Officials say new procedures are being considered that do not confer permanent certification to a building. In 2009, USGBC unveiled new continuing education and re-certification requirements for LEED-Accredited Professionals. Periodic performance checks may become mandatory for LEED buildings. The USGBC seems to have garnered support from many critics by introducing the new LEED v3 (Cheatham, 2009a, 2009b; Environmental Protection, 2009; Stephens, 2008; USGBC, 2009d, 2009e). The continual emergence of refinement and new programs reflects the USGBC's desire to periodically raise the bar. These adaptations address a wider range of construction types and have been more carefully operationalized and calibrated (USGBC, 2009c).

The sustainability movement can benefit from analysis of how the LEED system is working, who is using it, how they are using it, and what positive and negative outcomes are accruing. Assessing how organizations achieve certification can reveal if they avoid certain types of challenges or divert resources (from approaches that could most benefit the environment) for the sake of earning LEED credits.

Some critics say LEED promotes point-chasing and perpetuates ineffective green gadgets. It may promote cumbersome technologies over basic vernacular and passive approaches that have stood the test of time (Gifford, n.d.; Udall & Schendler, 2005). Assessing credit categories that applicants most often use – and tracking if this has changed over time – may shed light on these issues.

Critics also fear that the LEED system is becoming too absorbed in making money. Regulating and monitoring the program requires a substantial amount of time and effort. Applicants pay steep fees to cover the cost of certification. Although administrative costs are high and the level of bureaucracy in LEED appears to be substantial, there is clear indication that the USGBC is re-investing funds in ways that do improve the system (Cheatham, 2009a, 2009b; Environmental Protection, 2009; Stephens, 2008; USGBC, 2009d, 2009e).

The programs released in 2009 required USGBC to develop hundreds of new forms, manuals, and technical standards. The USGBC also recently ungrouped its activities – transferring responsibility for certification and accreditation to a new sister organization (the Green Building Certification Institute, GBCI). This move allows USGBC to focus on defining and improving the LEED system. To assuage the types of criticisms and fears described above, however, studies that assess outcomes are essential. Applicants – and society at large – need to know if input funds produce effective results. Universities are well suited to conduct this type of research.

**Harnessing research potential.** The green movement necessitates basic and applied research. These are areas where universities excel (Kerr, 1995; Levin, 2003; Rhodes, 2001). The hundreds of LEED-certified buildings on campuses provide an ideal source of study. Conducting such research can help postsecondary institutions protect their investments and improve performance (of buildings and of LEED). Building research represents an ideal way for postsecondary institutions to track their performance and integrate feedback into future operations as recommended by Birnbaum (1988), Holcomb (2001), and Wilson (1997). What society learns from planning LEED buildings and tracking their performance can also enhance planning theory.

For those who want to improve higher education, understanding how institutions are addressing sustainability is important. LEED is just one method for improving campus sustainability, and it can be an expensive endeavor. Weak design and poor building performance can have tremendously negative consequences. It is important for researchers at universities to get involved in (a) refining green building programs and (b) tracking the results of the financial investments made by their organizations. This study represents an attempt to contribute university resources to investigating such issues.

### Assumptions and Limitations

This study explored existing literature and then investigated issues quantitatively. It utilized data provided by the USGBC and IPEDS to enable longitudinal comparisons among LEED users and among their projects. The study was shaped by possibilities offered by existing datasets. It adopted operational definitions provided by IPEDS and LEED and thus assumed the limitations of the existing measures and their definitions. Since no specific operational definitions of leadership or knowledge-generation were provided through LEED or IPEDS, other signifiers were employed. The overall LEED rating – which is derived from the total number of points achieved in each category and which is sometimes identified as a leadership rating – was used as the primary indicator of leadership. Certification and innovative design credits were employed as close representations of knowledge generation. The imprecision of these signifiers limits the value of the findings.

Generalizability of the study is further limited by the characteristics of the sample. The 181 projects included in this study did not achieve the same versions or achieve the same ratings, on average, as the balance of the population (i.e., the 265 projects certified through December 7, 2009 that were not included). This difference between the two groups in rating and version was statistically significant, which means that some patterns evident within the sample do not hold true for the larger population.

This study did not assess outcomes of the new version of LEED, but attempted to contribute understanding of how the older version was used. It aimed to provide better understanding of what types of postsecondary institutions have implemented the system, how they did this, and the degree of success they had in obtaining certification, providing leadership, fostering innovation, and generating knowledge.

**Conclusion**

This study examined how postsecondary institutions have used categories within LEED v2. It investigated relationships between university characteristics, use of LEED categories, and LEED ratings achieved. This exploratory study attempted to understand and describe how universities use LEED and what they achieve by doing so.

It aimed to harness existing LEED and IPEDS data to provide helpful feedback that might improve LEED. The hope was to find patterns that could inform future development of the LEED system and help postsecondary institutions use the system more effectively. The investigation began with a review of literature related to (a) environmental sustainability, (b) higher education's role in environmental sustainability and green building, (c) features of the LEED Green Building Rating system, and (d) ideas about leadership, innovation, and knowledge-generation. This literature review is presented in the following chapter.

## Chapter 2: Review of Literature

This chapter explores environmental sustainability in relation to higher education. It defines sustainability and describes what universities are doing to encourage and promote it. It provides examples of environmental activities that help meet higher education's overall purpose within society. It discusses how institutions provide leadership and generate knowledge about sustainability. The chapter seeks to provide readers with a basic understanding of "green building" terms and approaches. The chapter ends with a discussion of how universities have been using the LEED® Green Building Rating system to achieve a range of goals. The chapter provides a foundation for the research methodology described in Chapter Three.

This study's empirical design used existing data to assess universities' achievement in the areas of LEED certification, leadership rating, and innovation. With implementation of many green programs fully underway, tracking efforts, measuring results, and perfecting techniques is becoming critical (Barnetson, 2001; Holcomb, 2001; Presley & Leslie, 1999). Programs cannot evolve without conscientious assessment over time – assessment that informs future action (Birnbaum, 1988; Wilson, 1997). This study seeks to evaluate how universities have been using one specific green building program (LEED-NC v2). It is part of a growing dialogue that investigates, critiques, and offers insight to improve formal sustainability programs.

Knowledge of environmental issues is emerging and quickly evolving. There is little prior research on outcomes of LEED. Little is known about how LEED buildings perform over time, or who has been using the LEED system and how. This literature review incorporates a wide array of sources in an effort to build a base of understanding.

The review incorporates findings from books and peer-reviewed journals. Because much of the relevant information has not made its way into scholarly publications, it also utilizes reports, fact sheets, news articles, white papers, organizational mission statements, and documents from meeting and conferences. The chapter follows Palmer's (1998) suggestions to (a) frame a particular moment in time, (b) describe the social discussion occurring, (c) help push environmental ideas forward, and (d) foster growth.

**Environmental Sustainability**

Most environmentalists have adopted the World Commission on Environment and Development's (1987) definition of sustainable development (Bartlett & Chase, 2004; McDonough & Braungart, 2002). The Commission defined *sustainability* as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 43). The green building movement fosters development practices and collaborative strategies that meet contemporary needs without overharvesting resources or depleting nature. Construction methods employed throughout the past century have required vast material resources. They cause unnecessary waste and pollution. North America's over-reliance on cheap energy has reached crisis proportions (Steffen, 2008; Wackernagel & Rees, 1996).

Buildings consume 65% of the electric power used in the US and 36% of all energy (Landsmark, 2008). They account for 39% of greenhouse gasses, 30% of all raw material usage, and 30% of waste generation. Buildings are responsible for half of United States' greenhouse emissions (Gifford, n.d.; Udall & Schendler, 2005). As many as 30% have "sick building syndrome" and thus expose occupants to stale, moldy, or toxin-laden air (Roodman & Lenssen, 1995).

The nation's population is growing and so is the need for new buildings. Cortese (2005) indicates that within 50 years, there will be a need for twice as many buildings as currently exist. It is crucial to long-term survival that humans do not destroy their own habitats as they build. The United States Environmental Protection Agency (2009) identifies harmful effects of construction as: detriment to human health, degradation of the environment, and loss of resources. The Agency describes *sustainable design* as "the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction" (¶ 1).

Designers can help alleviate negative impacts by: using energy, water, and materials effectively; providing daylight, ventilation, and materials that promote wellbeing and foster productivity; reducing waste, pollution, and environmental degradation (United States Environmental Protection Agency, 2009). The general prerogative of the construction industry is to simply meet the minimum requirements of building codes and zoning regulations and to do so with the least expense possible (Gowri, 2004). Programs like LEED offer incentives for owners and builders to exceed minimum standards.

*Green building* seeks "to improve overall building performance, and minimize life-cycle environmental impact and cost" (Gowri, 2004, p. 56). Many sustainability advocates also want to create designs that replenish the natural environment (McDonough & Braungart, 2002). People with this goal often aim to exceed LEED standards (Dudley, 2009; Woolliams, 2007).

***The sustainability movement.*** Environmental advocates hope to achieve a net zero ecological footprint and to restore what has been lost through human activity (Orr, 2007; Wackernagel & Rees, 1996). Making the transition from "disposable" to "regenerative" requires a great deal of ingenuity and research (Iverson & Chance, 2007; McDonough & Braungaurt, 2002). LEED adopts a sort of middle ground, promoting change that is within reach and fostering swift, incremental progress (USGBC, 2007). Change has upfront costs and inevitable implementation dips.

Dips typically occur when a product or system does not seem to function as well as what it is replacing (Fullan, 2001; Holcomb, 2001). They are evident in the emergence of all sorts of new products, where the technologies improve slowly at first. Once the technologies reach a tipping point, throngs of people eagerly adopt them (Gladwell, 2000). Early adopters absorb much of the upfront cost associated with initial product development. This is true with green building components and technologies. Up-front costs tend to decrease over time as production capacity grows. On the other hand, several green building technologies cost far less than alternatives that are in standard use today. Passive solar heating and natural ventilation techniques have, for instance, always cost less to install and operate than large heating and cooling systems.

The true environmental cost of products and buildings is difficult to see or assess (Bradley & Crowther, 2004; Patelski & Poling, 2008). People tend to focus on purchase price at the cash register – without giving much thought to the environmental degradation associated with their choices. Harvesting, mining, processing, packaging, operating, and maintaining industrial products causes tremendous environmental damage (McDonough & Braungart, 2002). Environmental cleanup, depletion of resources, and destruction of species and habitats have been ignored in price-setting and left for future generations to resolve (Wackernagel & Rees, 1996). Researchers are currently working to measure the long-term costs of production. They have developed Lifecycle Cost Analysis (also known as Life Cycle Assessment or LCA) to estimate impact. LCA quantifies the cost of all materials and energy flows and the environmental effects associated with manufacturing, operating, and maintaining a building or product (Scheuer & Keoleian, 2002).

Many researchers endeavor to understand quality-of-life issues using quantitative methods. Fisk (2002), a scientist at the Lawrence Berkeley National Laboratory numerically assessed the benefits of improved indoor air quality. His studies showed substantial health, economic, and productivity benefits of clean indoor air. He conducted this research through a university partnership with the US Department of Energy and the California Institute for Energy Efficiency. This is not the type of research corporations usually conduct or share with others, since having basic research and theoretical knowledge does not provide a competitive edge (Rhodes, 2001). It takes universities to produce this kind of knowledge. Basic and applied research can be used to improve building codes as well as incentive programs like LEED.

The Energy Star rating program and the Forest Stewardship Council's wood certification program are systems that implement emerging research. Goleman (2009) indicates that programs like these are fostering a new, radical level of transparency in labeling. He wants producers and distributers to describe exactly what goes into making the items people buy, use, and ingest. This will help individuals make better, more conscious purchasing decisions. LEED, Goleman says, is a step in the right direction.

Product development usually happens in the industrial sector (Goleman, 2009). However, architects, designers, and individuals in non-profit organizations (such as universities and think tanks) are conducting much of the research on green building. Tracking the resources used to manufacture building components and operate facilities requires complex science. Goleman identifies databases that are being developed by public and private entities to facilitate costs and benefit analysis and interpretation. Although many rating systems are still in their infancy (and do not yet offer comprehensive or highly reliable information) Goleman says they are quickly improving.

Working together, scholars, designers, and advocates are making remarkable contributions to enhance the practice of green building. William McDonough + Partners' (2008) design research provides precedents for LEED and for thousands of green buildings existing today (Oberlin College, 2007b). The architecture firm developed a range of innovative approaches and techniques, working in collaboration with Professor David Orr and students at Oberlin College. In the mid 1990s, Orr (1999) first initiated the planning of an environmental study center and rallied support for it. This building continues to serve as an incubator for research and development in sustainability.

Today, hundreds of universities are creating initiatives to support environmental activities and green building programs. Even universities that lack passionate environmental experts can achieve some degree of sustainability in their construction projects by implementing LEED. Participating in the LEED program provides universities a forum for developing sustainable technologies, implementing new techniques, and sharing knowledge. It fosters society's overall capacity to produce green buildings, implement innovative technologies, and generate green power. LEED also helps universities to gain public recognition for their work.

***Universities and sustainability.*** Cortese (2005) says interest is growing exponentially among students and faculty, planners and facilities managers to have "their campuses' infrastructure model sustainability" (¶ 6). Educational and facilities planning groups (like APPA and the Society for College and University Planning) have rapidly expanded their offerings to support the green movement. The USGBC (n.d.) reasons that "with roughly 240,000 buildings spread across over 4,100 higher education institutions, colleges and universities can benefit from making green building a central element of sustainability planning" (¶ 1).

Today, postsecondary institutions are adopting green practices to support their "triple bottom line – financially, environmentally, and socially" (Patelski & Poling, 2008, p. 125). Building green is a way to simultaneously balance ecology, economy, and social equity (McDonough & Braungart, 2002). Universities use green building to promote health, save money, preserve the environment, and reflect values of social responsibility and optimism in their building practices (Bartlett & Chase, 2004; Steffen, 2008).

**University Activities in Environmental Sustainability**

Hundreds of universities across the United States are placing environmental sustainability at the forefront of their efforts today (Bartlett & Chase, 2004; Second Nature, 2009). Universities are integrating sustainability into an array of traditional and new activities. Green building is a small but critical part of this work. Environmental programs involve teaching, research, and service, in addition to university administration and facilities operation (AASHE, 2009b).

The ideas and techniques that universities develop can help people on campus and in the larger community. Hundreds of universities have joined environmental knowledge-sharing networks. They are involved in formal and informal activities to exchange ideas with organizations and promote learning by people of all ages (Alvarez & Rogers, 2006; Cortese, 2005; Smith, 1999). Bartlett and Chase (2004) describe themes within the nation-wide campus greening movement: environmental stewardship, curriculum development, green design and construction, student and community engagement, and crosscutting system-wide initiatives. Cortese (2005) asserts, "Nowhere has the interest in sustainable design been more palpable than in the education system, particularly higher education" (¶ 6).

Hopkinson, James, and van Winsum (2004) define three main areas where universities affect the environment. The first involves direct impact that university activities have with regard to energy and water flows, travel by staff and students, and the like. The second involves student knowledge and behavior regarding the environment. The third involves research about environmental issues.

The *Talloires Declaration*, developed by the Association of University Leaders for a Sustainable Future's (1990), posited that universities "have a major role in the education, research, policy formation, and information exchange" regarding environmental sustainability (¶ 4). "University leaders must," it declared, "initiate and support mobilization of internal and external resources" to promote sustainability (¶ 4).

Participants in the *Talloires Declaration* specifically agreed to: (1) increase understanding of sustainable development, (2) create a culture of sustainability within each institution, (3) foster environmental citizenship, (4) develop environmental literacy across society, (5) "practice institutional ecology," (6) involve as many stakeholders as possible, (7) foster collaborative, interdisciplinary approaches, (8) enhance the capacity of K-12 schools, (9) provide broader service and outreach at the national and international level, and (10) stimulate the green movement (Association of University Leaders for a Sustainable Future, 1990, ¶ 5).

Universities' environmental activities are increasingly visible to the public. Achievements are featured in media outlets like *USA Today* (Joiner, 2009) and on websites that pool and share innovative ideas (like www.worldchanging.org). Many institutions participate in the National Wildlife Federation's Campus Ecology Program, host sustainability conferences, or contribute research through scholarly venues including the *International Journal of Sustainability in Higher Education* and the *Journal of Green Building* (Bartlett & Chase, 2004).

Many universities have also joined the Association for the Advancement of Sustainability in Higher Education (www.aashe.org) or conducted programs with Second Nature (www.secondnature.org). AASHE's (2009a) membership includes over 690 colleges and universities in the United States. Second Nature (2009) is a non-profit organization that was founded in 1993. It aims to accelerate "a sustainable future by serving and supporting senior college and university leaders in making healthy, just, and sustainable living the foundation of all learning and practice in higher education" (¶ 1).

Universities enroll about 15 million students in the United States today (Goodchild, 2007). They provide education and outreach to millions more who are not formally enrolled. What universities do to teach better ways of valuing and managing resources can greatly influence how society behaves (Cortese, 2005).

## University Leadership in Environmental Sustainability

More than 140 postsecondary institutions have established internal offices for sustainability (Kadden, 2009). Many have appointed campus-wide sustainability directors (AASHE, 2009c). Some universities focus on a few topics – such as energy conservation or green building – while others use sustainability to foster community spirit, promote comprehensive learning, and facilitate holistic development. There is collaborative, cross-disciplinary action and dialogue among faculty, students, staff, and administrators.

The Sustainable Endowments Institute (2009a) and AASHE (2009d) both describe high levels of activity and investment in environmental sustainability as "leadership." This leadership role is made visible to the public through green rating systems conducted by LEED, the Princeton Review, and the Sustainable Endowments Institute. AASHE distributes Campus Sustainability Leadership Awards annually, and the green rankings published by *US News and World Report* reach a mass audience.

The Sustainable Endowments Institute's (2009a) *College Sustainability Report Card 2010* is also known as the Green Report Card. It provides information on current conditions and facilitates tracking of progress over time. Founded in 2005 the non-profit Sustainable Endowments Institute (2009b) conducts research and provides education "to advance sustainability in campus operations and endowment practices." The Green Report Card released October 7, 2009 identifies 26 of the 332 participating universities as "Overall Sustainability Leaders."

Both AASHE (2009d) and the Sustainable Endowments Institute (2009a) identify institutional endowment as an important factor in fostering campus sustainability. The Institute indicates that its 332 participants hold endowments totaling over $352 billion.

This represents 95% of all endowment assets for higher education in the United States. Although endowment values declined 23 percent or so last year, involvement in green initiatives continued to flourish (Kadden, 2009).

Kadden (2009) says that despite the current economic downturn, universities are investing more in sustainability as a way to save money, foster pride, and attend to stakeholder expectations. In the past year, the percentage of participating universities that have sustainability offices increased dramatically, from 22% last year to 45% today. Grades on the Green Report Card went up for 56% (Sustainable Endowments Institute, 2009b). Kadden notes that only 13% of participating universities showed declines in their sustainability ratings, and that declines were slight.

**University Innovation in Environmental Sustainability**

Cortese (2005) encourages faculty, administrators, trustees, staff, students, and higher education organizations to assume prominent leadership roles in sustainability. He insists that universities should lead society as they did in the "space race" and the war on cancer. The leadership role he envisions would prepare students and also generate knowledge and information "to achieve a just and sustainable society" (¶ 14). In his model, universities would model biological and social sustainability. Higher education would reflect a symbiotic interdependence in local, regional, and global contexts. Education in all fields would adopt innovative new approaches to learning and practice.

Boyer (1990) identified crosscutting scholarly activities. He described them as "the scholarship of *discovery*, the scholarship of *integration*, the scholarship of *application*, and the scholarship of *teaching*" (p. 16). Academics have traditionally assumed these roles and conducted work as a form of "public good" (Slaughter & Rhoades, 2004, p. 2).

**Research as a way of generating and disseminating knowledge.** Research is a critical part of the work universities do (Goodchild, 2007; Karabel, 2006; Levin, 2003; Thelin, 2004). Universities "have always reflected their wider societies," Cullingford (2004a) explains; "their purpose has evolved as societies have evolved" (p. 13). American universities have held a proud position in society since the founding of Harvard in 1636 and the College of William and Mary in 1693 (Thelin, 2004). Universities establish direction for the nation's intellectual pursuits. One of their primary purposes is to generate knowledge through research (Kerr, 1995).

Applying research, and teaching people to use it, are core purposes of the academy. They date back to the Morrill Land Grant Acts of 1862 and 1890, which compelled postsecondary institutions to provide educational outreach as a form of service (Kerr, 1995). The 1887 Hatch Act established agricultural experiment stations and the Smith-Lever Act of 1914 established the Agricultural Extension Service and infused research into agricultural practice. These acts sought to provide educational outreach to mass audiences (Goodchild, 2007; Thelin, 2004). They focused on issues related to geography and the agricultural context.

During this period, the federal government communicated the individual and collective benefits of higher education benefits in a way Americans understood (Bowen, 1977; Lazerson, 2007). Today, the American public expects higher education to expand frontiers of knowledge and protect the greater good. Since World War II, universities have assumed primary responsibility for conducting basic and theoretical research (Kerr, 1995; Lazerson, 2007; Levin, 2003; Rhodes, 2001).

Levin (2003) asserts that this type of research cannot be conducted as effectively in the business world, which demands immediate results and clear payoff. In the university, research topics are identified and funded based on "inherent scientific interest and promise rather than [their] direct commercial value" (Rhodes, 2001, p. 192). This research model has been strikingly successful in generating new knowledge and in addressing challenges that have emerged over time (Kerr, 1995; Levin, 2003).

The United States' hybrid system of education and research in tandem has been highly effective in fostering student creativity and invigorating the enterprise of research (Kerr, 1995; Rhodes, 2001). Levin (2003) argues that by "engaging students in intellectual inquiry, making them active participants in intellectual inquiry, and fostering their problem-solving abilities, universities and colleges contribute to economic growth" (p. 91). Research also helps address the "search for significance, our innate sense of duty, our commitment to justice, our groping for meaning, our quest for linkages and relationships" (pp. 182-183). Here and abroad, universities produce and disseminate knowledge in areas deemed critical to human development.

Odell, Grayson, and Essaides (1998) discuss ways to improve the transfer of knowledge from theory to practice. Many of these ideas are relevant to green building. They identify four important enablers in the knowledge transfer process: culture, development of infrastructure for knowledge transfer, effective use of technology, and means for measuring various effects of knowledge transfer. Successful transfer, they find, requires: a compelling need for change, clear-eyed appraisal of problems and opportunities, a comprehensive design, and a good plan for implementation and management. This can help overcome barriers that typically include ignorance, lack of individual capacity to absorb new knowledge, absence of collaborative relationships, and lack of motivation. All these factors influence LEED use as well.

Over the centuries, American colleges and universities have been instrumental in creating knowledge in areas such as agriculture, medicine, health care, technology, and national security (Karabel, 2006; Thelin, 2004). These fields can inform the sustainability movement, but the compartmentalized approach that universities have taken over the past century presents a hindrance (Bartlett & Chase, 2004; Kerr, 1995). Holistic, proactive approaches by university stakeholders can foster environmental success (Lauer, 2006; Rowley, Lujan, & Dolence, 1997; United States Department of Education, 2006).

***Generating knowledge in environmental sustainability.*** America's universities have come to define higher education worldwide (Kerr, 1995). The United States Department of Education (2006) indicates the nation's universities are losing their edge, however, and that they need to pay closer attention to issues such as transparency, accountability, innovation, and learning. Environmental leadership is a way to help American higher education regain stature and enhance its relevance to society (Cullingford, 2004b). Universities are uniquely positioned to lead a global movement toward sustainability. This challenge is befitting higher education's record of past achievement (Goodchild, 2007; Saltmarsh, 2009). Today, institutions and individuals are approaching "change" as a fun, creative process instead of a task (Steffen, 2008). They now understand that sustainability can be profitable as well as enjoyable.

***Generating knowledge through green building.*** This innovative spirit is evident in many Research and Development programs on campuses today. Popular programs include the United States Department of Energy's (2009) Solar Decathlon and the United State Green Building Council's LEED Green Building certification program. Incentive and encouragement programs like these can foster healthier, better performing buildings (McDonough & Braungart, 2002). University participation in these formal programs helps push the green movement forward (USGBC, 2007). It provides models for responsible decision-making and behavior among students and the general public.

Figure 10: *Students teaching visitors about how their green buildings work.*


Levin (2003) urges universities to "keep extending the frontiers of science and improving the efficacy of our pedagogy" (p. 94). Such is evident in the United States Department of Energy's (2009) semi-annual Solar Decathlon. This competition promotes innovation through green building research and development. Students and faculty conduct and apply research in the design and construction of green homes (see Figure 10). Every other year, twenty solar houses are constructed on the Mall in Washington DC for competitive evaluation and public display. Students and faculty provide tours and teach visitors about energy and environmental design. This is a service to society that seamlessly integrates research and teaching.

**Teaching as a way of generating and disseminating knowledge.** Universities typically diffuse knowledge to students through teaching. They also transfer knowledge through publications, professional conferences, public programs, extension activities, and service-related events. Environmental issues are finding their way into lectures, discussions, and assignments in a broad range of courses.

Innovators in higher education have found that hands-on problem solving facilitates high-quality learning (Cortese, 2005; Hannan & Silver, 2000). Inquiry-based learning activities help students understand concepts better and retain what they have learned longer than traditional delivery formats. Experiential learning provides the underpinning for environmental education in hundreds of universities today (AASHE, 2009b; Smith & Williams, 1999). Study of the environment, once confined to the pure and natural sciences, is now seen as a central issue that requires input from many fields.

In 2008, more than 66 sustainability-related degree programs were initiated in North America. Thirteen new research centers for sustainability opened and 33 more were in development (University World News, 2009). More than half of all four-year institutions in the US offered majors and/or minors related to environmental sciences, management, policy, and the like (Cortese, 2005). Many new graduate programs have emerged in environmental planning, design, engineering, and management (Cortese, 2005). More and more resources are available to help teach students about sustainable design and construction (LaGro, 2008; Lechner, 2009; Mendler, Odell, & Lazarus, 2006; Porteous, 2005; Sassi, 2006; Szokolay, 2004; Steele, 2005; Thomas, 2006).

Institutions that adopt comprehensive approaches to curricula understand that coursework must bridge liberal arts with technical sciences. This requires significant curricular change (Orr, 2007). Educators share new methods for integrating sustainability into courses about the built environment (Edwards, 2004; Graham, 2000; Orr, 2007). They also discuss teaching methods in the field of construction (Riley, Grommes, & Thatcher, 2007; Tinker & Burt, 2004), architectural design (Chance, 2005; Johns, 2003; Malone, 2008; Palleroni, 2004), and engineering (Carew & Mitchell, 2008; Rowden & Striebig, 2004). Hopkinson, James, and van Winsum (2004) assert that environmental topics elicit strong student involvement, meaningful applied research, and productive learning. They cite transportation, energy, water management, and waste handling as research topics that spark students' enthusiastic engagement.

Educators also discuss ideas for integrating environmental issues into general coursework (Bowers, 1997; Timpson, Dunbar, Kimmel, Bruyere, Newman, & Mizia, 2006; Smith & Williams, 1999). Some describe how to integrate sustainability into liberal arts (de Lorenzo, 2000; Orr, 1999; Stanisstreet & Boyes, 1997) and teacher preparation (Bowers, 1999; Cajete, 1999; Corcoran, 1999). Teacher preparation programs can help foster wide scale change, since students in such programs will convey their knowledge, values, and assumptions to the next generation.

***Imparting skills, knowledge, and values.*** Educators need to help transform "the way our students interact with the world and one another," say Smith and Williams (1999, p. 5). In emerging models, students are "active generators of new knowledge" and curriculum supporters are "participants in new problem-solving networks" (Palmer, 1998, p. 147). Under this new paradigm, the role of the teacher and researcher is that of a collaborative participant engaged in inquiry. The teacher is no longer seen as the primary source of intellectual authority but as an agent of growth and change.

Despite recent shifts, however, most curricula still "condition students to view the natural world as a collection of objects that can be manipulated through science, technology, and human economic interests" (Cajete, 1999, p. 193). Cortese (2005) cautions that "remedial education" to correct misperceptions and destructive behaviors are not as effective as establishing healthy patterns at the outset. He recommends taking action to ensure the environment takes priority in students' (and organizations') decision-making and that positive behaviors are transformed into habit. Educators must foster a sense of ownership for environmental issues among students and empower them to act (Palmer, 1998). When students investigate local environmental issues – or work in collaboration with educators, community representatives, and each other – they reflect higher levels of ownership and analytical questioning (Orr, 1999; Smith & Williams, 1999). Virginia Tech provides an example of this type of shift.

Virginia Tech's 2009 Common Book Project focused on environmental sustainability and reached students in every major (Owczarski, 2009; Zhao & Kuh, 2004). Virginia Tech provided all new freshman, transfer students, and their faculty with copies of Goleman's (2009) book *Ecological Intelligence* (Trejbal, 2009). The university encouraged faculty members who teach incoming students to integrate the book into their coursework and to facilitate discussion on critical issues (Owczarski, 2009). Approximately 5000 students read about and discussed environmental sustainability (Hincker, 2006). Such activities enhance the overall effect of teacher-student interactions, amplifying and extending learning through meaningful peer-to-peer exchange (Garrett & Zabriskie, 2004; Pasque & Murphy, 2005).

***Modeling behavior.*** A model serves to represent something else. It provides "a pattern of something to be made" or "an example for imitation or emulation" (Model, 2009). Lyons Higgs and McMillan (2006) investigated techniques that four secondary schools used to model sustainability for their students. They found modeling to be an effective way to promote knowledge, behaviors, and values that support sustainability. The schools in their study reinforced positive environmental practices when: (1) individuals modeled positive behavior, (2) facilities and modes of operation were redesigned to support the natural environment, (3) school governance reinforced collaborative and environmental practice, and (4) culture shifted to reflect new values.

Like the four schools Lyons Higgs and McMillan (2006) studied, universities model behavior for individuals on and beyond campus (Cortese, 2005). By operating in ways that are healthy for people and nature, academic communities are able to demonstrate positive behaviors and techniques. Participation in LEED represents a way for universities to model green strategies and green decision-making.

Campuses represent microcosms where ideas can be applied at a visible scale (Cortese, 2005). The ways postsecondary institutions conduct their activities reflects their priorities and the supports specific types of behaviors. The 4391 institutions of higher learning in the US carry weight socially and economically (Goodchild, 2007; Lee, Cheslock, Maldonado-Maldonado, & Rhoades, 2005; Levin, 2003; Rhodes, 2001). Based on 2002 data, the combined operating budgets of postsecondary institutions in the US exceeded all but the 25 wealthiest nations in the world (Cortese, 2005). The decisions universities make – and the facilities they create – send powerful messages (Orr, 1999).

Cortese (2005) says, "We need new indicators of movement toward sustainability and institutional success because we measure what we value and manage what we measure" (¶ 17). Universities must take care in the way they use and track energy and other resources. Universities convey messages through choices related to operation, transportation, recycling and waste handling procedures, purchasing, and construction.

***Using buildings as pedagogical tools.*** Fox (2007) and Orr (2007) study ethical implications of how societies construct objects, deal with material culture, and teach about the material world. The study of ethics now encompasses the way societies (and entire generations) behave and how they manage resources such as energy. Buildings "ought to demystify the world, making us mindful of energy, food, materials, water, and waste flows" (Orr, 2007, p. 220).

Course work, as well as the buildings in which courses are taught, can impart values and change behavior (Orr, 1999). Designing buildings that respect nature, people, and economic forces requires making choices. Decisions involving energy, land use, water distribution, waste handling, materials and resource consumption "are inescapably political," argues Orr (2007, p. 219). Making these choices requires leadership; it also communicates values.

When buildings, landscapes, and campuses are designed with an emphasis on community, ecology, and public education, the results draw people closer to nature (Orr, 1999, 2007; McDonough & Braungart, 2002). Places and buildings can convey a sense of history. They can communicate messages regarding energy and materials, seasonal rhythms, and natural ecosystems (Orr, 2007). "Buildings and landscape reflect a hidden curriculum that powerfully influences the learning process," argues Orr (1999, p. 229). The typical academic facility communicates that energy is abundant and cheap. It implies that connections to the larger environment are unimportant. Campus buildings, Orr insists, instruct students "as fully and as powerfully as any course" (p. 229).

As a faculty member at Oberlin College, Orr (1999) spearheaded a campus-wide sustainability movement. Its activities have included planning and construction of the Adam Joseph Lewis Center for Environmental Studies, a high-functioning building that is integrated into its site in a way that teaches people about the environment. The Lewis Center was "one of the first and most innovative green buildings on a college campus. It helped launch the green building movement of the mid 1990's" (Engstrom, n.d., ¶ 2).

This building predates LEED. It clearly influenced the development of the system and it continues to do so (Oberlin College, 2007b). The Center models how buildings and landscapes can work as pedagogical tools, and demonstrates holistic approaches that are now being implemented at other campuses (Oberlin College, 2007b).

Today, the Lewis Center makes it easy for users to see relationships between humans and the natural environment. It helps them understand the environmental impact of their actions. This building is still breaking technological ground. Through the collaborative efforts of students, interns, and National Renewable Energy Lab (NREL) staff, the College recently implemented a system for monitoring building performance (Oberlin College, 2007b).

The LEED Green Building Rating system grew out of grassroots efforts like Oberlin College's (Dudley, 2009). Today building owners in 91 different countries are working to achieve LEED certification (USGBC, 2009f). When Orr (1999) originally conceived of the Environmental Center at Oberlin, he had to prod university leaders to support this type of groundbreaking work. Although they allowed him to proceed, they also required his team to secure all necessary funding for the building, without tapping existing donors. Today, universities everywhere are using sustainable development as a way to attract new donors.

***Progress over time.*** Several organizations are tracking how universities integrate sustainability into teaching. AASHE (2009b) collects data about various curricula. Professional organizations are also getting involved. The American Institute of Architects' [AIA] (2009a) Committee on the Environment (COTE) spearheaded a survey of sustainability coursework in American schools. The United States Environmental Protection Agency (2009) lists COTE and LEED as two early milestones in the green building movement. COTE programs help teach professionals, improve education and practice, and contribute to the knowledge base regarding sustainable building construction. Its programs include (a) energy reduction targets, (b) a sustainable design continuing education requirement for all AIA members, and (c) conference and publications related to sustainability in architecture and higher education (AIA, 2009a).

**Service as a way of generating and disseminating knowledge.** The Wisconsin Idea originally proffered "that education should influence people's lives beyond the boundaries of the classroom" (Van Hise cited in The Board of Regents of the University of Wisconsin System, 2007). The Idea birthed the first extension system, which brings knowledge to residents throughout Wisconsin even today. The Regents explain that this

Idea "has become the guiding philosophy of university outreach efforts in Wisconsin and throughout the world" (¶ 1).

Through various land-grants acts, the federal government brought an extensive system of agricultural research and training programs to states around the nation. These programs are designed to meet the needs of local communities (Kerr, 1995; Levin, 2003). Rhodes (2001) calls this system "the most distinctive and most successful example of public service by American universities" (p. 195). The cooperative extension service has been expanded over the years to provide programs that deal with urban as well as rural issues. However, the system has always been involved in environmental issues and it provides an ideal mechanism for extending universities' current work in sustainability.

Rhodes (2001) recommends expanding cooperative extension to better address today's most pressing social problems. This university-based system can experiment with potential solutions and find new ways of applying them. The extension service has been remarkably successful in harnessing knowledge, applying it creatively, and running demonstration models. Its programs educate individuals, families, and community groups and encourage them to cooperate effectively. It provides linkages between problems, programs, and solutions in ways "conventional agencies" cannot (Rhodes, p. 98).

Kerr (1995) praises the effectiveness of this system and he, too, emphasizes the need for universities to become much more involved in applying research. Addressing environmental problems can help universities overcome their current crisis of identity, Kerr (1994, 1995) argues. It can help renew their sense of purpose and expand their value to society as recommended by the United States Department of Education (2006).

Universities draw from their heritage of public service in the sustainability programs they conduct today. Cornell University's extension service, for instance, educated builders about ways to reduce construction waste. The program applied research by waste management scholars like Tinker and Burt (2004). Such programs take theories and move them into common practice (Odell et al., 1998). Furman University (2009) contributes similar types of service through programs for recycling, activities that reduce consumption, methods of green building, and resources to help constituents integrate sustainability into their everyday lives. Rhodes (2001) wants higher education to utilize, and further develop various service mechanisms in such ways, to extend their impact.

Architecture students at the University of Wisconsin-Milwaukee provide another example. They "challenge renovation projects underway within the university system. When there are plans to build or remodel a campus facility, the students conduct analyses and simulations and offer alternate design proposals to show how the project could be greener," explains Novitski (2009). These students, Novitski says, see LEED proficiency as vital to their future practice. Many have earned credentialing as LEED Accredited Professionals (LEED-APs).

In the pursuit of green building, universities often rely on external sources for information and guidance. They look to organizations like the USGBC, AASHE, Second Nature, and the AIA (2009b) which:

> recognizes a growing body of evidence that demonstrates current planning, design, construction, and real estate practices contribute to patterns of resource consumption that seriously jeopardize the future of the Earth's population. Architects need to accept responsibility for their role in creating the built environment and, consequently, believe we must alter our profession's actions

> and encourage our clients and the entire design and construction industry to join with us to change the course of the planet's future. (¶ 1)

Many universities also reflect the values underlying the AIA's (2009c) position statement on LEED and related programs:

> The AIA supports the development and use of rating systems and standards that promote the design and construction of communities and buildings that contribute to a sustainable future. (¶ 1)

Universities bring knowledge about the environment to diverse audiences through informal, as well as formal, means. Students provide leadership and set positive examples when they conduct environmental clean-up days, provide educational programs, or tutor schoolchildren. Service activities help students learn by teaching and by applying ideas in real-life settings (Alvarez & Rogers, 2006). In this way teaching, research, and service are mutually reinforcing. They frequently overlap and are most effective when they do (Axtell, 1998; Colbeck, 1998; Gappa, Austin, & Trice, 2007; Toews & Yazedjian, 2007).

Cortese (2005) asserts that student-led efforts have had surprisingly powerful results. Student initiated programs on over 500 campuses have fostered major changes in everything from campus planning and building design to transportation, purchasing, and collaborative spirit (Cortese). A major goal of the early colonial colleges was to produce teachers and ministers who would educate and direct the values of their communities (Thelin, 2004). Graduates then provided formal and informal programs to help people achieve better, healthier lives. A revival of this spirit is evident across universities today.

Fostering widespread environmental change will require participation from citizens of all ages. It is critical to extend environmental knowledge, skills, and values to the general population and to disseminate knowledge widely. Attracting participants is important to the success of environmental programs. Smith and Williams (1999) indicate that people are more likely to engage in such programs when they "believe they can contribute to the welfare of others" (p. 9).

Smith (1999) defines non-formal programs as those that do not confer degrees, licenses, or diplomas. Non-formal programs can help "get the word out" about advantages of green design, in a way that appeals to a wide range of people (Walker, 2009). A recent study at Michigan State University (2009) found people who see their neighbors enroll in environmental conservation programs are more likely to do so as well. Universities can use this knowledge of human behavior to increase participation.

**Administrative Functions that Generate and Disseminate Knowledge.** Adopting a collaborative, service-oriented approach to university administration helps support environmental sustainability (AASHE, 2009c). "Society has been going through revolutionary changes," notes Keller (2008, p. xi). It is critical that everyone involved in higher education recognize these changes, he says, and collectively "rethink and redesign" administrative operations (p. xi).

Collaborative, interdisciplinary models that integrate feedback and foster creativity can be used to enhance planning and development activities (Chance, 2008; Chance, 2010; Lauer, 2006). These activities reflect a paradigm shift. It is also apparent in the creation of sustainability offices on hundreds of campuses throughout the country (Edwards, 2005). Individuals on campuses everywhere have been empowered to think holistically and work across traditional boundaries.

***Shift toward organizational learning and collaboration.*** The environmental movement is part of a larger shift in thinking that emphasizes the social construction of knowledge (Palmer, 1997). Bartlett and Chase (2004) assert that achieving environmental sustainability requires constructing an alternate vision of the future. Realizing this vision means "learning, questioning, trusting, competing, at times coercing, and at times building together" (p. 7). Relationships are essential in this process (Michigan State University, 2009). Servant leadership and other leadership techniques that emphasize relationships can help foster environmental change (Evans, 2007; Purpel, 2007; Sergiovanni, 2007). Facilitating change, leaders must help their constituents develop a shared overarching vision (Fullan, 2001).

Shared vision helps channel effort. It gives individuals confidence and guides individual and collective action (Fullan, 2001). Administrators and faculty on campuses tend to work in silos, but this is something to be avoided (Kerr, 1995; Lauer, 2006). It limits their efficacy. By pooling knowledge, talents, and abilities, university communities can better adapt to today's rapidly changing context (Chance, 2008; Kiernan, 1996).

Collaboration and proactive planning are essential today (Lauer, 2006; Rowley et al., 1997). Effective leadership requires considering many alternative scenarios and providing flexibility to address issues as they emerge (Kennie, 2002). Chaffee (1985) argues that planning models are most effective when they include: (1) a foundation in rational analysis, (2) flexibility and ability to respond to unforeseen changes creatively, and (3) a future-oriented strategy or metaphor to help people conceptualize various situations/solutions and construct their collective future.

Universities' first responses to sustainability used rationalist approaches. Sharp (2009) recommends supplementing these linear approaches with more sophisticated planning and management techniques that "diagnose and reform the very nature of our organizations" (p. 3).

***Directing the change.*** Operational units on campus are applying new techniques in a myriad of ways. This reflects the transfer of knowledge from theory into practice described by Boyer (1990). AASHE (2009b) describes an escalating trend among universities to hire sustainability directors and to establish environmental offices on campus. Sustainability professionals are leading change-management teams and coordinating environmental efforts across various academic and administrative units. These individuals must use "diagnostics, creative problem solving and pre-emptive action to address a wide variety of real or perceived risks and barriers" (Sharp, 2009, p. 4).

Last year, AASHE (2009b) listed 64 position announcements for sustainability directors, coordinators, or managers. Forty or more institutions hired individuals to direct their sustainability efforts. At least three of these hires were at the level of vice chancellor or vice president, underscoring the importance that universities are beginning to place on this issue. When AASHE held its 2008 conference to share knowledge about campus sustainability, more than 1700 people registered. They hailed from 400 different institutions, representing 48 states and 15 different nations.

**Purpose and History of LEED**

The Leadership in Energy and Environmental Design (LEED) program "encourages and accelerates global adoption of sustainable green building and development practices through the creation and implementation of universally understood and accepted tools and performance criteria" (USGBC, 2009g, ¶ 1). As mentioned previously, LEED uses a market-driven approach to hasten the integration of sustainable practices across the building industry. LEED programs are developed and implemented by the United States Green Building Council (USGBC, 2009h). This nonprofit member-driven organization is based in Washington, DC. It was formed in 1993 to support environmental sustainability through buildings that save energy and are cost effective. LEED's success has been in marketing green building and in fostering policy change (Scheuer & Keoleian, 2002).

LEED is among the several green building rating systems created "to objectively evaluate energy and environmental performance that spans the broad spectrum of sustainability" says Gowri (2004, p. 56). The earliest of these programs is the Building Research Establishment Environmental Assessment Method (or BREEAM). It is widely used in Europe, Canada, and Australia. Variations of this program include: BREEAM GreenLeaf, BREEAM Canada, and BEPAC (Building Environmental Performance Assessment Criteria).

A third major green building rating system – the Green Building Challenge – is adaptable to regional contexts and has taken root in over 20 countries (Gowri, 2004). Its designers intended to create a system that could be used globally. LEED is quickly gaining appeal on the world stage, however, with countries like India and Canada choosing to adopt tailored variants of the system (Malin, 2009). Although LEED was designed for use in North America, LEED projects are currently underway in 91 countries and all 50 states (Gowri, 2004; USGBC, 2009f).

Scheuer and Keoleian (2002) indicate that although LEED is not the oldest of the green building rating systems in the United States, it is the only one national in scope. It has been adopted by private organizations including Herman Miller, the Ford Motor Company, and the Natural Resources Defense Council. Many local governments (including Portland, Seattle, and San Jose) and federal government agencies such as the Department of State and the General Services Administration (GSA) use the system for all new construction.

**The host organization.** The USGBC aims to transform the building industry through the LEED Green Building Rating system and various educational initiatives (Turner & Frankel, 2008). The USGBC (2009h) hosts an annual Greenbuild International Conference and Expo and it advocates for environmental policies. Today, the USGBC (2009d) is also expanding its capacity to conduct research.

Since 1993, the USGBC (2009a) has gathered a highly diverse group of members. It constitutes one of the most visible forums on green building. It provides national and world leadership as "a unique, integrating force for the building industry" (USGBC, 2009a, p. i). The organization is committee-based. Volunteering members develop strategies and guide the work of staff and expert consultants. USGBC's members define activities, targets, goals, and priorities. They review USGBC's progress each year. In USGBC's (2009a) consensus-based approach:

> We work together to promote green buildings, and in doing so, we help foster greater economic vitality and environmental health at lower costs. We work to bridge ideological gaps between industry segments and develop balanced policies that benefit the entire industry. (p. i)

USGBC members include more than 20,000 corporations and builders as well as universities, government agencies, and nonprofit entities "working together to transform the way buildings are designed, built and operated" (USGBC, 2007). USGBC (2009d) also has 78 local chapters, affiliates, and organizing groups. It has conferred accreditation on 131,000 LEED-APs (individual consultants who can guide design teams through the certification process). Responsibility for accrediting professionals and certifying buildings recently shifted to a third-party organization (the Green Building Certification Institute, GBCI), allowing USGBC to focus on program development and research.

USGBC members contribute to the development of LEED in various ways. The New Building Institute, for example, is a non-profit member of USGBC that is dedicated to healthy and sustainable development. The Institute describes itself as a think tank that works to transfer successful ideas to states, regions, researchers, and industry. This organization produced a report on *Energy Performance of LEED for New Construction Buildings* (by Turner & Frankel, 2008) that is helping improve the LEED system (Malin, 2009). The USGBC is currently taking action to address the performance gaps identified in that study (Cheatham, 2009a, 2009b; Environmental Protection, 2009; Stephens, 2008; USGBC, 2009c, 2009d, 2009e).

**Focus of LEED.** LEED uses a whole-building perspective to anticipate environmental performance over a building's life span. The program seeks to provide "a definitive standard for what constitutes a green building in design, construction, and operation" (USGBC, 2009a, p. xi). The LEED Green Building Rating program has become the gold standard for sustainable construction (Goleman, 2009).

LEED provides "ecological transparency where there was none before" asserts Goleman (2009, p. 136). The system raises awareness and helps correct problems, such as "the dangers of indoor air pollution [and] the high operating cost of cheap heating and air-conditioning" (p.135). LEED identifies ways that buildings impact the natural environment and it provides measures for improvement. The program also reveals "the hidden costs to a building's owners and users of the old way of doing business," Goleman argues, and it "creates a virtuous cycle by offering ready market alternatives" (p. 136).

Soon after the USGBC (2009a) was formed in 1993, its members identified the need to define green construction standards and measure them. A team of architects, real estate agents, building owners, lawyers, environmentalists, and industry representatives researched existing rating systems. This informed the development of the USGBC's own LEED Green Building Rating system.

Most rating systems focus on five main performance categories: (1) site, (2) water, (3) energy, (4) materials, and (5) healthy indoor environments (Gowri, 2004; USGBC, 2009h). LEED adds a category for innovation and exemplary performance. LEED version 1 (v1) served to pilot ideas and standards. It began in 1998 and certified just 20 projects (Kibert, 2005). Following extensive modifications, the USGBC (2009a) released LEED v2.0 in 2000, v2.1 in 2002, v2.2 in 2006, and v3 in 2009.

Many version 2 projects are still underway. Although v3 (also known as LEED 2009) took effect in 2009, projects that were registered under an earlier system may apply for certification under that version. Or, their owners may choose to adopt the new version if they like. Some may be pressed to upgrade because v3 establishes phase-out dates for the older systems. Advantages of using the new system are that the measures have been better calibrated and definitions that did not make sense have been removed (Tim Cole, personal communication, October 3, 2009; Nathaniel Allen, personal communication, November 8, 2009). The point system is also clearer and has been weighted to reflect emerging values – energy and water management are allotted a larger share of the credits than in previous versions (Aarons-Sydnor & Miller, 2009; Nexus Green Building Resource Center, 2009; USGBC, 2008b, 2009a, 2009c).

All versions of LEED share a common philosophy and a similar award structure. The system currently encompasses 35,000 buildings that are either certified or registered to become certified (USGBC, 2009f). Institutions of higher education in the United States own 3,589 of these, or roughly 10.25% of all LEED-designed buildings worldwide (USGBC, 2009i). LEED was originally developed for commercial structures but quickly gained momentum throughout the building industry.

By 2004 LEED encompassed 12-15% of all public construction and 2% of privately owned construction in North America (Gowri, 2004). The USGBC (2009a) now works to engage various user groups by developing tailored programs. These address various types, sizes, and sectors of construction. LEED for Neighborhood Development, LEED for Schools, LEED for Retail, LEED for Healthcare, LEED for Commercial Interiors, and LEED for Homes complement long-standing programs for New Construction, and Core and Shell development.

**LEED's approach to sustainability.** LEED provides formal mechanisms to support sustainable construction. Benefits of participation include government endorsements and tax incentives (for profit-making entities). LEED also carries social prestige. It signifies that a building's owner is leading the way for a more sustainable future (President and Fellows of Harvard College, 2009). LEED represents a way to address the growing moral imperative to protect the natural environment (Association of University Leaders for a Sustainable Future, 1990; Architecture 2030, 2009; Reid, 2009). This imperative is depicted in Figure 1 (p. 5) as "corporate responsibility."

LEED was designed to promote innovation and to continually "raise the bar" with regard to building performance. The system helps generate, apply, and test new approaches. Governments and organizations can then formally adopt and/or institutionalize the practices that work best. Increased participation in green construction is likely as technologies become economically feasible and are proven to work. This is what USGBC means when it says it is "market-driven."

LEED's vice president Tom Hicks asserts, "USGBC is dedicated to continuous improvement." This includes refinements "of the technical and scientific foundation of LEED, of our consensus processes, and of the level of customer service we deliver. We've learned a lot… and are proud to be able to incorporate that knowledge into how we're working today" (USGBC, 2009j, ¶ 2).

Rating systems like LEED help make the unseen visible. They measure qualities that exceed most humans' sensory and cognitive perception (Goleman, 2009; Stanisstreet & Boyes, 1997). Such systems guide people in interpreting the meaning of abstract information and understanding of how it affects their own lives. Gardner (2008) explains that humans have difficulty making meaning of large numbers and of global concepts. Rating systems that describe environmental and health benefits in very simple terms can help people make quick (and hopefully accurate) comparisons and value judgments. LEED provides this sort of mechanism.

“Shared intelligence grows through the contributions of individuals who advance… understanding and spread it among the rest of us,” asserts Goleman (2009). LEED seeks to share intelligence through members and participants who scope out new possibilities. It addresses our need for “scouts, explorers who alert us to ecological truths we have either lost touch with or newly discover” (p. 49). USGBC founding members and early adopters of LEED have scouted new frontiers. Goleman says they are trendsetters and leaders in environmental design. LEED reflects Goleman’s recommendations for achieving ecological intelligence: (1) know your impacts, (2) favor improvements, and (3) share what you learn (p. 49).

**The need for LEED.** Robertson (2007) asks: “How can one fashion and deliver, in a democratic, pluralistic, commercially driven culture – healthy settings that protect and enhance the natural world and are at once practical, elegant, just and achievable?” Architecture, he says “establishes the physical setting for our lives” (p. 46) and in doing this it embeds meanings, values, and priorities and it communicates them over time. LEED aims to guide people in this endeavor. It provides a comprehensive and holistic framework that promotes action and evolution (Goleman, 2009).

This level of activity and change means that each day “new technologies and products are being introduced into the marketplace, and innovative designs and practices are proving their effectiveness” (USGBC, 2009a, p. xi). Since LEED is intended to evolve over time, tools and reference guides are continually being developed and released by USGBC (2001, 2002, 2007, 2009a).

Owners and design teams also push existing boundaries and explore new methods of sustainable design. They are applying knowledge and integrating new techniques in the process of design. "Public institutions and private sector businesses must be willing to take risks and explore new technologies," insists Wilde (p. 50).

Despite widespread change being fostered by LEED today, many view the system as too conservative. They assert the need to reach far beyond LEED's top rating, and soon. "If we built all our projects to the highest level of LEED," asserts Woolliams (2007), "we would still be a long way from sustainability" (p. 61). Many people encourage owners to reach beyond LEED's Platinum rating (Browning, 2002; Dudley, 2009; Wilde, 2007; Woolliams). Wilde studied one Platinum-rated v2 building and found it "uses 62 percent less energy and 56 percent less water than a conventional building" (p. 50). He says, however, that this level of improvement is not enough.

Universities' first responses to sustainability used rationalist approaches (Sharp, 2009). LEED ratings, too, rely heavily on rationalist cause-and-effect assumptions and checklists that may be too limiting (Malin, 2003). Educational planning research describes overreliance on linear, rational thinking as a weakness that inhibits the efficacy of planning (Chaffee, 1985; Chance, 2008, 2010; Presley & Leslie, 1999). Research suggests that the digital modeling software and various formulae used to predict future performance are not accurate enough. These instruments may incorporate too many faulty assumptions about natural phenomena and human behavior (Environmental Protection, 2009; Gifford, n.d.; Turner& Frankel, 2008; Scheuer & Keoleian, 2002).

However, as a clearly organized, well-recognized program, LEED provides users a needed sense of security (Malin, 2003). Most large-scale organizations require the assurance of an established framework in order realize substantial change (Hannan & Silver, 2000). Each new version of LEED integrates new standards based on the

USGBC's (2009a) assessment of them as "proven existing technologies." This helps ease concerns of risk-adverse institutional leaders. Stephens (2008) notes that attempting "to please both early adopters and mainstream audiences" represents a formidable challenge for LEED (¶ 3).

The LEED Green Building Rating system was developed to build capacity and momentum, grow upon success, and continually reach higher. Effective response to emerging criticisms is critical to overcoming problems that exist within the system.

***Increased capacity and momentum.*** LEED was designed to elicit enthusiastic participation and become a learning organization that continually assimilates new findings. LEED v3 responds to concerns that "the certification process [has been] too complicated and costly," Rick Fedrizzi explains. "We wanted to make sure that we were listening to our community to ensure that LEED is the most effective tool it can be" (USGBC, 2009j, ¶ 1). Capacity-building through LEED includes formal mechanisms to harness new ideas and draw them into the system. Many applicants earn Innovative Design (ID) credits by proposing new measures for sustainable performance in areas not addressed by LEED programs. LEED v3 reinforces this practice (USGBC, 2009c).

***Evolutionary stance.*** Thresholds for achieving certification are intended to rise over time. As emerging conceptions are tested, they become affordable and readily available (USGBC, 2009k). With more LEED projects underway, there is increasingly more "information available to USGBC about the needs of those users, and of the market as a whole" (USGBC, 2009j, ¶ 2). Integration of user feedback is evident in various features of LEED v3. A new category for Regional Priorities (RP) has emerged, prompting LEED applicants to address local differences in climate and geography.

LEED is also evolving in ways that support educators. Before 2007, many primary and secondary (K-12) schools used the standard LEED-NC system (USGBC, 2009k). LEED-NC was originally designed for new office and commercial buildings, although "it has been applied to many other building types by LEED practitioners" (USGBC, 2009a, p. xiv). LEED-NC's terms and definitions have not always made sense for other types of applicants (Nathaniel Allen, personal communication, November 8, 2009). LEED v3 seeks to rectify this (Tim Cole, personal communication, October 3, 2009; USGBC, 2009c).

K-12 projects registered since April 20, 2007 have been required to use LEED for Schools (a LEED v3 program). USGBC recommends, although it does not yet require, educational facilities for early childhood education, daycare, and higher education to use LEED for Schools. Tailored aspects of LEED for Schools include energy guidelines, classroom acoustics, youth health issues, mold prevention and indoor air quality, site assessment, and master planning. Recognizing the needs and interests of diverse users – and creating programs that engage them – is one way that USGBC extends its reach.

**Need for further research.** Postsecondary institutions construct over 1500 buildings and additions each year and modernize 2500 more (Cortese, 2005). Research is needed to assess the environmental impact of this construction, to compare results, and to hone techniques. Universities have proven their capacity to conduct research that has value to society; they must be involved in this work (Kerr, 1995; Levin, 2003).

They – and the larger scientific community – have established a system that controls for bias (Gall, Gall, & Borg, 2007). This is a major reason for having universities conduct research on LEED performance and building outcomes. Much of the research that has been funded by USGBC at this point appears to have been channeled through non-profit organizations that are not associated with universities. This could increase the probability for bias in reporting. It is important that established research standards (such as peer review) are followed in order to ensure credibility.

Rhodes (2001) says that collecting facts and data – and refining equations and processes – is critical for human survival and wellbeing. Research constitutes a public trust and a sort of "unwritten social contract" (p. 163) that balances the interests of individual researchers with benefits to the general public. Rhodes says this system involves an "act of faith" but has served America well. It has resulted in an array of fortuitous, unintended scientific discoveries. Engagement in LEED involves similar types of trust. Stakeholders act in faith that their efforts will yield long-term benefit (Cheatham, 2009a, 2009b). Beyond altruistic motives, universities need to protect their own investments of time and money. They must ensure that the cost of LEED yields tangible environmental and health benefits.

Critics have raised a number of issues that need to be addressed through research (Cheatham, 2009a, 2009b; Novitski, 2009; Stephens, 2008). Some see LEED as a form of greenwashing – a phenomenon that exchanges style for substance. Goleman (2009) asserts that greenwashing "steals market share from products that genuinely have more benefits and hampers the success and market penetration of better innovations" (p. 74). Gifford (n.d.) criticizes the USGBC for this practice, arguing:

> The LEED system is not only ineffective, but is harmful to the environment, to the prosperity of our country, and to effective energy saving methods which are ignored in favor of the image of energy efficiency. LEED should be abandoned

immediately, and be replaced with a system that is based on actual verifiable energy use measurements. (p. 11)

Gifford fervently recommends that the USGBC assign LEED credit only for actual (rather than predicted) energy, water, and air quality performance. Tentative ratings could be granted at the outset of a building's operation, he suggests, with full certification pending performance.

To be effective, LEED will require higher levels of what Goleman (2009) describes as radical transparency. Recent action by USGBC (2009a, 2009d) indicates a shift in this direction (Cheatham, 2009a, 2009b; Stephens, 2008). Goleman (2009) says that comprehensive product labeling and rating systems (what he calls radical transparency) have the potential "to reinvent the marketplace" (p. 82). Effective rating systems provide quick, accurate information that can help consumers make better decisions, he asserts. They help individuals make good choices quickly and in a way that supports superior products. Goleman argues that such rating systems must be trustworthy as well as impartial, comprehensive, and authoritative. It appears that LEED v2 may not have been transparent or comprehensive enough, but new LEED programs reflect improvement (Cheatham, 2009a, 2009b; Stephens, 2008; USGBC, 2009c).

It is in each institution's best interest to think critically about its use of LEED and to assess the outcomes of its investments. The following narrative describes how university researchers, standards organizations, and USGBC can – and have – worked together to improve practice through ongoing analysis. One of USGBC's member organizations defined a priority and initiated research. It enlisted university researchers Scheuer and Keoleian (2002) to conduct exploratory research. The master's thesis project was conducted under contract for the Building and Fire Research Laboratory of the National Institute of Standards and Technology (NIST). NIST funded the study as a model for using Life Cycle Assessment to help refine LEED.

Scheuer and Keoleian (2002) investigated solid waste and energy performance of a campus building that was certified under LEED v2.0. They compared credit earnings and subsequent performance in the categories of (1) Materials and Resources and (2) Energy and Atmosphere. They found a lack of alignment between LEED ratings and their own Life Cycle Assessment of the building. They indicated that some credit thresholds were overly simplistic and had not produced the desired results.

Although LEED appears "to be accomplishing the goals of an eco-labeling program… as a marketing and policy tool," Scheuer and Keoleian (2002) found that it was less successful as "a comprehensive methodology for assessment of environmental impacts" (p. 93). They provided a number of specific recommendations for calculating credits, calibrating thresholds, and enhancing reliability of LEED measures. Their findings sparked curiosity and precipitated a subsequent study by the USGBC that was conducted by Turner and Frankel (2008). The latter forms the basis for Gifford's (n.d.) vocal critique. These studies pinpointed performance discrepancies and provided a platform for change. As such, Scheuer and Keoleian provide a precedent for using exploratory research to prompt the evolution of LEED. The overall scenario underscores the importance of exploratory research by universities.

Although Scheuer and Keoleian (2002) investigated performance of just one building, Turner and Frankel's (2008) USGBC-funded study involved 121 LEED-NC buildings. Owners of all 552 buildings certified under v2 up through 2006 were invited to participate and 21% accepted the invitation. Each submitted one complete year of energy use data for their buildings. The researchers compared performance data for LEED certified buildings against three other measures: (1) national data on Energy Use Intensity, (2) Energy Star criteria, and (3) the design and baseline information generated for each LEED application.

Turner and Frankel (2008) found that a majority of LEED certified buildings outperformed non-certified buildings in energy. On average, LEED buildings saved energy. However, 12 of the 121 buildings used more energy than even the basic building codes require (and far more than the digital simulation models had predicted). These underperformers had earned the full range of LEED ratings (Turner and Frankel grouped them as Certified, Silver, and Gold-Platinum). Buildings with high process loads (such as laboratories) frequently underperformed. The researchers recommended calibration of energy modeling software, more stringent baseline standards, and increased verification of performance over time.

A basic requirement of scientific inquiry is that methods are both (a) open to public scrutiny and (b) fully described to allow other researchers to replicate existing studies (Gall et al., 2007). Results of the Scheuer and Keoleian (2002) study were put before peer review. The Turner and Frankel (2008) study were open for public scrutiny. They were the topic of heated debate.

Gifford (n.d.) took issue with the parameters Turner and Frankel (2008) used. He replicated their study and found even more significant underperformance among many LEED buildings. It appears that the initial report was then reviewed by an independent third party at USGBC's request. Adjustments were made following this review and were openly reported. The USGBC used this research to identify existing problems and opportunities for improvement (Cheatham, 2009a, 2009b; Environmental Protection, 2009). The organization indicates it is gearing up to conduct, solicit, and fund much more research in the coming years (USGBC, 2009a, 2009d).

Gifford (n.d.) even acknowledges that LEED has "contributed more to the current popularity of green buildings in the public's eye than anything else" (p. 1) and that it has "accomplished some notable goals" (p. 2). He has, however, bemoaned that LEED v2 does not require owners to track or report energy use of LEED buildings over time. LEED v3 now requires building owners to provide the USGBC access to performance data on water and energy use (Aarons-Sydnor & Miller, 2009; Cheatham, 2009a, 2009b).

Gifford (n.d.) represents a critical voice speaking from outside the system. Wilde (2007), who encourages building owners to "reach beyond platinum," represents a change agent working within the LEED framework. Both advocate evolution of the system, indicating that there is a great deal of room for improving LEED.

Bartlett and Chase (2004) caution "sustainability issues make for messy, complex research problems, requiring new professional skills and new criteria of evaluation" (p. 11). Little formal peer review has occurred with LEED-related studies. The professional community and USGBC members openly debate issues and critique findings, however. This is one way to challenge the work and test its accuracy (Gall et al., 2007).

***Who conducts research on green building.*** Universities are not alone in the effort to improve LEED and generate knowledge about environmental sustainability. Thousands of USGBC member organizations conduct research themselves, or in collaboration with universities. One example is the Leonardo Academy (2009a), a non-profit organization that belongs to USGBC and is:

> dedicated to advancing sustainability and environmental stewardship. We approach sustainability as the creative merging of environmental stewardship, social responsibility and economic prosperity that empowers doing well by doing good. We strive to make sustainability practical for everyone by utilizing an interdisciplinary approach to strategy development, implementation and education. (¶ 1)

The Leonardo Academy (2009b) assisted in developing the LEED for Existing Buildings (LEED-EB) program. Serving as a contractor to the USGBC, the Academy managed the pilot program and was primary author of the training manual. The Academy also reviewed all applications for LEED-EB certification from 2000-2007. The organization works for building owners today, helping them implement LEED criteria and apply for LEED-EB certification.

Public-private partnerships are being employed to explore LEED performance issues. Member organizations help track outcomes in an effort to feed information back into the system. For instance, the City of Seattle hired Paladino and Company (n.d.) to track the performance of two of the city's LEED-certified buildings. The company developed 20 performance indicators. Initial findings of its study were presented at the USGBC's 2005 Greenbuild Expo (Athens & Erwine, 2005). This scenario is fairly typical of the way USGBC has been generating, sharing, and integrating information. It is interesting to note that Paladino and Company has served as the primary sustainability consultant for more than 80 LEED-certified buildings and 220 other green buildings. This indicates that many owners are working toward sustainability without utilizing LEED.

***Emerging problems and concerns about LEED.*** Engstrom, Oberlin College's sustainability coordinator, notes that LEED is a "highly contested" program (cited in Dudley, 2009, ¶ 4). He sees LEED participation as a starting point, rather than an ultimate goal of his College's environmental efforts. Engstrom seeks to exceed LEED standards. His College has adopted goals of (a) achieving carbon neutrality and (b) obtaining LEED Silver or better for all new buildings. Engstrom finds that LEED is moving "towards continual improvement," and periodically "raising the bar" (as cited in Dudley, 2009, ¶ 4). Recent changes in LEED strongly support his claim (Cheatham, 2009a, 2009b; Environmental Protection, 2009; Stephens, 2008).

USGBC (2009a, 2009d) is placing increased emphasis on research that informs development. This reflects ongoing efforts to become a true learning organization, one that integrates findings from past experience to enhance future action (Birnbaum, 1988). Such organizations collect data and integrate feedback through an iterative and ongoing process (Wilson, 1997). Large entities – particularly universities – have not been known for their skill in this area (Presley & Leslie, 1999; Rowley & Sherman, 2001; Swenk, 2001; Wilson). Emerging USGBC programs and recent staff hires indicate that USGBC is integrating feedback and responding to criticism (Cheatham, 2009b; Environmental Protection, 2009; Stephens, 2008; USGBC, 2009c).

Wedding and Crawford-Brown (2007) describe the need to calibrate LEED based on research regarding the: scale of influence a measure has, severity of a given hazard, amount of exposure, consequence of inaccuracies, and current state of the environmental condition. Like Gifford (n.d.), Udall and Schendler (2005) indicate that applicants may actually be shifting resources away from approaches that could really benefit the environment, simply for the sake of earning LEED credits. Presley and Leslie (1999) have raised this concern about educational planning efforts in general. It appears, however, that LEED is actually a pioneer in strategic planning precisely because it provides measurable outcomes that include (but also go beyond) dollar amounts. What society learns from LEED has the potential to enhance all sorts of planning efforts.

In response to criticism, LEED administrators say the system integrates feedback and has already improved (Navarro, 2009). Some previously certified buildings would no longer meet LEED certification standards. This does not mean that they lose their LEED certification, although this condition may change (Novitski, 2009). New procedures are being considered that do not confer static recognition. In fact, LEED Accredited Professionals are now required to retest periodically in order to maintain their accreditation. Navarro indicates that buildings may have to meet ongoing performance requirements as well. This is the case with Energy Star, where certification applies only to the specific years the building meets energy performance goals.

Udall and Schendler (2005) recognize the vast contributions that LEED has made, but they also describe many ways the system has been ineffective. They say that as of 2005, (1) participating in LEED added too much cost, (2) obsession with earning credits undermined the true intention of the program, (3) the required energy modeling was enormously complicated, (4) the system reflected a crippling level of bureaucracy, and (5) claims related to benefits were overstated and misleading. On the other hand, Udall and Schendler acknowledge the

> USGBC has been enormously successful at publicizing the need for, and benefits of, greener buildings. Thanks to the USGBC and LEED, we now have momentum, media attention, broad understanding of green building, and motivated clients. Next, we need to make sure we're using the best possible tool for the job. (¶ 61)

***Utilizing research to improve LEED processes.*** Wedding and Crawford-Brown (2007) provide a thorough and concise review of research about the outcomes of various green rating programs. They explain that quantitative analysis of LEED has focused on: cost issues related to decision-making, problems in predicting energy usage, credit-chasing, and the need for better point weighting and adaptability to regional conditions. LEED v3 takes steps to address all these concerns (USGBC, 2009a). The organization's website provides examples of how the USGBC (2009l) uses research to improve LEED programs. Whole divisions within USGBC are devoted to this type of work. A new position, Director of Research, was recently established to enhance USGBC's research capacity (USGBC, 2009d).

Sustainable buildings require a very different process for design and construction than conventional buildings (Browning, 2002; Huff, 2007; Malin, 2003). Because LEED requires a collaborative, interdisciplinary, team design approach, it affects the way various consultants work together. Engineer Ronald Mazza (2007) says LEED "has triggered a fundamental change in the design process of [green] buildings" (p. 12). Holistic design, and the LEED system itself, requires re-structuring the way owners, architects, consultants, and contractors interact.

Researchers are working to understand working relationships and refine design processes. At the University of Pittsburgh, Bilec and Ries (2007) are conducting ongoing analysis. They use both qualitative and quantitative methods – to identify patterns in the working relationships that surface in the construction of sustainable buildings. They aim to improve formal methods of project delivery.

Mazza (2007), a practicing engineer, explains that in "order to design truly sustainable buildings, it is necessary that all members of the design team work in a fully integrated fashion and that the building be viewed as an integrated whole" (p. 17). In such a case, growing pains are inevitable. Change theory refers to this pattern as implementation dip (Fullan, 2001; Holcomb, 2001).

Outcomes research is critical to understanding and improving LEED, and it is something that cannot wait (Del Percio, 2009; Murphy, 2009). This type of analysis requires careful attention to standardized protocols, funding, providing the industry with feedback, and fostering owner commitment (Athens & Erwine, 2005).

***Utilizing research to improve energy prediction.*** Mazza (2007) explains that the "rapid evolution of increasingly sophisticated, accurate, and easy-to-use energy modeling software now allows the investigation of many building design options, with different building system combinations and permutations" (p. 17). This can help identify the most efficient, cost-effective solutions for a specific site and building program. Mazza notes that just ten years ago, such tools did not exist. However, the models employed today need substantial overhaul if they are to accurately predict energy consumption. Many scholars are perfecting these simulation programs. Poch, Comas, Rodriguez-Roda, Sanchez-Marre, and Cortes (2004) are "designing and building real environmental decision support systems" (p. 875) through various universities in Spain.

Wedding and Crawford-Brown (2007) have developed models to simulate energy impacts of LEED buildings. The Institute for the Environment at the University of North Carolina (UNC) at Chapel Hill and Cherokee Investment Partners fund their work. Their model uses Monte Carlo analysis and is being used to enhance LEED v3 programs. It integrates data from the United States Department of Energy, the National Renewable Energy Laboratory (NREL), the Environmental Protection Agency's (EPA's) Energy Star program, and the USGBC.

Software developers from universities and the private sector are pushing technological boundaries. Their work provides means to predict specific aspects of building performance. Up until recently, a designer would need to use one program to assess acoustics and an entirely different program to simulate energy use. More sophisticated programs that can integrate information about all sorts of issues and systems are being developed and refined. These new systems, known as Building Information Modeling (BIM), allow a wide array of information to be studied in a single digital model. These programs are still young and awkward, but many architectural design firms are using them today. Buy-in from firms helps build capacity within BIM software offerings, and their usage is often client-driven (Mosley Architects, personal communication, November 14, 2008).

Keysar and Pearce (2007) surveyed the decision-making tools available within the design and construction industry. They found a lack of tools to facilitate LEED design. They are integrating existing approaches into digital tools to help designers make complex decisions related to LEED. Their work is intended to support early adopters of LEED, such as the US Department of Defense. The researchers represent a partnership between a university and a non-profit organization, and their work is funded by the National Defense Center for Environmental Excellence (NDCEE). They have already developed a database of resources that have "the potential to create better matches between designers new to the field of green building and tools that can help them achieve specific project goals related to LEED" (p. 169). Huff (2007) underscores the need for decision-making tools that assess complex inter-relationships. He indicates that available tools can predict the cost associated with individual credits, but not those involving multiple credits that work together synergistically.

LEED needs input from a wide array of stakeholders. At the NESEA forum, USGBC's Brendan Owens admits that his organization "could do better to educate the public that the [LEED] model isn't good enough, yet. We haven't really gone through and said 'this is the first step in a 6 or 7 or 8 step process'" (cited in Del Percio, 2009, ¶ 3). He indicates, "LEED is an assessment of potential for a building to perform. That's all it is" (¶ 3). Wedding and Crawford-Brown (2007) emphasize, however, that LEED "was intended to be an instrument for market change, not a scientific tool for assessing the environmental impacts of buildings" (p. 166). They say, however that "in the absence of widely accepted methods for assessing building-related impacts, many… stakeholders look to LEED to serve this more quantitative purpose" (p. 166).

With further development, LEED can move beyond its current limitations to provide a reasonable expectation of savings in energy, water, material, indoor air quality, and the like. Wedding and Crawford-Brown (2007) assert that criticisms generally overlook contributions LEED is making in categories besides energy. Adding to the complexity of the system, they indicate, could discourage owners from using the system.

They hope that improvements incorporated into LEED v3 will render the system "more meaningful and comparable across buildings in terms of environmental impacts" (p. 166).

## Overview of What LEED Offers Universities

The USGBC (2009m) aims to work in partnership with higher education to strengthen sustainability efforts, increase accessibility to LEED facilities, support student efforts, and enhance curricular reform. As of December 2009, higher education had earned 531 ratings and registered 3058 more buildings though various LEED programs (USGBC, 2009i). Fedrizzi (2009) indicates that about 14% of all LEED ratings have gone to higher education.

The USGBC is continually developing new resources and tools that are tailored to K-12 and higher education. This is part of a commitment to bring "green buildings to students of all ages, from early childhood and elementary schools to college and university campuses" (USGBC, 2009n, ¶ 1). The USGBC supports hands-on teaching and research programs conducted by universities including the Department of Energy's Solar Decathlon competition. It provides sessions specifically geared to higher education at its annual Greenbuild Expo. Participation in LEED allows institutions to improve their overall building stock, provide a positive example, and contribute momentum and innovative ideas to the cause. Institutions can also help build the capacity of green systems through their purchasing decisions (Goleman, 2009).

***Certification through LEED.*** A major goal of LEED participants is gaining certification (Dudley, 2009). Other motivators are the desire to (a) innovate, (b) be seen and recognized as leaders and as champions of the environment, and (c) "do the right thing" to protect the natural environment and human health. LEED is also an attractive way to meet growing expectations of students and other stakeholders and address calls for public accountability (Ehrenberg, 2002; Tonkovich, 2009). LEED's Green Building Rating program provides formal mechanisms for assessment and this may be a reason why so many postsecondary institutions are registering their projects today. LEED offers a range of clearly defined measures and a recognizable seal of approval. Unlike most strategic planning processes used in higher education, LEED also provides mechanisms for evaluating outcomes and monitoring its own implementation.

To invoke even higher levels of participation, the USGBC has developed several new programs geared to campuses and large-scale developers. Ried (2008) explains that LEED's new Portfolio Program provides additional recognition and support services for applicants who own several LEED-certified buildings. The LEED for Neighborhood Design (LEED-ND) program encourages comprehensive green planning and is ideal, Ried says, for campuses that are highly committed to environmental sustainability. The LEED for Schools program has been tailored for K-12 organizations but provides useful criteria for higher education as well (USGBC, 2009k).

**Advice to higher education leaders using LEED.** The American Planning Association (n.d.) provides strategies for using values-based messages to motivate various audiences. "The practice of sustainability," Reid (2009) insists, can provide "a holistic ethical lens for our collective practice" (p. 30). Through participation in programs like LEED, postsecondary institutions can help shape an ethic of social responsibility regarding material culture (Fox, 2007). Leadership experts stress the role of values, morals, and ethics in spurring collective change (Evans, 2007; Fullan, 2001; Kouzes & Posner, 2007; Purpel, 2007).

Ried (2008) provides advice for institutions of higher education that want to use LEED. She explains that LEED provides an appropriate fit for institutions that have a commitment to and/or prior experience with green building in addition to an "appetite for experimentation in green building" (p. 7). For maximum benefit, Ried recommends universities: (1) establish commitment at the top, (2) create supportive programs and policies, (3) build institutional capacity, (4) incorporate LEED into long-range and strategic planning, (5) think creatively and build momentum for sustainability programs, (6) involve local government and work synergistically, (7) involve, draw from, and educate the university and local community, and (8) start with one LEED project.

Ried (2008) says institutions that already have experience in green building can increase their benefits when they: (a) support LEED activity with university staff to streamline efforts and save money, (b) establish relationships with knowledgeable consultants beyond the campus, (c) begin compiling LEED documents early in the design process, and (d) participate actively in the design process, so that they "get the most out of LEED and learn from others" (p. 16).

Postsecondary institutions can anticipate several specific challenges (Ried, 2008). Tumultuous economic conditions can threaten green building projects, so Ried recommends protecting the effort to build green by including it in formal policies and strategic plans. Adapting to the process of green building requires expertise; it may affect timelines and management structures. Innovation also requires a higher level of flexibility, so academic institutions must weigh risks against costs and potential benefits.

Ried cautions that institutions typically face resistance to green building programs from some stakeholders and warns administrators to be prepared.

**Innovation through LEED.** Participation in LEED can help universities meet their core mission. Rhodes (2001) describes this mission as facilitating learning and transforming facts "into useful information, information into meaningful knowledge, and knowledge into useful judgment" (p. 234). Rhodes says residential campuses are particularly effective as catalysts for transformational leadership and learning.

Parker, Wade, and Atkinson (2004) indicate that to be effective, environmental research must: (1) engage different types of knowledge, including local and indigenous knowledge, (2) proactively seek research opportunities that develop global citizenship and provide education for a sustainable future, and (3) create research communities that cut across across disciplinary boundaries. "New knowledge and new skills are now more important to the advance of civilization worldwide than ever before," argues Kerr (1994, pp. 9-10). Because higher education is so important to contributing new skills and knowledge, Kerr asserts that it is rising in importance among the various systems defining and shaping society.

Rhodes (2001) contends that knowledge is also central to national wellbeing. Faculty members are being called upon to provide skills, leadership, and other support in all sorts of learning environments (Lee, Cheslock, Maldonado-Maldonado, & Rhoades, 2005; Rhodes). Science and technology have become driving forces, and Rhodes insists that the nation's fate depends on generating new knowledge. His list of critical issues seems to mirror LEED: economy, energy, manufacturing, health, public safety, security, and environmental quality. Knowledge is autocatalytic, he says, and will play an increasingly decisive role in 21st century society.

Similarly, Kerr (1994) identified transformational changes underway. Most of them have been absorbed into LEED: electronic and computer technology, energy conservation and new sources of energy, new materials, biotechnologies, and environmental sciences. Kerr anticipated the expansion of higher education's functions. He foresaw "more efforts at applied research and at transmission of research into applications" (p. 10).

The United States already has the technologies to facilitate sweeping change but society needs ideas, strategies, and vision to rally behind (Rhodes, 2001). Environmental sustainability provides this sort of unifying vision. LEED also creates strategies to support this vision.

By participating in green rating programs, they can measure their achievements and demonstrate success to the public. Such efforts can help address concerns raised by the United States Department of Education (2006) that "American higher education has become what, in the business world, would be called a mature enterprise: increasingly risk-adverse, at times self-satisfied, and unduly expensive" (p. xii). Paying attention to environmental sustainability can help universities reduce costs, enhance learning, and transfer knowledge in useful and meaningful ways.

Innovation and optimism are essential features of today's green movement. Steffen (2008) insists that despite being in a state of environmental crisis:

> we also find ourselves in a moment of innovation unlike any other that has come before. We find ourselves in a moment when all over the world, millions of

> people are working to invent, use, and share worldchanging tools, models, and ideas. We live in an era when the number of people working to make the world better is exploding. Humanity's fate rests on the outcome of the race between problem solvers and the problems themselves. The world is getting better – we just have to make sure it gets better faster than it gets worse. (p. 22).

Postsecondary institutions aim to transform knowledge into wisdom (Rhodes, 2001). This is a very lofty, and perhaps unattainable, goal. "But… without knowledge that is ordered, tested, refined, related, and applied," Rhodes says, "wisdom will have but modest scope and little power in the larger issues of life" (p. 234).

"Green development needs to be an integrated effort," Browning (2002) cautions, "not a piecemeal activity involving tacked-on concepts and technologies" (p. 78). Many traditional and vernacular building types that integrated climate into their designs appear to perform much better than those that rely on new technologies (Freeman, 2008; Krier, 2007; Orr, 2007). The overall embodied energy in traditional and vernacular buildings is likely to be lower. Moreover, Edwards (2004) cautions that within the construction industry discussion has been "preoccupied with energy rather than the broader concerns of sustainable development" (p. 129). Fox (2007) describes the need to provide comprehensive solutions that go extend beyond the question of energy consumption. "We clearly need an ethics that can directly address concerns at the relatively intangible level of design" (Fox, p. 122).

Despite of shortfalls in energy performance, LEED has brought the need for green building to the forefront of public awareness. Universities and other non-profit organizations have generated research that spurs evolution of LEED. The USGBC is taking action to address empirical research findings (USGBC, 2009a, 2009c, 2009d). Universities are poised to provide even more research and leadership in green building and in LEED.

**Leadership through LEED.** Kolb (1984) indicates that behaviors such as leadership can be observed among organizations as have been observed among individuals. AASHE's (2009c) annual awards program recognizes individuals as well as educational organizations for contributing leadership in the environmental movement.

Judy Walton, the founding executive director of AASHE, says that by "helping to build a green economy, tackling climate change, [and] shaping local and national policies, our colleges and universities are right at the forefront of change" (AASHE, 2009c, ¶ 3). Since postsecondary institutions appear to be taking a major role in environmental sustainability, Kolb's (1984) theories suggest they can be considered leaders. LEED, in fact, incorporates all quadrants of Kolb's (1984) decision-making model and does so in the iterative fashion described by Chance (2010). Universities' contributions in green building are also significant. They are providing leadership to foster the overall green building movement. This is consistent with USGBC's (2007a) description of leadership.

In 2008, universities initiated 700 new environmental programs and undertook design and/or construction of approximately 130 LEED buildings (AASHE, 2009c). Hundreds of universities provided information to green ranking program conducted by the Princeton Review (2009) and the Sustainable Endowments Institute (2009a). The nearly 300 signers of the American College and University Presidents' Climate Commitment provided 2008 data on their universities' greenhouse gas emissions to allow for research and comparison (AASHE, 2009c; University World News, 2009). The *AASHE Digest 2008* (AASHE, 2009b) featured 1350 stories of environmental leadership on 700 different campuses. Through such activities, postsecondary institutions are taking a clear position on the importance of environmental sustainability.

Postsecondary institutions' active engagement in sustainability moves beyond social criticism to propose and implement viable solutions. Universities seek to transform information into knowledge and use it to shape healthy, positive behavior. Many institutions use the Leadership in Energy and Environmental Design as a way to demonstrate leadership in sustainable building (AASHE, 2009d, 2009c; President and Fellows of Harvard College, 2009, 2010).

Today, leadership implies more than a collection of traits or skills (Northouse, 2010). It also involves proactive behaviors and effective response to changing contexts. To facilitate change, Fullan (2001) recommends that leaders "make knowledge building a core value" (p. 90). Leaders should, he says, create opportunities for constituents to engage the knowledge building process. Universities share this core purpose. They offer faculty, students, staff, and community members opportunities to engage the process, create their own create knowledge, and apply it in various situations.

Under contemporary leadership models, effective leaders create contexts for learning. When individuals "realize they own the problem," says Fullan (2001), "they also discover that they can help create and own the answer – and they get after it very quickly, very aggressively, and very creatively" (p. 112). Steffen (2008) supports such claims, providing hundreds of examples of grassroots environmental change initiatives.

Garvin (2000) studied leadership within knowledge-generating organizations. He found that to be effective, leaders must: (1) create settings and activities that prompt learning, (2) define the tone, behavioral norms, and acceptable rules of engagement, and (3) lead the process of generating knowledge by facilitating discussion, listening carefully, posing questions, framing debate, providing feedback, and directing closure. Universities clearly engage in these processes, and as such, they can be considered leaders in the area of knowledge-creation. Their activities in the area of environmental sustainability reflect an increased reliance on aspects of leadership described by Gavin. Through LEED, universities follow principles of Garvin's leadership model. They contribute ideas and momentum to a system that promotes learning. They help define viable construction practices, and help frame social discussion of this topic. They provide incremental closure in the form of green buildings.

Over the past few centuries, colleges and universities have played an essential role in generating and testing ideas within American society. They contribute to the development and refinement of specific strategies for enhancing environmental sustainability, such as LEED, and are being called to do even more of this (Architecture 2030, 2009; Association of University Leaders for a Sustainable Future, 1990; United States Department of Energy, 2009).

However, "any system with the words 'Leadership' and 'Energy' in the name," Gifford (n.d.) contends "must, by definition, recognize buildings that have achieved measured and verifiable energy savings" (p. 10). Universities can help provide leadership in the green movement by contributing to what gets measured and how. They can take the lead in developing new standards and implementing measures that go beyond the base requirements. Accepting new challenges and allowing their research practices to evolve will help postsecondary institutions become more energetic and vigorous in their work, Rhodes (2001) says. "It is this emerging community – analytic and affirming, critical and creative, inclusive and inquiring, engaged and enabling" – that will provide higher levels of leadership through its teaching, research, and service (p. 244).

The research model universities use helps ensure quality and reinforce ethical reporting, but it also encourages exploration for the sake of learning. Rhodes (2001) says universities are uniquely equipped to develop new ideas and approaches precisely because of their "remarkable degree of institutional independence and academic freedom," (p. 237).

Universities provide leadership by exploring issues that industry cannot or will not effectively support – those issues that are vital to society as well as those with unclear direction (Rhodes, 2001). Levin (2003) notes that basic research conducted as many as 50 years ago directly influences product innovations today.

The enthusiasm that university leaders have shown for LEED reflects an effort to contribute leadership in new and innovative ways. Frameworks like LEED help universities set priorities, secure funding, and establish reputation (Hannan & Silver, 2000). They are important means for implementing large-scale innovation today. Hannan and Silver indicate that such mechanisms provide a sense of safety that counterbalances the sense of risk, ambiguity, and novelty inherent with innovation. Unfortunately, that same sense of security often masks the need for outcomes assessment and for collecting and using formative feedback (Hannan & Silver; Wilson, 1997). People often assume results are accruing without seeking verification (Presley & Leslie, 1999).

Hannan and Silver (2000) studied a major initiative to promote innovative education in the United Kingdom. Their findings provide insight for leaders who want to foster innovation through LEED. They indicate that highly structured programs (like LEED) meet the needs and capabilities of larger organizations. In higher education, schemes for innovation become increasingly centralized as they are implemented. Hannan and Silver found that what began as "guided innovation" merged into various forms of "directed innovation" (p. 9). At this point, LEED can be seen as a form of guided innovation that allows participants to innovate without having to establish all parameters and metrics themselves. Some LEED applicants, however, use its checklists as a form of directed innovation – a tendency that should be avoided (Malin, 2003).

Hannan and Silver (2000) found that an overarching sense of structure and order were necessary to help foster innovative activity at the local level. Individual units that could not create change on their own could contribute essential parts to the larger movement. Some were able to lead specific aspects of the larger change movement by using the framework effectively. Hannan and Silver assert it is important to monitor the forms of standardization that accrue as a by-product of innovation initiatives. Organizers of programs like LEED must ensure their system allows for adequate range of innovation and does so in multiple ways and at various levels.

Universities can provide leadership in generating LEED designs, applying new techniques, and assessing results. Assessment helps ensure innovation programs foster continual upgrade and do not stagnate over time. Hannan and Silver (2000) indicate that schemes for implementing innovation in the UK were enhanced through formal mechanisms for funding, encouragement, evaluation, and dissemination. Fortunately, LEED already incorporates these aspects.

**Conclusion**

Although planners and innovators intend to foster improvement, their work does not always achieve its stated goals. Hannan and Silver (2000) note that change initiatives generally imply higher levels of control by some outside agency. They are likely to meet resistance. It is important to question whose innovation is being promoted and what its underlying values and intent are. Hannan and Silver indicate this is critical to assessing outcomes and underlying purposes of national programs like LEED.

Despite criticisms that LEED is not meeting stated energy goals, the program clearly promotes a range of other tangible benefits. Many LEED buildings provide natural light, for instance, which has been shown to improve worker and student productivity (McDonough & Braungart, 2002). A study by the Heschong Mahone Group found that students working under the best lighting conditions "progressed 20 percent faster on math tests and 26 percent on reading tests in one year than students with the worst daylighting" (cited in Building Operating Management, 2005).

Overall, this study probed LEED as a mechanism for fostering environmental sustainability. The study was born in the belief that (a) formal programs to support green building are valuable and (b) they can be enhanced through analysis and knowledge sharing. The intent of this study is to investigate outcomes by looking for patterns in data that have been collected by various organizations. The study sought to identify trends that could help (a) LEED applicants become more intentional in their approaches and (b) USGBC refine and tailor its programs.

The literature lacks research on the outcomes of LEED, particularly regarding how LEED operates, how it fosters innovation, and how it constitutes leadership. Existing research does, however provide an extensive description of environmental sustainability and what universities are doing to promote the environment through teaching, research, service, operations, and administration. Colleges and universities are major leaders in the larger social discussion of environmental issues. They are enthusiastically embracing green programs such as LEED. The literature indicates universities already have the enablers are essential for the transfer of knowledge (Boyer, 1990; Odell et al., 1998). They can and should direct their skills toward solving environmental problems (Cortese, 2005; Kerr, 1994, 1995; Rhodes, 2001).

Postsecondary institutions are fostering an increasing culture of environmentalism. Many are transferring emerging knowledge through the process of design and construction. In keeping with the criteria set forth by Odell et al. (1998), universities appear to use LEED as a framework for applying new knowledge and developing innovative techniques. For institutions that have not shaped their own green building agendas from scratch, LEED provides a compelling means and vision for change, a clear appraisal of existing problems and opportunities, and a reasonable plan for implementation. For more ambitious institutions, LEED provides a framework for transformational leadership.

## Chapter 3: Methodology

This study investigated ways postsecondary institutions in the United States use the Leadership in Energy and Environmental Design (LEED®) Green Building Rating system. It sought to understand what types of universities use the LEED system and how they use it. The study utilized data that had already been collected by USGBC and NCES and were available in quantitative form. The unit of analysis was the individual building that had garnered a LEED rating.

This descriptive, exploratory study tapped existing data sets to see if they could help answer the overarching research question: *To what degree have institutions of higher education used LEED® to earn certification, provide leadership, and foster innovation in environmental sustainability?*

This study sought to describe how the LEED system had been used through the start of 2010. It identified relationships within (a) data provided by the United States Green Building Council about the use of LEED and (b) data provided by the National Center for Education Statistics via the Integrated Postsecondary Educational Data System. IPEDS data are publically accessible via an Internet website. LEED data were obtained directly from USGBC after establishing a confidentiality agreement. By employing statistical procedures it was possible to identify patterns regarding universities' (a) institutional characteristics, (b) use of various LEED categories, (c) use of Innovative Design credits, and (d) LEED ratings.

The study filled a gap in existing knowledge by offering interpretations of how a substantial user group has approached LEED. As indicated in Chapter Two, higher education's 531 LEED-certified and 3058 LEED-registered buildings represent about

14% of the population of LEED users (Fedrizzi, 2009; USGBC, 2009i). This study adopted an exploratory approach because prior research had not investigated such topics.

As shown in Figure 1 (p. 5), USGBC claims that LEED measures innovation, energy savings, corporate responsibility, and carbon footprint. Some of these claims had been explored by others using empirical methods. A few studies were available on the issues of energy savings and carbon footprint. However, an extensive literature review did not reveal any empirical studies involving innovation or corporate responsibility. This study attempted to assess LEED in these areas. It equated innovation with knowledge transfer – noting that universities are known for generating knowledge and for transferring it from theory to practice (Levin, 2003, Rhodes, 2001). The study associated corporate responsibility with universities' acknowledged leadership role in the green building movement (AASHE, 2008b, 2009d; Cortese, 2005; Goleman, 2009; Second Nature, 2009). It drew this comparison in order to understand and explore the USGBC's claim that participation in LEED does, in fact, constitute "Leadership" in Energy and Environmental Design.

The primary intent of this study was to harness existing data to enhance society's understanding of how postsecondary institutions have been using the LEED Green Building Rating system. A major goal was to provide feedback that could (a) improve the LEED system and (b) enhance educational organizations' efforts in green building.

This chapter begins with an overview of the study's design and methodology. It outlines the steps employed to investigate the overarching research question. It then provides specific operational definitions for each variable and describes how data were collected from various sources. It provides rationale for including each of the variables.

Finally, it discusses ethical safeguards and ends with a description of data management procedures.

**Research Questions**

Four major steps were developed to explore the central question: *To what degree have institutions of higher education used LEED® to earn certification, provide leadership, and foster innovation in environmental sustainability?* Each step involved asking multiple questions. Each of the first three steps also corresponds to an overlap between two of the spheres of knowledge used to delineate the study (see Figure 6, p. 21). The fourth step corresponds to the central question.

Step 1 explored overlaps between institutional characteristics and LEED ratings. Step 2 investigated relationships between institutions and their use of LEED credit categories. Step 3 explored relationships between LEED ratings and institutions' use of Innovative Design credits. These steps were intended to support the central theme – a seemingly nebulous question at the heart of the Venn diagram where issues of characteristics, categories, innovation, leadership, and ratings all overlap.

A complicating factor in this study was a lack of full data regarding LEED credit categories. Although this study originally intended to study an entire population, data on the use of credit categories were not available for all campus buildings that had earned LEED ratings. The study's design was modified as a result. It ultimately focused on a convenience sample of 181 institutions for which the USGBC had "credit tally data" available. The sample was studied in Steps 1-3 and then compared with the balance of the population in Step 4. This final step investigated change over time and assessed how well the sample was representative of the larger population of higher education LEED users.

Questions of generalizability posed in Step 4 helped transfer results of earlier steps into usable findings related to the central question.

To facilitate exploration, widely acknowledged institutional variables were selected. These variables had been previously named, defined, and operationalized by the USGBC and NCES. Moreover, these organizations had already collected vast amounts of data using these definitions.

Chapter One provides basic information about how the existing measures represent each of the three major spheres of study. Figure 6 (on p. 135) identifies the source of data used to study each sphere, while Figure 5 illustrates how these spheres relate to the process of earning LEED certification. Together, these two diagrams constitute the conceptual framework of this study. Each overlap in Figure 6 (and, coincidentally, each arrow in Figure 5) directly corresponds to one of the steps below. In each step, data were analyzed in order to identify existing relationships among variables.

*Step 1: Assess ratings earned by institutions.*

1a) What types of postsecondary institutions use LEED and what leadership ratings do they earn?

1b) What is the relationship between institutional characteristics (region, control, type, enrollment, and endowment) and rating?

*Step 2: Assess how institutions use LEED credit categories.*

2a) What categories do institutions typically use to achieve certification?

2b) What is the relationship between use of the six categories and overall rating?

2c) What is the relationship between institutional characteristics and use of categories?

*Step 3: Assess how institutions use LEED categories to foster innovation.*

3a) How frequently do postsecondary institutions earn Innovative Design (ID) credits?

3b) What is the relationship between the rating earned and use of ID credits?

3c) What is the relationship between institutional characteristics and use of ID?

*Step 4: Assess generalizability.*

4a) To what degree has LEED use changed over time, based on the version of LEED employed?

4b) To what degree has LEED use changed over time, based on inclusion in USGBC's credit tally?

4b) How does the sample compare to the population of postsecondary LEED users?

**Data Analysis**

Table 2 reiterates the research questions and identifies the specific variables used to study each question. It also indicates the methods employed to analyze relationships among variables. All were performed using an alpha level of $p$=.05 to determine significance. It was apparent that relationships between LEED ratings and the use of individual credit categories were highly correlated, as one might expect. The rationale for using each of the specific statistical tests is described in Table 2.

Table 2: *Research questions, variables, and analysis methods.*

| Question | Variables | Method |
|---|---|---|
| ***Step 1: Assess ratings earned by institutions.*** | | |
| 1a) What types of postsecondary institutions use LEED and what leadership ratings do they earn? | Institutional characteristics and LEED ratings | Descriptive Statistics |

| | | | |
|---|---|---|---|
| 1b) What is the relationship between institutional characteristics and rating? | Institution's region, control, type, enrollment, and endowment | LEED ratings | Analysis of Variance (ANOVA) & Chi-Square Analysis |
| ***Step 2: Assess how institutions use LEED credit categories.*** | | | |
| 2a) What categories do institutions typically use to achieve certification? | LEED categories | | Descriptive Statistics |
| 2b) What is the relationship between use of the six categories and overall rating? | LEED ratings | Use of LEED categories relative to total points available | Multiple Regression & Multivariate Analysis (MANOVA) |
| 2c) What is the relationship between institutional characteristics and use of categories? | Institution's region, control, type, enrollment, and endowment | | ANOVA & Multiple Regression |
| ***Step 3: Assess how institutions use LEED categories to foster innovation.*** | | | |
| 3a) How frequently do postsecondary institutions earn Innovative Design (ID) credits? | Innovative Design credit earnings | | Descriptive Statistics |
| 3b) What is the relationship between the rating earned and use of ID credits? | LEED ratings | Proportion of ID credits earned | MANOVA |
| 3c) What is the relationship between institutional characteristics and use of ID? | Institution's region, control, type, enrollment, and endowment | | One-Way ANOVAs |
| ***Step 4: Assess generalizability.*** | | | |
| 4a) To what degree has LEED use changed over time, based on the version of LEED employed? | LEED version under which projects received certification | LEED ratings, total points, categories, and institutional characteristics | Chi-Square Analysis, ANOVA & MANOVA |
| 4b) To what degree has LEED use changed over time, based on inclusion in USGBC's credit tally? | Projects included in the sample compared with balance of the population | Version, ratings, points, and institutional characteristics | Chi-Square Analysis & Independent Samples *t*-Tests |
| 4c) How does the sample compare to the population of postsecondary LEED users? | Sample and population means | Institutional characteristics, ratings earned, and version of LEED used | Chi-Square Analysis & One-Way ANOVAs |

**Step 1.** The USGBC uses LEED rating as its primary measure of leadership. The first step sought to understand what *leadership ratings* institutions earned using the Green Building Rating system. It approached this issue using two sub-questions.

Question 1a utilized descriptive statistics (frequency counts, means, and standard deviations) to determine what types of postsecondary institutions use LEED and what levels of certification they typically earn. Question 1b used Chi-Square analysis to study categorical variables and One Way Analysis of Variance to study continuous variables related to institutions.

**Step 2.** The second step assessed how *institutions* have used LEED credit *categories*. The first sub-question (Question 2a) employed descriptive statistics to determine what LEED categories were most heavily used to achieve certification. Descriptive statistics were appropriate because no comparison was being drawn in this question. The question simply sought to understand how members of the sample had used each of the six LEED credit categories.

Question 2b used stepwise Multiple Regression as well as Multivariate Analysis (MANOVA) to explore relationships among the six categories and the overall ratings achieved. The Multiple Regression created a model for predicting LEED rating based on earnings in each credit category. MANOVA was used to identify where specific differences occurred. It helped pinpoint, for instance, how Gold-level earners used credit categories differently than Silver-level earners.

Question 2c required the use of individual ANOVA tests and Multiple Regressions. This question studied relationships between institutional characteristics and the overall use of categories. ANOVAs were used to study categorical variables, while Multiple Regression facilitated the study of continuous variables.

**Step 3.** The third step assessed how institutions used LEED *categories* to foster *innovation.* As in previous steps, the first question (Question 3a) employed descriptive statistics. These showed how frequently institutions have used the five available Innovative Design (ID) credits.

Question 3b paralleled Question 2b. It focused specifically upon the category of Innovative Design, whereas 2b looked at all categories simultaneously. Question 3b referred back to the MANOVA and one follow-up ANOVA generated in Question 2b, giving particular attention to the relationship between the rating and use of ID.

Likewise, Question 3c was designed to parallel Question 2c but to provide special focus on the innovation category. It used the results of Question 2c (which employed Multiple Regression and ANOVA) to explore how specific institutional characteristics related to the sample's use of ID credits.

**Step 4.** The final step in this study assessed generalizability of results. This step sought to understand how representative the sample was of the larger population. The population included all 446 postsecondary institutions that had used LEED up through December 7, 2009. The sample included only the 181 cases for which the USGBC provided credit tally data.

Question 4a employed Chi-Square Analysis, ANOVA, and MANOVA to study the degree to which LEED use has changed over time. It looked for patterns based on the LEED version (v2.0, v2.1, or v2.2) each building employed. It used Chi-Square Analysis to assess rating, ANOVA to assess the total number of points, and two separate

MANOVA tests to investigate (a) use of each category and (b) institutional characteristics.

Question 4b compared the sample with all other cases in the population. It compared variables when data were available for both the sample and the balance of the population. The distinguishing feature of the sample group was the availability of credit tally data. All other variables – institutional characteristics, LEED ratings, LEED versions, and total points earned – were known for the balance of the population as well. The sample constituted 40.6% of the population. A side-by-side comparison of these 181 buildings with the 256 cases that did not have credit tally data revealed differences.

The sample, it was reasoned, was likely to include applicants who had been involved with LEED the longest. This is because early applicants would have had more time for the USGBC to pull their data from the application forms into the master credit tally spreadsheet. In such case, the sample would represent early adopters of LEED. Because there was likely to be a chronological relationship, Independent Samples *t*-Tests were used to determine if and how the sample and balance groups differed. Chi-Square Analysis was used to compare their categorical variables.

Question 4c provided a final way to study changes over time. It employed Chi-Square Analysis & One-Way ANOVAs to assess how the sample compared with the entire population regarding institutional characteristics, ratings, and version used.

**Sample**

This study analyzed data about postsecondary buildings that have earned certification using the second version of LEED for New Construction and Major Renovations (LEED-NC v2). This is the main system that has been used to evaluate green buildings in the United States over the past ten years. It grew out of a pilot program known as LEED v1.

The sample for this study encompassed 181 buildings owned by colleges and universities that were *also* included in the master credit tally spreadsheet provided by the USGBC on January 9, 2010. The sample represents a sizable portion of the populations' 446 buildings. For the purposes of this study, the population includes all postsecondary buildings certified through LEED-NC v2 as of December 7, 2009.

The study did not include the handful of university buildings certified using LEED v1, LEED for Existing Buildings, LEED for Homes, LEED Neighborhood Design, or the newly-unveiled LEED v3 (also known as LEED 2009). The study did not include projects that had been registered with USGBC but had not yet earned LEED ratings.

The USGBC made the initial classification of ownership. It provided information for every building associated with higher learning. Buildings that were not owned by an institution of higher education were culled from the list. This included educational facilities owned by private foundations, corporations, and military organizations, as well as those shared by multiple institutions. This yielded a population of 446 LEED-NC v2 projects.

The USGBC provided spreadsheets with LEED ratings, point totals, and versions for each user. It provided separate credit tally spreadsheets indicating which of the 69 credits had been awarded to each building in the sample. Tallies of the credits used by the 265 buildings not included in the sample had not yet been harvested from the application forms. Tom Dietsche (personal communication, March 3, 2010) indicated that a system was being developed to allow automated harvesting. He indicated that this capability should be in place by the end of 2010. It will facilitate broader investigation of credit use and of the nature and intent of ID credits.

**Instrumentation**

Data in this study were collected using definitions, instruments, and procedures created by USGBC and NCES. This section provides operational definitions for each variable. It discusses the validity and reliability of LEED and IPEDS data. It also describes ethical safeguards undergirding the study.

This exploratory study was possible due to the existence of extensive datasets. However, the definitions and procedures used to collect and store the data also set parameters for the study. They limited what it was possible to study.

Conducting this study required adopting some of the assumptions built into the USGBC and NCES data collection systems. Research questions were framed around what had been measured. The intention of the study was to understand if universities had been using LEED to generate knowledge and provide leadership. These constructs could not be assessed directly.

The study employed USGBC's indicator of leadership, the LEED rating earned by each applicant. Interestingly, the USGBC provides no specific operational definition for leadership despite its overt implication that leadership is a primary objective of the system. On the other hand, the USGBC has operationalized innovation. Doing so is difficult, because the very nature of innovation precludes predetermination. This study utilized the number of credits earned in Innovative Design as an indicator of knowledge generation, transfer, and application.

This study focused on areas where reliable data were accessible. The overall validity of this study is heavily dependent upon the reliability and validity of measures developed by USGBC and NCES. Each of these systems represents the most extensive and reliable source of current information in its respective field. The USGBC's precise standards and procedures for assessing each application were designed to yield highly reliable (and easily replicable) data. A similar level of quality assurance is not provided by IPEDS, because NCES relies on self-reporting and does not have as clear a system of checks and balances.

LEED applicants face a high level of scrutiny. Trained third-party assessors have carefully evaluated the applicant's request for each LEED credit. No such system is in place to verify the accuracy of IPEDS data. Federal law mandates providing data to NCES through IPEDS. Alternatively, providing data to USGBC and making it public is a matter of choice. LEED participants are allowed to maintain their anonymity if they so desire; IPEDS participants are not.

Clarity (of definitions and calculation procedures) is critical to consistent measurement in both systems. To achieve reliability, the individuals making calculations and entering data must understand the requirements and they must be committed to accuracy. IPEDS data are entered by university staff members who may, or may not, have received training. They may or may not be committed to accuracy. Applicants, who cannot earn credit without providing accurate information, enter LEED data. The individuals entering the data are typically LEED Accredited Professionals who have studied the system in detail. They are accountable to their clients, their design teams, and their accrediting boards. Trained third-party reviewers verify data they submit.

Changes that occur in LEED and IPEDS over time can affect reliability. In both systems, the definitions and methods for calculating variables have been refined and calibrated over time. This can increase precision, but it may also cause confusion for those entering data. LEED definitions appear to have a higher level of continuity from year to year than those used by IPEDS. IPEDS definitions often shift dramatically. One must take care to understand the operational definitions used in each collection period. The LEED system has been designed to make it easy for applicants and consultants to use multiple versions at once. Overall, individuals calculating and entering IPEDS data appear to face more confusion, fewer third-party checks, and less direct accountability for the quality of the data they provide.

**Individual IPEDS variables.** The National Center for Educational Statistics [NCES] (2009a) is the federal entity that collects and analyzes education-related data. NCES (2009b) describes IPEDS as a comprehensive system of interrelated surveys for collecting data about individual postsecondary institutions. Much of this survey data is accessible to the public, using the IPEDS homepage (NCES, 2009c).

Shifting definitions can significantly impact the comparability of data sets from year to year. For those accessing IPEDS data, the system provides detailed definitions for each year's variables. IPEDS definitions that are straightforward and that have remained constant over a long period of time are most likely to yield reliable data.

Snyder, Dillow, and Hoffman (2009) explain that about 6500 postsecondary institutions submit information using IPEDS. This exceeds the 4391 institutions classified by the Carnegie Foundation for the Advancement of Teaching (2005).

The IPED System was implemented in 1986; it replaced an earlier system known as the Higher Education General Information Survey (Snyder et al., 2009). Today, IPEDS includes nine interconnected components. It is used to collect information regarding the programs postsecondary institutions offer, the financial and human resources they utilize, and the students they matriculate. The study by Snyder et al. identified IPEDS as the nation's most comprehensive database for higher education. This system provides information about almost all postsecondary institutions because the federal government requires every institution that enrolls *any* student who receives federal financial aid through Title IV to report data. Appendix B provides a description of how data for this study were obtained using IPEDS.

***Definition of each institutional variable.*** This study employed five specific institutional factors. Data for most of these variables were obtained directly from IPEDS. These five variables – region, control, type of institution, enrollment, and endowment – were selected based upon their availability as well as their potential to influence a university's participation in LEED.

*Region.* The location of each institution was determined using national accrediting standards. Spreadsheets provided by USGBC listed the state where each project was located. The University of Texas at Austin (2008) provided an on-line list of states included in each collegiate accreditation region.

Each building in the LEED sample was tagged with a regional designation. As per The University of Texas at Austin (2008), Region 1 includes middle states (Delaware, District of Columbia, Maryland, New Jersey, New York, and Pennsylvania). Region 2 encompasses New England states (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont). Region 3 is known as North Central (it includes Arizona, Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, New Mexico, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, West Virginia, Wisconsin, and Wyoming). Region 4 represents the northwest (Alaska, Idaho, Montana, Nevada, Oregon, Utah, and Washington). Region 5 includes southern states (Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia). Region 6 is known as the Western Region (California and Hawaii). These six regions have been treated as categorical variables.

*Control.* IPEDS was used to determine the source of control for each institution. The IPEDS codes employed were: (1) public, (2) private not-for-profit, and (3) private for-profit. The IPEDS dataset regarding "Institutional Control or Affiliation" for 2008-09 was obtained. Where data were missing for this academic year, the listing for 2005-06 was utilized. IPEDS provides informational boxes explaining that public institutions are those where activities and programs are supported by public funds. Appointed or publically elected school officials operate them. Private not-for-profit institutions are operated by agencies or individuals who receive no compensation beyond rent, wages, and expenses related to assuming risk on behalf of others. They may be independent or religiously affiliated. Private for-profit institutions are operated by agencies or individuals that receive compensation over and above rent, wages, and/or payment for assuming risk.

*Type of institution.* This study had a specific interest in possible links between type of institution and LEED participation, due to the supposition that LEED provides a means for applying emerging knowledge through green design. Data on type of institution were derived using the institution's IPEDS listing for "Carnegie Classification 2005: Basic." The standard Carnegie coding system is shown in the first column of Table 3. Each institution was placed in one of four type groups for this study: (1) Associates colleges, (2) Baccalaureate colleges, (3) Masters colleges and universities, and (4) Doctorate-granting universities. The Internet was used to obtain information on the programs offered by each Special Focus Institution, in order to estimate the level of research each conducted and assign each to a comparable group.

Table 3: *Basic classifications from the 2005 Carnegie Classification system.*

| **IPEDS Code** | **SPSS Code** | **Basic Classifications** | **Defining Characteristics** |
|---|---|---|---|
| 1-14 | 1 | Associates Colleges | Institutions where no more than 10% of all undergraduate degrees are at the Associates level. |
| 21-23 | 2 | Baccalaureate Colleges | Institutions where 90% or more of all undergraduate degrees are above the associate level and which awards fewer than 50 Masters or fewer than 20 doctoral degrees per year. |
| 18-20 | 3 | Masters Colleges and Universities | Institutions that award 50+ Masters degrees per year. |
| 15-17 | 4 | Doctorate-granting Universities | Institutions that award 20+ doctoral degrees per year. |
| 24-32 | varies | Special Focus Institutions | Institutions awarding a high concentration of degrees (baccalaureate or higher) in one or more closely related fields. |
| 33 | n/a | Tribal Colleges | Institutions funded as Tribal Colleges. |
| 0 | n/a | Not Classified | |
| -3 | n/a | Not Applicable | Institutions that are not accredited or do not grant degrees. |

Adapted from: IPEDS Dataset Cutting Tool (http://nces.ed.gov/ipedspas/dct)

Table 3 provides defining characteristics for each Carnegie Classification. The 2005 Carnegie Classification is the most recent version of the system and was used in this study. It represents the evolution of a scheme that was first introduced in 1970. Type of institution is known to correlate with other characteristics used in this study. Although the topic was not a primary focus of this particular study, it was explored as an aid to future researchers (see Appendix C).

*Enrollment.* The study also questioned if the size of an institution related to how it used LEED. Enrollment data from fall 2007 were utilized as an indicator of institutions' relative size. This was determined using IPEDS data on "Full-Time Equivalent (FTE) Enrollment." Where data were missing from the 2007 listing, replacement data were obtained from the fall 2005 listing.

FTE enrollment reflects individuals registered for credit at each institution on October 15 of a given year. The number provided by IPEDS reflects all full-time students plus a weighted percentage for part-time students. NCES makes these estimates based on the institution's control and classification as well as the level of the students involved (undergraduate, graduate, or thesis/dissertation). NCES derives enrollment data by combining the information institutions report for enrollment by race and ethnicity.

*Endowment.* It was speculated that an institution's endowment and its overall financial stability might influence its use of LEED. Data on end-of-year endowment assets per student were obtained from IPEDS for academic years 2005-06 and 2006-07. These data were based on FTE and reported in two discrete sets (GASB and FASB institutions). Information on endowment per student is not reported as a discrete category in IPEDS. The system derives this information using other datasets.

Possibilities for cross-comparison are limited by the fact that postsecondary institutions use two different reporting systems within IPEDS, depending upon how they are funded. The Governmental Accounting Standards Board (GASB) collects data on public institutions, while the Financial Accounting Standards Board (FASB) collects data about private institutions. A few public institutions do, however, use the FASB system for various reasons. GASB and FASB have been calibrated differently because public and private funding mechanisms and accountability differ greatly. Although there is not a direct correlation between FASB and GASB data, NCES (2009d) indicates the system has been revised to make comparisons "somewhat easier between FASB and New GASB" (¶ 16). This study used data that were adjusted by IPEDS to facilitate comparison. However, FASB and GASB data have not been completely standardized. The two datasets may thus reflect slightly different criteria. This means that comparisons made *within* each dataset (FASB or GASB) are likely to be more precise than comparisons made *across* datasets. Nevertheless, these data are part of the "new" system, which attempts to facilitate cross-system comparison. A detailed description of the variables NCES used to calculate and report endowment is provided in Appendix B.

The lack of matched financial data for GASB and FASB presented a limitation in this study. It was impossible to make detailed comparisons of financial data because so little was available on IPEDS that had been standardized across systems. Only two year's worth of standardized data were available, and only on one specific issue, "Endowment assets (year end) per FTE enrollment." It is not clear why such data were available for just two year's time, but they do represent an attempt by NCES to facilitate cross-comparison. These two particular years (2005-06 and 2006-07) provide a picture of economic conditions before the economic downturn and during much of the operation of LEED v2 (2000 to 2009 and beyond). Data were obtained for 2006-07. Where data were missing, the prior year's data were used.

***Validity and reliability of IPEDS data.*** The quality of this study was limited by how well the IPEDS variables were defined and reported. Shifting definitions and self-reporting present limitations. However, NCES does use several mechanisms to monitor the validity and reliability of its measures.

The NCES Taskforce for IPEDS Redesign (Peng, Korb, Rose, Snyder, Cohen, Ludwig, et al., 1999) conducted a study that led to a major overhaul of the IPED System ten years ago. The *Digest of Educational Statistics: 2008* (Snyder, Dillow, & Hoffman, 2009) explains that this redesign was intended to improve consistency in definitions and enhance the reliability, validity, and accuracy of measures and surveys. It did not however, address accuracy *within* the self-reported data that institutions provide.

Research by Jackson, Peecksen, Jang, and Sukasih (2005) focused on the validity and reliability of data provided to IPEDS by institutions during the 2002-2003 academic year. The study compared data collected through IPEDS with other, parallel systems in order to assess its quality and consistency. These parallel system included Title IV and the Thomas Peterson database on postsecondary education. The researchers focused on eight specific issues (price and tuition, employees, completions, enrollments, financial aid, finance, salaries, and graduation rates). They looked to see if institutions submitted significantly different data when they reported it on two different occurrences. They studied the types and magnitude of changes between these two collection points. They assessed the influence changes had on the accuracy of data initially reported.

Jackson et al. (2005) found that institutions reported data consistently. When data did not match at two collection points, the magnitude of the changes did not greatly affect the validity of what had been reported originally. The researchers found that IPEDS data were more reliable than Thomas Peterson's and other sources. They concluded that IPEDS data for 2002-2003 were accurate and that IPEDS provides the most comprehensive data on higher education.

***Ethical safeguards for IPEDS data.*** All IPEDS information is publically accessible. The federal government requires institutions to provide this information for public use; using it does not pose significant risk to individuals or organizations involved in the study. However, because some users of the LEED system have elected to remain anonymous, none of those institutions have been identified by name in this study.

**Individual LEED variables.** This study utilizes existing LEED data in order to explore patterns of use. Variables were selected for this study based upon their availability and relevance to the research questions. Critical variables include LEED ratings, credits earned in each category, and ID credits obtained. These variables have tremendous consequence for the green building movement and for development of standards, techniques, and products. Studying how these variables are used can help green rating systems evolve. The LEED data used in this study were collected by the USGBC. The Council's data collection and management system has emerged over time and it is currently undergoing substantial revision. Recent changes address prior weaknesses affecting validity and reliability (Stephens, 2008; USGBC, 2009c).

The study supposed that the level of certification and use of credit categories might relate to other characteristics of a building's owner. It was also speculated that Innovative Design credits could provide understanding of how universities generate and apply knowledge about environmental sustainability. This section describes specific LEED variables employed in the study and provides rationale for using these measures.

The section ends with a discussion of validity and reliability and a description of recent changes to the system.

The following information was requested from the USGBC for each higher education building that had earned certification using LEED-NC v2. The first four items were available; the last two were not.

1) Name of university
2) Version of LEED-NC used (2.0, 2.1, or 2.2)
3) List of credits achieved
4) Certification level awarded
5) Breakdown of credits earned in the category of *Innovation in Design* – in order to distinguish between credits earned for Innovative Design (ID), Exemplary Performance (EP), and simply having a LEED Accredited Professional on the design team
6) Title of each *Innovation in Design* ID credit earned

The first four items were available using either USGBC's comprehensive "not for public" file or its master credit tally spreadsheets. A Data Use Agreement was submitted in order to obtain access to confidential "not for public" files.

The last two items requested for the study were prohibitively difficult to obtain because they had not been harvested from the digital application forms (Tom Dietsche, personal communication, November 20, 2009). The last two items were still not available as of March 3, 2009. Dietsche explained that the data harvesting issue has been addressed in LEED v3. He indicated that it may be possible to conduct future research on v2 by either (a) manually harvesting those data or (b) waiting for USGBC to harvest the data with software that is now in development.

***Definition of each LEED variable.*** The USGBC has developed detailed definitions and measurement criteria for its LEED programs. Its operational definitions were adopted for this study. Full descriptions of each category and credit are available in the *LEED for New Construction Reference Guide, Version 2.2* (USGBC, 2007). The document describes v2.2 and indicates the ways it differs from v2.0 and v2.1. Information essential for understanding this study is provided herein.

LEED-NC v2 offers 69 possible credits that fall into six different categories. An applicant accrues credits toward one of four LEED ratings. Individual measures reflect current knowledge of ways to improve energy performance and decrease a building's negative environmental impact.

USGBC (2007) describes these measures – and the techniques used to calculate them – in great detail. Its reference guides explain the benefits each credit seeks to achieve. USGBC also provides examples of strategies that may help achieve a credit, but it does not prescribe specific techniques that must be used. This permits flexibility in meeting performance thresholds.

*LEED ratings*. All versions of LEED have offered four rating levels: Certification, Silver, Gold, and Platinum. Table 4 displays the minimum number of credits that must be achieved to earn each rating. In includes thresholds for LEED v2 and v3 programs. The basic structure of ratings, credits, and categories has remained consistent across all versions of LEED. Although the specific names of some categories and credits shifted slightly over time, this has been accomplished in a way that allows for easy comparison.

Table 4: *Minimum credits required for LEED certification at various levels.*

| LEED-NC Certification Levels | Version 2 (v2.0-v2.2) | Version 3 |
|---|---|---|
| Certified | 26 | 40 |
| Silver | 33 | 50 |
| Gold | 39 | 60 |
| Platinum | 52 | 80 |

Compiled from: USGBC (2001, 2002, 2008b, 2009a)

For instance, the prerequisite in the Sustainable Sites category was called "Erosion & Sedimentation Control" under v2.0 and v2.1 but has been renamed "Construction Activity Pollution Prevention" in v2.2 and v3.0 (USGBC 2001, 2002, 2008b, 2009a). The intent of the credit did not change, nor its abbreviation (SSp1). Making changes in this way helps design teams shift back and forth between multiple systems (Aarons-Sydnor & Miller, 2009).

*Use of LEED categories.* The study used USGBC's (2007) credit categories, rather than individual credits, to facilitate identification of patterns. Six LEED categories have remained constant across all LEED v2 programs. They are: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), Indoor Environmental Quality (IEQ), Innovation and Design Process (ID).

Table 5: *Number of credits available in each LEED category.*

| LEED-NC Categories | Credits in v2 (2.0-2.2) | Credits in v3 |
|---|---|---|
| Sustainable Sites (SS) | 14 | 26 |
| Water Efficiency (WE) | 5 | 10 |
| Energy and Atmosphere (EA) | 17 | 35 |
| Materials and Resources (MR) | 13 | 14 |
| Indoor Environmental Quality (IEQ) | 15 | 15 |
| Innovation & Design Process (ID) | 5 | 6 |
| Regional Priority (RP) | n/a | 4 |
| **Total Points Available** | 69 | 110 |

Compiled from: USGBC (2001, 2002, 2008b, 2009a)

The points available in each of these categories have also remained constant across all LEED v2 programs (see Table 5). This study looked at the raw number of credits earned in each category relative to the total number of points available.

The USGBC (2007) provides very detailed information to help applicants and reviewers assess compliance. For each of the 69 possible credits, the LEED Reference Guide defines: Intent, Requirements, and Potential Technologies and Strategies. It also provides a Summary of Referenced Standards (i.e., standards that have been developed by other organizations in the building industry). For each credit, this is followed by: (1) suggested approaches and various ways to implement them, (2) calculations for assessing actual and/or predicted performance, (3) criteria for achieving Exemplary Performance for applicable credits, (4) documents that must be submitted, (5) information about related economic and environmental issues, (6) additional resources to help the design team make decisions, (7) definitions of important terms related to that credit, and in some cases (8) a short case study of a project that earned that particular credit. A table of individual credit titles is provided in Appendix A. It lists the specific credits available in LEED v2.2 and v3. (In v2.0 and v2.1, the names of these credits were either similar or identical to the ones listed in this table.)

*Use of Innovative Design credits.* The study placed particular emphasis on applicants' accomplishments in the Innovation in Design (ID) credit category. It assessed the number of ID credits each building earned relative to total credits earned. Unfortunately, the data provided by UGSBC did not distinguish between Innovative Design (ID) and Exemplary Performance (EP). All Innovation in Design credits were recorded in the same manner (ID and EP were indistinguishable from one another).

Although it was possible to differentiate the one credit provided for having a LEED Accredited Professional on the design team, this information was not helpful because almost all applicants earn the LEED AP credit (Tom Dietsche, personal communication, November 20, 2009).

***Validity and reliability of LEED data.*** This study employs LEED variables that have been carefully defined and closely evaluated by USGBC. Applicants submit detailed information to support their request for each credit. Trained third-party consultants scrutinize each application. This is intended to yield very high levels of consistency and reliability in credit awards.

The USGBC has not faced criticism regarding the *internal reliability* of its measures. In fact, some critics actually suggest that LEED assessors may be too detailed in reviewing credit applications (Udall & Schendler, 2005). Nevertheless, the overall validity and external reliability of LEED measures have come into question. As for *external reliability*, critics claim that the tools (instruments, software, and calculations) used to *predict* energy performance are not reliable enough.

Criticisms of the *validity* of using LEED involve all of the following: (a) content validity, (b) criterion validity, and (c) consequential validity. Sampling represents the major concern with regard to *content validity* of LEED. Critics have questioned if appropriate content is being sampled and assessed.

Concerns about criterion validity have emerged regarding the *predictive* as well as *concurrent* validity of LEED. Discrepancies – between levels of energy savings predicted in LEED applications and actual performance over time – negatively affect LEED's predictive validity. Moreover, a recent study reported that Energy Star instruments (which analyze performance over time) have not yielded the same results as LEED instruments that confer static ratings based on predictions (Navarro, 2009). This brings the concurrent validity of LEED into question. Concurrent validity considers how well its predictions align with measurements on other instruments.

Consequential validity asks if a given instrument supports its own values, or if its use has unintended consequences that undermine these principles. Regarding the consequential validity of LEED-NC v2, critics have been asking: Do results match intentions? What are the social and environmental consequences of using the instrument? Are applicants wasting resources as a result of LEED participation? It is clear that more research needs to be done to investigate these issues and promote evolution of the system (Gifford, n.d.; Udall & Schendler, 2005).

***Ethical safeguards for LEED data.*** USGBC provides users the option to keep information about their identities and their projects confidential. For this study, it was necessary to obtain some confidential data. Identities were acquired for all but eight members of the population in question. It was necessary to identify participating universities by name in order to obtain IPEDS data for them. (SPSS was set to exclude these eight in tests where data were missing. However, population analysis involving known variables, such as ratings and version, included these eight.)

A customized agreement regarding acceptable use of the data was developed to assure USGBC that data would be reported in an aggregate form that would not compromise any of the confidential identities. The USGBC did not request any special measures to obscure the names of participants from the working data files (Tom Dietsche, personal communication, November 20, 2009). The organization asked only that the names of institutions that chose to remain confidential not be shared with any persons other than the researchers directly involved in this project. To honor this request, the study did not report any identifying information involving LEED data.

**Procedures and Data Management Issues**

Data collection was discussed above and is further detailed in Appendix B. This section describes data management and data cleaning procedures. After obtaining LEED data, a master Excel file was created. All pertinent USGBC and IPEDS data were imported into this master file. Then the entire set of data was transferred into SPSS (its software package named PASW Statistics 18.0). Statistical analyses were then conducted as described in Table 2, p. 107.

At the start of data collection, information was provided by USGBC in Excel spreadsheets. Data not pertinent to this study were removed from the files. USGBC's list of postsecondary LEED users was evaluated for fit with the parameters of this study.

The USGBC's credit tally spreadsheets provided breakdowns of each credit earned through December 9, 2009 by 181 buildings. The 265 cases without credit tally data, plus the 181 in the sample group, comprise the population of 446 postsecondary buildings. Each member of the sample was assigned an identification number from 1-181 to facilitate data sorting. Other members of the population were assigned identification numbers 182-446, indicating that they did not have credit tally data. Data were available for the entire population with regard to: (1) LEED rating, (2) version used, and (3) total number of credits earned.

The USGBC's credit tally spreadsheet listed each of the 69 credits separately. Microsoft Excel was used to compute the number of credits each building earned in each of the six categories. However, the USGBC listed the total number of credits each building earned in two separate places (the credit tally spreadsheet and the master "not for public" spreadsheet). In comparing these datasets, ten discrepancies in total number of credits were found. The overall credit total for one building in the balance of the population (i.e., the non-sample group) was out-of-range; that score was deleted and treated as missing data. As such, that one case was omitted in analysis regarding total credits earned by the population. In the other nine cases, the total provided on the credit tally spreadsheet was utilized because it differed from the summary spreadsheet. The credit tally appeared to include newer data than the summary sheet. It also provided a higher level of accountability because it showed information about each individual credit.

All relevant USGBC data (regarding LEED rating, version used, total number of credits earned, and number of credits obtained in each of the six categories) were imported into a master file. Next, institutional data were obtained for each member of the population.

Spreadsheets were downloaded from IPEDS that included data on: control, Carnegie Classification, enrollment, and endowment. It was possible to locate data IPEDS data for all but the eight members of the population whose owners' names were not identified by the USGBC. As indicated earlier, missing data cells were left blank for these eight. They were included in the population analysis where data were available.

The IPEDS data files included a number of missing data cells as well. In addition, some of the items required conversion. Carnegie Classifications were translated to reflect four distinct types of institutions. Most transferred directly. The seven special focus institutions (three in the sample and four in the balance of the population) were each assigned to a research group based on the degree offerings listed on their websites. Regions were determined using the locations listed for each building in the USGBC's spreadsheets. These were converted based on national accreditation regions.

There were twelve cases (one in the sample and eleven in the balance of the population) without a Carnegie Classification. In six cases, a community college systems office owned the building. A state office of higher education owned one of the buildings. All twelve cases were missing IPEDS data about enrollment and endowment.

For cases where the building could be tied to one particular campus, IPEDS data were obtained for that campus using the Internet. These data were included in the spreadsheet to fill missing data cells. In instances where FTE was not provided on the colleges' websites, it was estimated by multiplying the total student count for each of these campuses by 0.5 (for community colleges) or 0.85 (for the residential college with missing data). In one case, enrollment was available only for the entire system (not the specific campus) – the system's total enrollment was divided by the number of campuses in the system.

In total, 27 members of the population (seven members of the sample and 20 of the balance of the population) had not provided information on endowment per student to IPEDS. Systems offices, some technical schools, and all institutions in Colorado fall into this group. Because these entities had reported no endowment to IPEDS, missing cells were assigned an endowment value of zero.

**Conclusion**

This study was designed to use existing data to assess the degree to which institutions of higher education had used LEED to earn certification, provide leadership, and foster innovation in environmental sustainability. It set out to explore relationships between (a) institutional variables, (b) LEED ratings, (c) use of the six LEED categories, and (d) use of Innovative Design credits. The design utilized existing data to build understanding of what types of institutions have used LEED and how they have used it. This study represents a step in addressing a gap in the literature. It advances society's understanding of outcomes of the LEED Green Building Rating System.

## Chapter 4: Analysis of Results

A sequence of four steps was implemented to study the higher education buildings certified under LEED-NCv2 prior to December 9, 2009. The methods used in Steps 1-3 focused on a sample of 181 buildings certified (40.6% of the population). A fourth step was taken in order to assess the generalizability of findings. This step attempted to answer the central question: *To what degree have institutions of higher education used LEED® to earn certification, provide leadership, and foster innovation in environmental sustainability?* To do this, the study looked for patterns in use that have changed over time. Results of Steps 1-4 are presented in this chapter, in the sequence outlined earlier.

### Step 1

The first step assessed ratings. It was designed to explore how postsecondary institutions obtained recognition of leadership. This was done by investigating the rating that institutions earned using LEED.

**Question 1a.** This question utilized descriptive statistics to determine (1) what types of postsecondary institutions use LEED and (2) what ratings they typically earn.

Frequencies were calculated for region, control, and type of institution. Of the 181 buildings, 48 were located in the North Central region (26.5% of the sample), 47 in the Southern region (26%), 29 in New England (16%), 22 in the Northwest (12.2%), and 21 in Middle States (11.6%), with 14 in California or Hawaii (7.7%).

The sample was evenly divided with regard to institutional control. Public institutions accounted for 88 of LEED-rated buildings (48.6% of the sample) while private not-for-profit institutions owned 93 of the buildings (51.4%). The sample did not include any private for-profit institutions.

With regard to type, 91 of the buildings were owned by Doctoral institutions (50.3% of the sample), 41 by Bachelors colleges (22.7%), 36 by Masters universities (19.9%), and 13 by Associates colleges (7.2%). The institutions in this sample reflected a wide spectrum of size and wealth. They had a median endowment per student of $27,647. Their median enrollment was 8993 students in 2007.

Within the sample, 44 buildings were rated using LEED-NC v2.0, 86 using v2.1, and 51 using v2.2. The 181 buildings accrued an average of 34.18 credits (with a median of 34.0). The average for the sample, therefore, falls at the lower end of the Silver rating, which is awarded when an applicant earns 33-38 points. Within the sample, 65 buildings earned basic Certification, 61 garnered Silver, 51 earned Gold, and 4 achieved Platinum.

The buildings in the sample were owned by 121 different institutions. Thirty-three of the institutions owned multiple LEED-rated buildings: 24 institutions owned two LEED buildings each, two institutions owned three LEED buildings each, and three owned four each. There was one private institution with five LEED buildings, one private institution with six, and one private institution with seven. A single public land grant institution owned eight LEED buildings – the most in this sample.

**Question 1b.** This question used One Way Analysis of Variance (to study continuous variables) and Chi-Square analysis (to study categorical variables). It investigated relationships between institutional characteristics and ratings. However, these tests yielded no significant findings.

Nonparametric tests confirmed (at the $p$=.01 level) that the data for enrollment, endowment, and type of institution were not normally distributed (see Appendix D). There was a floor effect in both datasets that rendered the general linear model ill suited to detect differences that might exist regarding enrollment and endowment. Many of the buildings in the sample belong to institutions with small student bodies and very small, or non-existent, endowments.

**Step 2**

Step two assessed how the sample group used LEED credit categories to obtain certification. The intention was to see which categories institutions relied upon most, and if using certain categories helped ensure success. Because of the nature of these variables, it was possible to assume causality. Accumulation of points in various categories directly influences LEED rating.

**Question 2a.** This question employed descriptive statistics about the use of LEED categories. Sampled institutions earned a grand total of 6187 credits (see Table 6). They earned 25.7% of their credits in Indoor Environmental Quality, 21.8% in Sustainable Sites, 18% in Energy and Atmosphere, 15.6% in Materials and Resources, 10.5% in Innovation in Design, and 8.4% in Water Efficiency.

Table 6: *Comparison the portion of LEED credits available to totals earned.*

| **Categories** | **Credits Offered to Each Applicant** | **Credits Earned by Sample Group** |
|---|---|---|
| SS - Sustainable Sites | 20.3% (14) | 21.8% (1348) |
| WE - Water Efficiency | 07.3% (05) | 08.4% ( 522) |
| EA - Energy and Atmosphere | 24.6% (17) | 18.0% (1111) |
| MR - Materials and Resources | 18.8% (13) | 15.6% ( 968) |
| IEQ - Indoor Environmental Quality | 21.7% (15) | 25.7% (1590) |
| ID - Innovation and Design Process | 07.3% (05) | 10.5% ( 648) |
| **Total** | 100% (69) | 100% (6187) |

The sample group used SS, WE, IEQ, and ID in higher proportion than EA and MR – in relation to the share of credits offered in each category. The overall proportion of Energy and Atmosphere earned (18%) was much lower than the portion offered (24.6%). The share of Materials and Resources earned was also lower than the proportion available. This means that the sampled institutions left many available EA and MR credits behind (or unearned) in the pursuit of LEED certification.

**Question 2b.** In this question, Multiple Regression and Multivariate Analysis (MANOVA) were utilized to explore relationships between the number of *credits earned* in each category and the overall LEED *rating achieved.* Having both perspectives may be useful to university administrators and design teams applying for LEED certification. Multiple Regression provided a model for predicting success, while the MANOVA identified where the greatest differences in use of categories occurred. The results of both procedures must be interpreted with caution due to the very small size of the Platinum group. These procedures use the mean for each rating group, and the mean generated using just scores of just four Platinum earners is not necessarily representative of a standard approach.

***Multiple Regression.*** This procedure was selected because it reveals what categories best predicted success, among sampled institutions, in earning LEED certification under v2. A stepwise regression was run using LEED rating (as the dependent variable) and raw scores in each category (as independent variables). Using stepwise regression, SPSS identified the single category that had the greatest influence and loaded it first. When the second-most influential variable was added, only the portion of the new variable's influence that was unique (in that it was unrelated to that covered by the first variable) was added to the model.

A One-Way Between Subjects ANOVA was used to determine that a significant model had been achieved: $F$ (6, 174) = 279, MSE = 19.897, $p<.01$. No problems arose (with regard to linearity, independence of errors, effects of outliers, or multi-collinearity) to challenge the validity of using this prediction model.

Table 7: *Regression coefficients using LEED Rating as the dependent variable.*

| Model | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | t | Sig. |
| (Constant) | -2.302 | .120 | | -19.205 | .000 |
| EA (Energy & Atmosphere) | .120 | .006 | .462 | 18.941 | .000 |
| SS (Sustainable Sites) | .132 | .010 | .327 | 13.299 | .000 |
| IEQ (Indoor Env. Quality) | .113 | .009 | .309 | 12.606 | .000 |
| ID (Innovative Design) | .135 | .015 | .218 | 8.706 | .000 |
| MR (Materials & Resources) | .121 | .012 | .242 | 10.316 | .000 |
| WE (Water Efficiency) | .149 | .016 | .230 | 9.091 | .000 |

The Multiple Regression indicated that each category independently explained a significant amount of the variance in overall rating (see Table 7). Energy and Atmosphere was more independently related to LEED rating than any of the other categories. It alone accounted for 41% of variance in rating (see Table 8). The model shown in Table 8 uses the following order of loading to generate the most accurate predictions possible: (1) Energy and Atmosphere, (2) Sustainable Sites, (3) Indoor Environmental Quality, (4) Innovative Design, (5) Materials and Resources, and finally (6) Water Efficiency.

Table 8: *Summary of regression model for LEED Rating.*

| Predictors of LEED Rating, in order of influence | R | $R^2$ |
|---|---|---|
| starting with EA (Energy & Atmosphere) | .641 | .411 |
| adding SS (Sustainable Sites) | .776 | .602 |
| adding IEQ (Indoor Env. Quality) | .854 | .728 |
| adding ID (Innovative Design) | .897 | .804 |
| adding MR (Materials & Resources) | .928 | .861 |
| adding WE (Water Efficiency) | .952 | .906 |
| R indicates relationship between category and LEED rating. $R^2$ indicates the portion of the category's variance shared with LEED rating. | | |

The first two predictors (EA and SS) accounted for 60.2% of the variance in ratings. By adding IEQ to the mix 72.8% of the variance was explained. The addition of Innovative Design brought the total to 80.4%. Taken together, the scores in all six categories account for 90.6% of the variance in LEED rating. These six categories have an overall relationship with LEED rating of R=.952. As would be expected, the higher the building's LEED rating, the higher number of points earned in various categories.

In earning ratings at all levels, individual buildings distinguished themselves more within the category of ID than they did within the categories of MR or WE. Innovative Design added more new and unique information than Materials and Resources or Water Efficiency. As such, ID was more valuable in making predictions than MR or WE when the entire set of categories was considered at once.

These results reflect how this particular sample group of postsecondary institutions used various categories to earn their LEED ratings. Although the results are specific to this group, they do indicate a very clear pattern of reliance on Energy and Atmosphere. The predictive value of each category was related to the variance within the particular category. It was not dependent upon the size of the category. In fact, the predictive model was nearly identical when it was run using the percentage (of earned to available credits) rather than the raw score in each category. Running the equation in this way controlled for size differences and it showed the same level of relative influence among categories.

Due to the Platinum group's small size, assumptions of equal group size were not met. The assumption of equal variances was also not supported (as indicated in the MANOVA conducted subsequently). Because of this, a follow up regression was run omitting the four Platinum cases. With just Certified, Silver, and Gold groups, the order of predictions was found to be identical to the one described previously. The overall prediction was almost the same (89.9%). However, EA contributed less (33.2%) under this particular scenario. EA was clearly important in helping high achievers earn Platinum, but this applied to just a few cases in the sample. Although the original regression gave each Platinum case more than its fair share of weight, EA still exerted the greatest influence over rating even when this preference was removed.

Regression provided an effective prediction model specifically because these data were lumped into categories (Certified, Silver, Gold, and Platinum). The relationship between the *raw score* in each category and the overall *point total* was, in fact, too perfect to use Multiple Regression. The standard regression procedure is unable to deal with perfect relationships. Lumping the data into rating groups reduced the precision, yet it facilitated the creation of a viable model. This regression model indicates that knowing the score in six categories predicts 90.6% of the variance in rating. The source of the other 9.4% of the variance is unknown; it is simply attributed to error in the model.

Regression provided one way to assess relationships in these data. A follow-up MANOVA provided a second way to assess patterns. The two procedures have different intentions and they convey different types of information. Using a Multiple Regression, the influence of the six categories was calculated *cumulatively*.

***MANOVA.*** Using MANOVA, the influence of each category was assessed *separately*. The reason for conducting this test was to determine which rating levels could be linked to the number of credits earned in each individual category. MANOVA was used (rather than individual ANOVAs) in order to control for alpha slippage.

A Pillai's Trace test confirmed that the overall MANOVA model was significant: $F(6, 172) = 3729.032$, value = .992, $p<.01$. A Box's Test indicated that the variances were not equal across rating groups ($F=2.465$, df1=42, df2=82864.22, $p<.01$). However, because the overall MANOVA was significant, it was appropriate to look at the ANOVA for each category. Each was identified as significant at the $p<.01$ level. Levene's Tests were used at this point to determine which individual categories violated the assumption of equal variances. Three categories (WE, MR, and ID) did not. The other three (SS, EA, and IEQ) did. These results were used to determine the appropriate post hoc tests to use. All post hoc tests were significant (see Table 9) and the overall Pillai's test for them was also significant: $F(18, 15.5) = 552$, value = 1.045, $p<.01$.

Table 9: *Follow-up tests for between-subjects effects for LEED Rating.*

| **Dependent Variable** | **Type III Sum of Sq** | **df** | **Mean Square** | **F** | **Sig.** | **$R^2$** |
|---|---|---|---|---|---|---|
| Sustainable Sites | 201.912 | 3 | 67.304 | 19.502 | .000 | .248 |
| Water Efficiency | 97.729 | 3 | 32.576 | 26.592 | .000 | .311 |
| Energy & Atmosphere | 917.283 | 3 | 305.761 | 52.025 | .000 | .469 |
| Materials & Resources | 46.088 | 3 | 15.363 | 5.607 | .001 | .087 |
| Indoor Env. Quality | 294.232 | 3 | 98.077 | 25.219 | .000 | .299 |
| Innovative Design | 69.162 | 3 | 23.054 | 14.842 | .000 | .201 |
| $R^2$ and Partial Eta Squared were identical in the MANOVA tests in this study. As such, the $R^2$ reported also indicates the Effect Size of each individual measure. | | | | | | |

Using these follow up tests, it was possible to locate exactly where significant differences occurred with regard to rating and credit use. The three with equal variances used Tukey HSD. The three with unequal variances used Games-Howell tests. SPSS output is provided for all six in Appendix F.

Although every one of the six credit categories significantly influenced LEED rating, the degree of influence each category had on rating varied drastically. In Table 9, this influence is indicated by $R^2$. Some of these differences are attributable to size of the category. Others are related to the amount variation in the number of credits earned within each category.

In order of independent influence, LEED rating shares: 46.9% of its variance with Energy and Atmosphere, 31.1% with Water Efficiency, 29.9% with Indoor Environmental Quality, 24.8% with Sustainable Sites, 20.1% with Innovative Design, and just 8.7% with Materials and Resources.

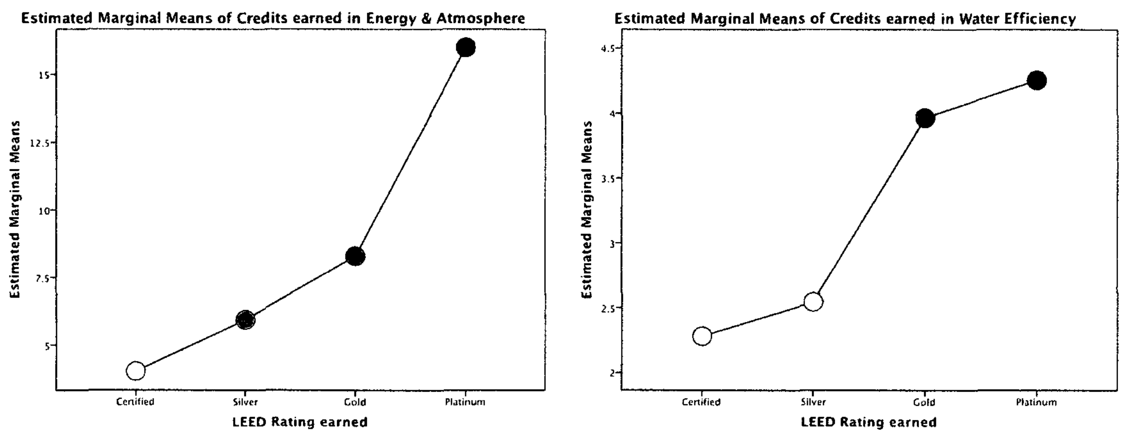
These values appear to differ from the Multiple Regression. This is because the MANOVA considered each category as a *stand-alone* component of rating while the Multiple Regression accounted for patterns *shared* among the categories. Results of the post hoc tests are explained below, with the categories presented according to their relative order of influence on rating.

***Energy and Atmosphere (EA).*** The MANOVA further confirmed what had been found using Multiple Regression – that Energy and Atmosphere was indeed the most significant determinate of overall rating. MANOVA showed that 46.9% of variance in rating was shared with the applicants' scores in EA. The USGBC offers 17 points in this category. In all, the sample earned 6.14 credits on average – just 36.1% of the EA points available. There was tremendous variation in the number of points the various groups earned. In fact, each of the four rating groups (Certified, Silver, Gold, and Platinum) used EA in ways were significantly different than every other rating group (see Figure 11).

In this sample, the 65 Certified buildings averaged just 4.03 credits in EA. The 61 Silver buildings earned 5.93. The 51 Gold buildings earned 8.29. The four Platinum buildings in the sample earned an average of 16 points or 94.1% of all Energy credits offered. Point totals and relative proportions for each category will be illustrated in Chapter 5 (Figures 22 and 23, p. 164).

Gold-rated buildings were found to average more than twice as many EA credits as the Certified buildings. Because each rating group was statistically different from the others, each was coded with its own unique color in the means plot in Figure 11 (left). EA was the only category where each and every one of the four rating groups differed significantly. Because assumptions of equal groups and equal variances were not met in EA, Games-Howell was used to control for multiple comparisons. It was also necessary to assess how the Platinum earners used this category. In accruing totals of 15, 16, 16, and 17 points in EA, they were consistent in their use of this category. This degree of stability provides support for the results reported.

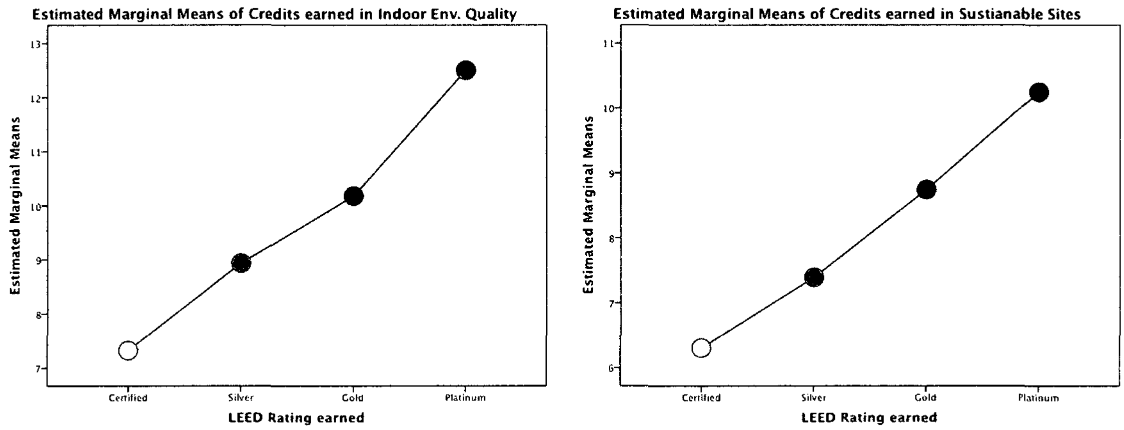
Figure 11: *Means plots for Energy and Atmosphere (left) and Water Efficiency (right).*




***Water Efficiency (WE).*** Overall, the sample earned an average of 2.88 credits (57.7%) of the 5 available Water Efficiency points. This category shared 31.1% of its overall variance with rating. Two distinct ways of using Water Efficiency emerged, and thus two colors appear in the means plot to the right in Figure 11.

Certified and Silver earners acted similarly and can be considered a single group with regard to how they used WE credits. They differed significantly from the way Gold and Platinum earners used WE. Certified earners accrued an average of 2.28 credits in WE; Silver accumulated 2.54 points. In the second group, Gold achieved 3.86 credits and Platinum earned 4.25.

Figure 12: *Means plots for Indoor Env. Quality (left) and Sustainable Sites (right).*




***Indoor Environmental Quality (IEQ).*** The USGBC provides up to 15 credits in IEQ, and the sample averaged 8.78 in this category. This represents 58.6% of the available total – a high level of use relative to most other categories. As noted earlier, this category provided the highest number of points to the sample group's total raw score.

In this sample, IEQ shared 29.9% of its variance with rating. In other words, increases in IEQ were not as directly linked with increases in rating as the increases in EA and WE were. Chapter Five will illustrate that Certified earners relied more heavily on IEQ than higher-level earners. A larger proportion of their points came from IEQ.

Assumptions of equal variances were not met in IEQ. Moreover, the four Platinum earners were quite inconsistent in their use of IEQ (accruing 10, 11, 14, and 15 points in this category). Games-Howell tests indicated that Platinum earners did not behave differently than other rating groups. Some acted like Gold earners but others earned IEQ points like lower level earners. On the other hand, there were significant differences in the way (a) Certified, (b) Silver, and (c) Gold earners accrued IEQ credits (see Figure 12). Buildings that earned basic Certification accrued an average of 7.32 points in IEQ; Silver earned 8.93; Gold amassed 10.18 IEQ points; and Platinum averaged 12.5 although the individual scores varied widely.

***Sustainable Sites (SS).*** The USGBC offers up to 14 credits in the category of Sustainable Sites (SS). Games-Howell tests identified three distinct groups: (a) Certified, (b) Silver, and (c) Gold and Platinum together. The sample earned an average of 7.45 SS credits, 53.2% of the points available in Sustainable Sites. Although assumptions of equal variances were not met in SS, the four Platinum earners were fairly consistent in their use of this category (accruing 9, 10, 11, and 11 points).

All told, 24.8% of the variance in LEED rating was shared with Sustainable Sites. Certified buildings averaged 6.31 points in Sustainable Sites. Silver buildings earned 7.39 SS credits. Gold earned 8.75 and Platinum earned 10.25. The means plot in Figure 12 indicates that the relationship between rating and SS was quite linear, which was also the case for IEQ. None of the other categories had such linear relationships.

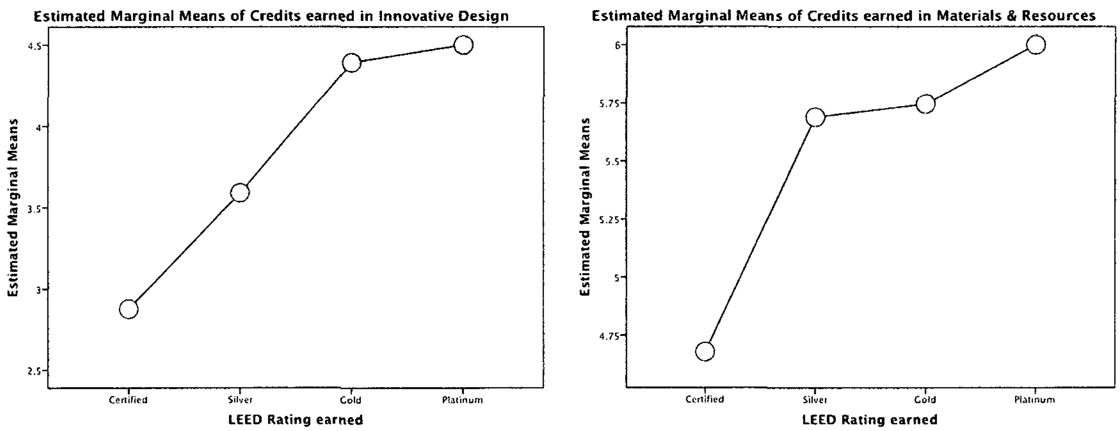
Despite the fact that Gold and Platinum earners had different raw scores in SS, these differences did not make statistically significant differences in the final ratings. In other words, the differences did not have a great deal of influence over whether the applicant earned Gold or Platinum.

***Innovative Design (ID).*** This category accounted for 20.1% of the variance in rating, though it provides the possibility of just 5 credits. The sample group earned 3.58

points in this category, which represents 71.6% of all Innovative Design points available. This represents a relatively high level of achievement in a single category.

There were only two significantly different groups with regard to ID. Figure 13 illustrates that the number of ID credits earned by Platinum and Gold buildings did not differ significantly. In this category, Silver earners were split. Some used ID like the Gold and Platinum earners, while others used ID in the manner of Certified earners. The assumption of equal variances was met in ID. However, a ceiling effect appeared due to a significant number of cases earning all five ID points. In the sample, Certified buildings earned 2.88 ID credits. Silver buildings earned 3.59. Gold earned 4.39 and Platinum earned 4.5 credits.

Figure 13: *Means plots for Innovative Design (left) and Materials and Resources (right).*




***Materials and Resources (MR).*** This category had the least influence over rating. Just 8.7% of its variance shared with rating. Although the category had an influence on getting rated, the four rating groups were not found to differ significantly in the number of MR credits they earned. Of the 13 MR credits available, all four used MR at similar levels. On the whole, members of this sample garnered an average of 5.35 credits in MR, which is just 41.1% of what this category offers. This was the lowest level of use of any category. Certified buildings earned 4.68 MR credits. Silver earned 5.69. Gold earned 5.75. Platinum averaged 6 credits. Because even the highest rating earners only accrued 6 of the 13 MR credits available, it is clear that most applicants are walking away with fewer than half of the credits they could earn in this category.

**Question 2c.** The final question of Step 2 followed a procedure similar to the previous question. It investigated relationships between *institutional characteristics* and *use of categories*. The intention was to see if the categories an applicant used to earn LEED credit corresponded in any way to its institutional characteristics. Individual ANOVA tests were used to investigate the categorical variables of region and control. Individual stepwise Multiple Regressions were conducted for continuous variables of enrollment, endowment, and type of institution (which had been arranged hierarchically in order to simulate continuous data). As discussed earlier, the linear regression model provided a weak fit with these non-normal distributions. The linear model was, nonetheless, able to detect some significant relationships.

***Region.*** A One-Way ANOVA initially reflected a relationship between regional groups and the number of credits earned in Sustainable Sites. However, the Tukey HSD post-hoc test did not find significant differences between any two regions in SS or any other category.

***Control.*** A second One-Way ANOVA explored possible relationships between control and use of categories. It yielded no significant results.

***Enrollment.*** Some statistically significant relationships were found with regard to enrollment, but they were weak. A One-Way Between Subjects ANOVA indicated that a significant regression model had been achieved: $F$ (2, 180) = 7.115, MSE = 9.349E8,

$p<.01$. Tests for collinearity and outliers did not raise concern. The strongest predictor of enrollment was the number of credits earned in *Sustainable Sites* (SS), which predicted 4.1% of the variation in enrollment. Together, SS and *Indoor Environmental Quality* explained 7.4% of the variance in enrollment. These relationships were statistically significant but, even together, they had a weak relationship with enrollment (R=.272) and the pattern of relationship (between size and points in SS and IEQ) was not easy to interpret.

***Endowment.*** A Multiple Regression using a log function of endowment as the dependent variable yielded a viable model: $F\,(1, 180) = 7.393$, MSE of the log of endowment = 8.958, $p<.01$. The log function was used to overcome some of the limits imposed by the non-normal distribution. This is a common procedure where dollar amounts are involved. Here again, the overall prediction capacity of this model was weak (R=.277). The number of credits earned in *Sustainable Sites* was the strongest predictor, accounting for 4.8% of the variation in endowment per student. Together, SS and *Water Efficiency* explained 7.7% of the variance, but again the pattern was unclear.

***Type of institution.*** Using Multiple Regression to identify predictors of type of institution yielded similar results. The One-Way Between Subjects Analysis indicated a significant model: $F\,(2, 180) = 7.463$, MSE = 6.995, $p<.01$. Checks for independence of errors, effects of outliers, and multi-collinearity were similar to those described for enrollment and endowment. The regression indicated that the strongest predictor of institutional type was, once again, the number of credits earned in *Sustainable Sites*. This factor predicted 4.7% of the variation in type of institution. Adding *Energy and*

*Atmosphere* accounted for 7.7% of the variation in type of institution. Again, these relationships were significant but weak (R=.278).

A follow up MANOVA was used to locate differences (see Appendix G for illustration and SPSS output). The Tukey HSD, a fairly conservative measure, determined that the differences in SS could be due to chance. On the other hand, it also indicated that the 13 Associates colleges actually earned the highest mean number of points (7.85) in Energy and Atmosphere. Bachelors and Doctoral institutions behaved alike (with 6.8 and 5.93 EA points on average). Masters institutions averaged just 5.28 points in EA.

**Step 3**

The third step assessed how institutions use LEED to foster innovation.

**Question 3a.** The first question in Step 3 employed descriptive statistics to assess the degree to which postsecondary institutions have used Innovative Design (ID) credits. The sample group earned a grand total of 648 credits in innovation. This represented 10.5% of all the credits they earned. The USGBC offers each applicant up to 5 credits in ID. The mean number of credits each applicant in this sample earned was 3.58, or 71.6% of what is possible. Applicants earned a higher portion of the credits available in this category than in any other category. The ceiling for this category is 5 points, and many Gold, Platinum, and even Silver earners reached this ceiling.

**Question 3b.** This question was answered fully by the Multivariate Analysis of Variance generated previously. The results described in Question 2b are reiterated in the paragraph below. They are illustrated in the means plot provided in Figure 13, p. 145.

The ID category offers just 5 of the 69 LEED credits. It represents 7.25% of the total points achievable. However, this small category independently accounted for 20.1%

of the overall variance in ratings earned. An ANOVA revealed that the number of credits earned in ID significantly influenced whether an institution's building earned: (a) Certification, (b) Silver, or (c) one of the two highest ratings. Certified buildings earned 57.5% of available ID credits. Silver earned 71.8%; Gold averaged 87.8%, and similarly, Platinum accrued 90%.

**Question 3c.** This question used a series of One-Way ANOVA tests to study relationships between institutional characteristics and use of ID credits. However, no significant relationships were found.

**Step 4**

The final step explored issues of generalizability. It investigated how well this sample represented the larger population of universities that have used LEED. The results are described and illustrated below.

**Question 4a.** The first question of this set used Chi-Square and ANOVA to explore patterns of LEED use over time. MANOVA was used where variables fell into discrete sets (institutional characteristics and credit categories). It was used to study patterns within each discrete set of issues.

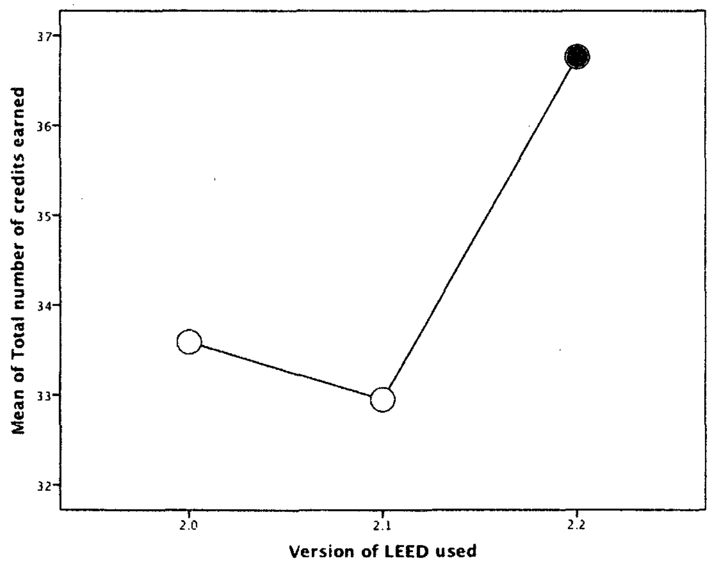
For this question, three sub-groups were created based on the specific version of LEED each applicant used (v2.0, v2.1, or v2.2). These three groups were compared based on rating (using Chi-Square Analysis), total points earned (using ANOVA), and institutional characteristics and scores in each LEED category (using MANOVA).

Kibert (2005) explains that LEED v1 was initiated in 1998, v2.0 in 2000, v2.1 in 2002, v2.2 in 2006, and v3.0 in 2009. This means that v2.0 was the primary program for a period of two years; v2.1 was primary for four years; v2.2 was primary for three years.

An applicant generally registers a project during its design phase but must wait until the end of construction to earn certification. Each applicant is required to register using the most current version. If a newer version has been inaugurated by the time the applicant has completed construction, the applicant may choose to use either the new version or the one under which the project was initially registered. Because these versions occurred chronologically, grouping users by version can help track changes that have occurred.

***LEED ratings.*** Pearson Chi-Square analysis, $\chi^2$ (6, N=181) = 13.095, $p<.05$, indicated significantly different ratings were earned with regard to version of LEED employed. LEED users in the sample had markedly higher success in earning Gold ratings using v2.2. In the given sample, the odds of earning Silver and Platinum also rose under v2.2. The means plot for rating earned is nearly identical to the means plot for total credits earned (see Figure 14). These results will be interpreted in Chapter Five.

Figure 14: *Means plot for total credits earned in the sample, by version.*

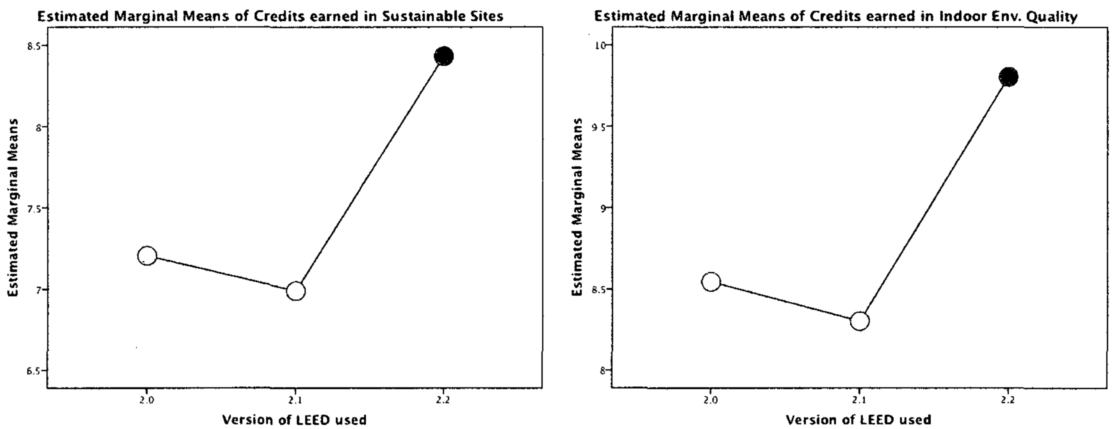



***Total LEED points.*** A One-Way ANOVA facilitated rejection of the null hypothesis: $F$ (2, 180) = 6.042, MS = 242.678, $p<.01$. The test indicated that differences in the total number of LEED points earned within each version were not due to chance in this sample. Institutions that used v2.2 earned significantly higher point totals than those that used prior versions. Users of v2.2 averaged 36.76 credits, while users of v2.0 averaged 33.59 points and v2.1 averaged 32.95 credits (see Figure 14).

***Institutional characteristics.*** The MANOVA for institutional characteristics did not yield a significant model. There were no detectable differences in the types of institutions using the three different versions of LEED.

***LEED categories.*** The final MANOVA assessed the number of points the sample group earned by category within each version of LEED. In this case, the assumption of equal variances was met: Box's M=30.030, $F$ (42, 58475)=.857, $p$=.730.

Figure 15: *Means plots for SS (left) and IEQ (right) for v2.0, 2.1, and 2.2 respectively.*

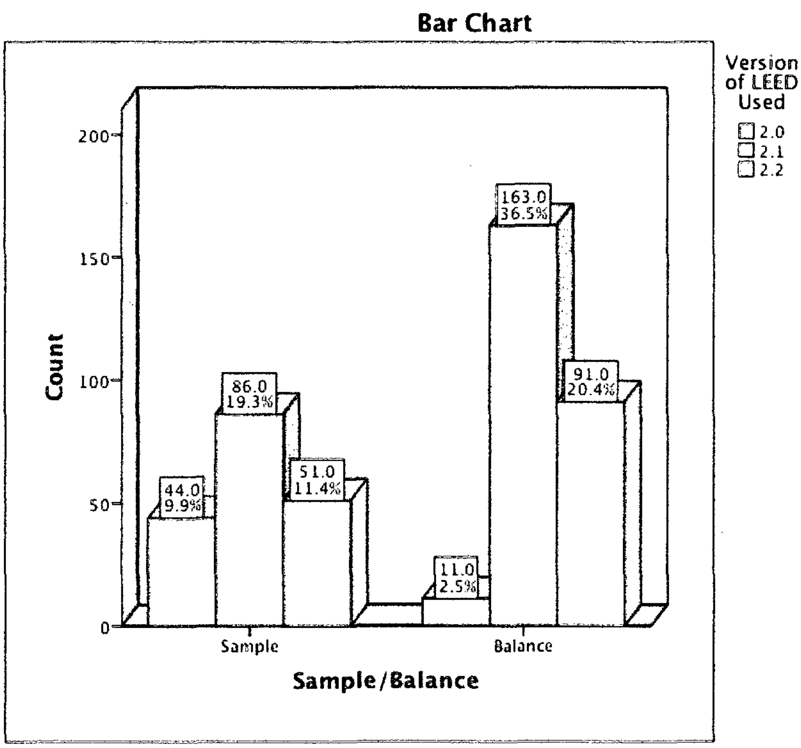



A Pillai's Trace test confirmed significance of the MANOVA model: $F$ (12, 348) = 2.459, value = .156, $p$<.01. Subsequent Levene's tests indicated that error within each of the six groups was equally distributed (see Appendix H for statistical output). Post hoc ANOVAs using Tukey HSD revealed significant differences by version within the categories of *Sustainable Sites* and *Indoor Environmental Quality*. The ANOVA for SS was significant: df=2, $F = 8.400$, MS = 35.047, $p<.01$. The ANOVA for IEQ was also significant: df=2, $F = 7.409$, MS = 37.754, $p<.01$.

Post hoc tests indicated that v2.2 users earned significantly higher averages in both *Sustainable Sites* and *Indoor Environmental Quality* than users of the prior versions (see Figure 15). Applicants averaged 8.43 credits in SS under v2.2 (exceeding the 7.2 and 6.99 they earned under v2.0 and 2.1). In the category of IEQ, v2.2 users averaged 9.8 credits (users of v2.0 earned 8.55 and of v2.1 averaged 8.3 credits).

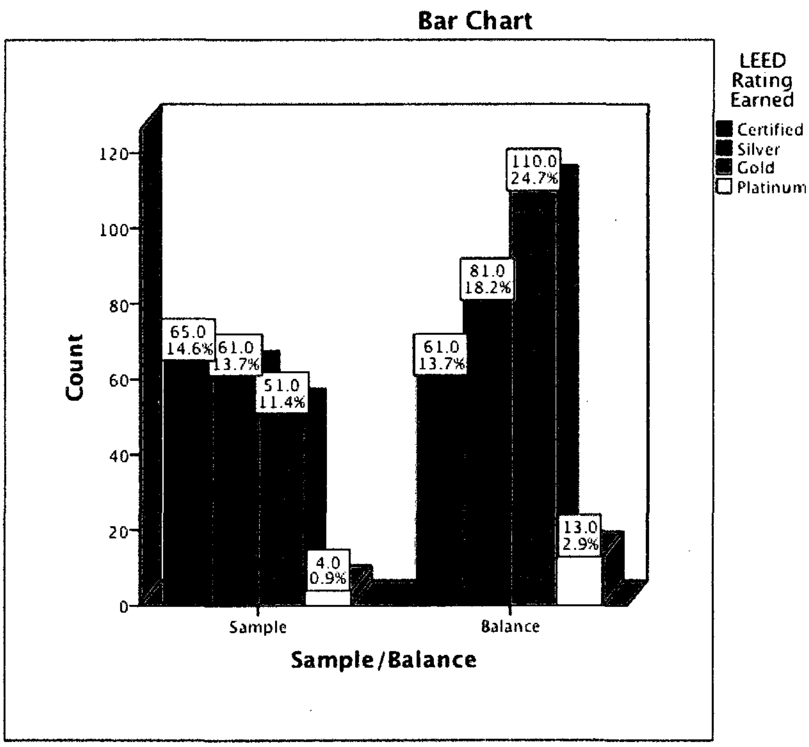
**Question 4b.** This question used Independent Samples *t*-Tests and Chi-Square analysis to study the degree to which the *sample* matched the *balance of the population*. It assessed equivalence with regard to: version used, LEED rating, total LEED credits earned, and specific institutional characteristics. The intent of posing this question was to help identify how LEED use had changed over time.

Figure 16: *Version of LEED used by sample and balance of population.*



***Version of LEED.*** Pearson Chi-Square analysis, $\chi^2$ (2, N=446) = 40.495, $p$<.01, indicated differences between the sample and balance of the population with regard to the version of LEED used. As illustrated in Figure 16, the sample used the earliest version (LEED v2.0) at a higher rate than the rest of the population. This supports the initial assumption of chronology; it indicates that the sample does, in fact, reflect early applicants. Due to policies that now require use of newer versions, the trend away from v2.0 will undoubtedly continue. Future use of LEED will shift from the way applicants used LEED v2.0 toward the way they have been using v2.1 and v2.2. Changes introduced in v3 will change these patterns even further.

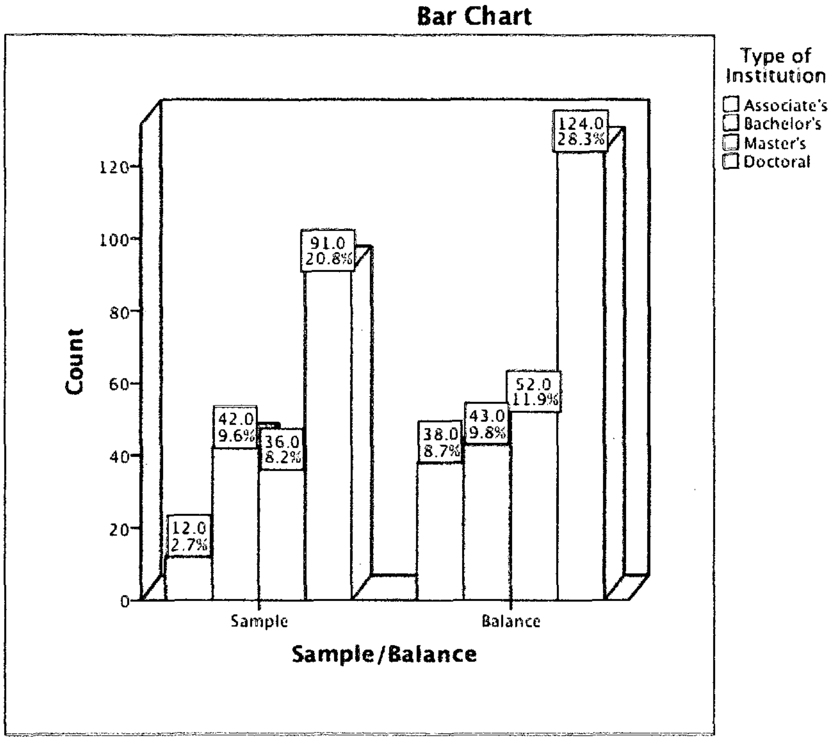
Figure 17: *Ratings earned by the sample and the balance of the population.*




***LEED ratings.*** Pearson Chi-Square analysis, $\chi^2$ (3, N=446) = 14.006, $p$<.01, indicated that the sample differed from the balance with regard to rating earned. The balance had higher proportions of Gold and Platinum earners than the sample. Over time, the proportion of universities reaching Gold and Platinum has increased. This will be discussed more in Question 4c, and in Chapter Five, because it affects generalizability.

***Total LEED points.*** An Independent Samples *t*-Test (df=444; *t*=-3.850, *p*<.01) indicated that the sample and balance groups also varied significantly on total number of LEED points. The sample averaged 34.18 while the balance averaged 36.8.

Figure 18: *Type of institution by the sample and the balance of the population.*




***Institutional characteristics.*** Independent Samples *t*-Tests were used to study enrollment and endowment. With regard to enrollment, the sample and the balance of the population were quite similar. Significant differences were found, however, with regard to enrollment. Using the log function of endowment, the sample was found to have a higher average endowment than the balance of the population (df=410; *t*=-2.672, p<.01). The sample's average endowment was $190,000 per student while the balance of the population averaged $146,000 per student.

To investigate categorical variables, Chi-Square tests were used. The sample and the balance of the population were not found to differ significantly regarding region or control. However Pearson's Chi-Square, $\chi^2$ (3, N=437) = 8.230, $p<.05$ indicated significant difference in type of institution (see Figure 18). The balance of the population reflected a higher proportion of Associates colleges than the sample. The proportion of Masters and Doctoral institutions using LEED remained fairly constant.

**Question 4c.** The intent of this question was to further explore the differences found in Question 4b in order to carefully determine how the sample differed from the population. The Cross-tabulations generated in the Chi-Square analyses above were used to compare the sample, balance, and population groups. One-Way ANOVAs were used to describe the population's use of the LEED system.

Together, the sample and the balance of the population comprised the total population (40.6% + 59.4% = 100%). Prior analyses had identified significant differences between sample and the balance of the population in the areas of: (a) type of institution, (b) LEED ratings, (c) total LEED points, and (d) version used. It was reasoned that any significant difference between the sample and the population could *only* occur in areas where there was a significant difference between the sample and the balance. Question 4c focused on these specific areas.

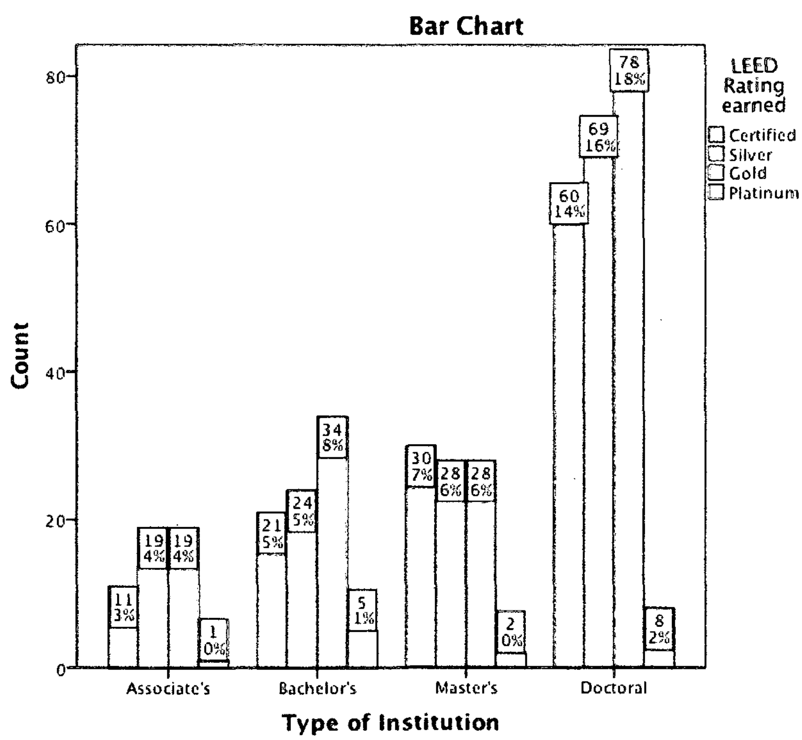
***Type of institution.*** The previous question indicated that the sample and balance of the population differed with regard to institutional type. The sample and the population also differ (see Table 10). The population had a higher proportion of Associates colleges and a lower proportion of Bachelors colleges.

Doctoral institutions own 49% all buildings certified through LEED-NC v2 prior to December 9, 2009. Although Doctoral institutions continue to dominate, the rest of the group of institutions using LEED has become more homogenous over time. Associates, Bachelors, and Masters institutions are using the system in more equal proportions.

Table 10: *Comparison by institutional type.*

| | | Type of Institution | | | | |
|---|---|---|---|---|---|---|
| | | **Assoc.** | **Bachelor** | **Master** | **Doctoral** | **Population** |
| Sample | Count | 12 | 42 | 36 | 91 | 181 |
| | Expected Count | 20.7 | 35.1 | 36.4 | 88.8 | 181 |
| | % of Total | 2.7% | 9.6% | 8.2% | 20.8% | 41.3% |
| Balance | Count | 38 | 43 | 52 | 124 | 257 |
| | Expected Count | 29.3 | 49.9 | 51.6 | 126.2 | 257 |
| | % of Total | 8.7% | 9.8% | 11.9% | 28.3% | 58.7% |
| Population | Count | 50 | 85 | 88 | 215 | 438 |
| | % of Total | 11.4% | 19.4% | 20.1% | 49.1% | 100.0% |

Figure 19: *Populations' ratings with regard to type of institution.*



***LEED ratings.*** Although analysis of the *sample* showed that LEED rating was related to type of institution, such was not the case for the population. A One-Way ANOVA did not find significant relationships between rating and institution type when all 446 cases were considered at the $p$=.05 level (see Figure 19). Patterns with each institutional group were roughly equivalent to every other group, although Bachelors and Doctoral institutions together garnered 13 of the 17 Platinum ratings.

It is important to note that the population had a much higher number of Platinum earners than the sample. Platinum earnings have escalated over time (see Table 11). In light of the results discussed previously – those indicating changes in the way LEED has been used over time – it appears likely that the four Platinum cases in the sample could differ markedly from the newer Platinum earners.

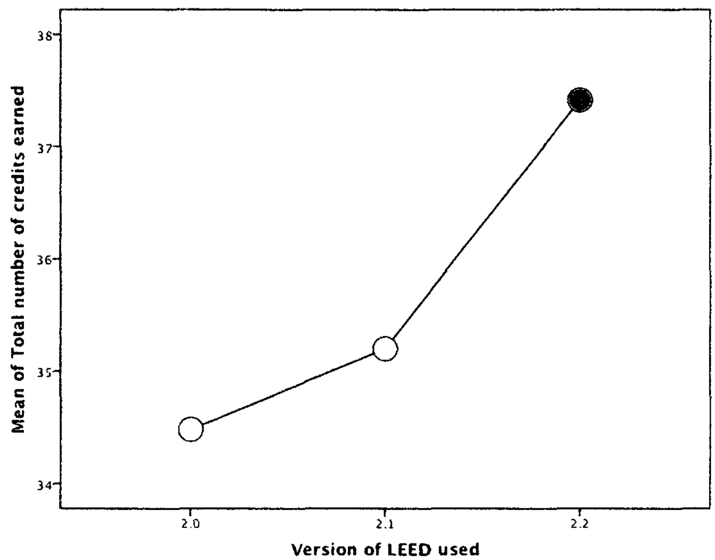
Table 11: *Comparison by rating earned.*

| | | **LEED Rating earned** | | | | |
|---|---|---|---|---|---|---|
| | | **Certified** | **Silver** | **Gold** | **Platinum** | Population |
| Sample | Count | 65 | 61 | 51 | 4 | 181 |
| | Expected Count | 51.1 | 57.6 | 65.3 | 6.9 | 181 |
| | % of Total | 14.6% | 13.7% | 11.4% | .9% | 40.6% |
| Balance | Count | 61 | 81 | 110 | 13 | 265 |
| | Expected Count | 74.9 | 84.4 | 95.7 | 10.1 | 265 |
| | % of Total | 13.7% | 18.2% | 24.7% | 2.9% | 59.4% |
| Population | Count | 126 | 142 | 161 | 17 | 446 |
| | % of Total | 28.3% | 31.8% | 36.1% | 3.8% | 100.0% |

***Total LEED points.*** Over time, institutions have earned increasing numbers of total credits through LEED. The population earned 1.64 points more, on average, than the sample. While the population averaged 35.82 points, the sample garnered just 34.18 credits. This reflects an increase of 2.4% of the total available credits and suggests that institutions are getting better at earning credits.

The population of v2.2 earned significantly higher points than users of prior systems. The ANOVA for differences was significant: $F\,(2, 444) = 5.814$, MS = 276.845, $p<.01$ (see Figure 20 for illustration and Appendix H for SPSS output). The users of v2.1 earned more points on average than users of v2.1 in the sample had earned. The population averaged 35.2 points using v2.1, while the sample averaged 32.95 credits. This was higher than in the under v2.1.

Figure 20: *Means plot for total credits earned in the population, by version.*




***LEED version.*** An ANOVA using Tukey HSD indicated that the population earned certification using v2.2 with more frequency than using v2.0 or v2.1. The differences were statistically significant: df=445, $F$=5.526, MS=4.190, $p<.01$ (see Appendix H for statistical results). Use of v2.0 is tapering off (see Table 12). The sample used v2.0 much more frequently than the population. In fact, the sample represents 44 of the 55 cases in the population that used v2.0. Only 11 of the more recent users applied under v2.0. This means that the results of this study reflect the way early applicants used LEED more than the way recent users have used the system.

Table 12: *Comparison by version of LEED used.*

| | | **Version of LEED used** | | | Population |
|---|---|---|---|---|---|
| | | **2.0** | **2.1** | **2.2** | |
| Sample | Count | 44 | 86 | 51 | 181 |
| | Expected Count | 22.3 | 101.1 | 57.6 | 181 |
| | % of Total | 9.9% | 19.3% | 11.4% | 40.6% |
| Balance | Count | 11 | 163 | 91 | 265 |
| | Expected Count | 32.7 | 147.9 | 84.4 | 265 |
| | % of Total | 2.5% | 36.5% | 20.4% | 59.4% |
| Population | Count | 55 | 249 | 142 | 446 |
| | % of Total | 12.3% | 55.8% | 31.8% | 100.0% |

**Conclusion**

The sample for this study represented a disproportionately high number of v2.0 users. Because the sample employed v2.0 at higher rates than the overall population, the results of this study are skewed toward the way early applicants used the program. Not all analyses generated from this sample reflect the way the population has used LEED.

The most significant findings of this study are not in how the sample group obtained certification, but in how the sample group differs from newer LEED users. Clear changes are evident over time. Results indicate applicants have been able to earn higher ratings over time and evolution has occurred with regard to meeting higher LEED measures. Evolution is likely to continue as the USGBC calibrates its instruments and as applicants learn even more about green technologies and the intricacies of the LEED system. These issues are explored further in Chapter Five.

## Chapter 5: Findings and Conclusions

Findings from this descriptive, exploratory study provide insight into the way LEED has been operating, who has been using it, and how they are likely to use LEED in the future. They address the overarching question: *To what degree have institutions of higher education used LEED® to earn certification, provide leadership, and foster innovation in environmental sustainability?* At the time of analysis, 446 institutions had earned certification through LEED-NC v2. The 181 postsecondary buildings in the sample earned relatively even proportions of basic Certification (65), Silver (61), and Gold (51) ratings. Only a handful garnered Platinum (4). Although the sample group averaged 34.18 credits and most frequently earned basic ratings, point totals as well as Gold and Platinum awards have risen among subsequent applicants.

Figure 21: *Sampled institutions' predictors for LEED rating.*

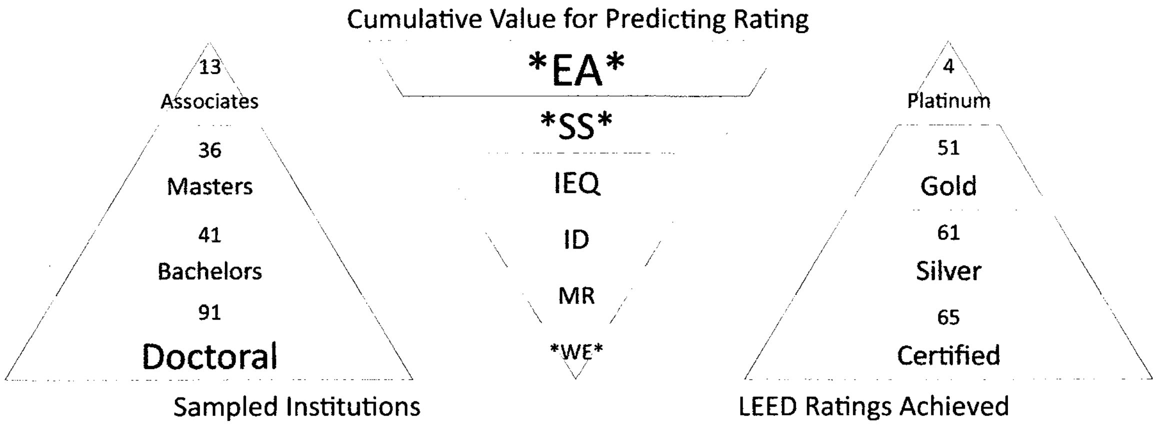



Diagram reflects sample. Red indicates areas that subsequently expanded under LEED v2.
Asterisks indicate areas of probable growth under LEED v3.

Several major findings of this study are depicted in Figure 21. Each triangle represents a step in the LEED certification process for the sample group. The first triangle indicates that many more Doctoral institutions used the system than other types of institutions. The second triangle shows that Energy and Atmosphere credits had the most influence over rating. Predictors are illustrated in descending order. Triangle three indicates that for the sample, high ratings were less frequently attainable than Certification and Silver. Trend studies indicate that the upper tiers in each step have been growing in recent years.

The sample depicted in Figure 21 over-represents early LEED users (those who applied under v2.0). The tiers shown in red in Figure 21 were found to have expanded most among subsequent users. Because there has been a four-fold increase in Platinum awards since the sample earned its ratings, and because EA is the number one predictor of Platinum, it is very likely that the EA tier has expanded as well. The results presented in Chapter Four show that users of v2.2 also excelled more in Sustainable Sites and Indoor Environmental Quality than those who applied under the two earlier versions of LEED.

LEED use has been growing among Associates colleges (the institution type which earned the most Energy and Atmosphere points according to sample data). Within the population, use of LEED recently declined among Bachelors institutions. Together, Bachelors and Doctoral institutions have earned most of the Platinum ratings). Overall, postsecondary institutions have secured higher numbers of Platinum and Gold certifications across time. Such trends are likely to continue for applicants using LEED v2 programs. Policy changes under LEED v3 will make high ratings more difficult to earn however.

Ratings are likely to drop in the early years of LEED v3. The USGBC (2009c) has raised point thresholds for each rating markedly and adjusted the weights of each category to better reflect its goals. Applicants in v3 are likely to use Energy and

Atmosphere, Sustainable Sites, and Water Efficiency at even higher rates than the sample did, because v3 offers a larger portion of its total credits in these particular categories. Previously popular categories that do not offer substantially more credits under LEED v3, such as IEQ and ID, can only expand so far. This will prompt applicants to shift focus toward weightier categories in order to accrue enough points. The most important findings described in this chapter are:

1) Energy and Atmosphere credits have had the greatest influence on rating.

2) Patterns such as the ones described above will affect future use of LEED and its categories.

3) Past changes reflect organizational learning and evolution.

4) Results of this study support the claim of organizational leadership.

5) LEED supports institutional goals within higher education.

6) LEED provides a tool for planning that has demonstrated its effectiveness by fostering higher levels of success over time.

This chapter explores such issues and proffers ideas for enhancing practice, extending research, and further refining policy.

**Primacy of Energy**

Findings of this study that are most likely to interest LEED users have to do with the critical relationship between Energy and overall LEED ratings. Several different analytical methods identified Energy and Atmosphere as the single biggest influence on the sample's ratings.

Figure 22: *Proportions of credits the sample earned in each category, based on rating.*

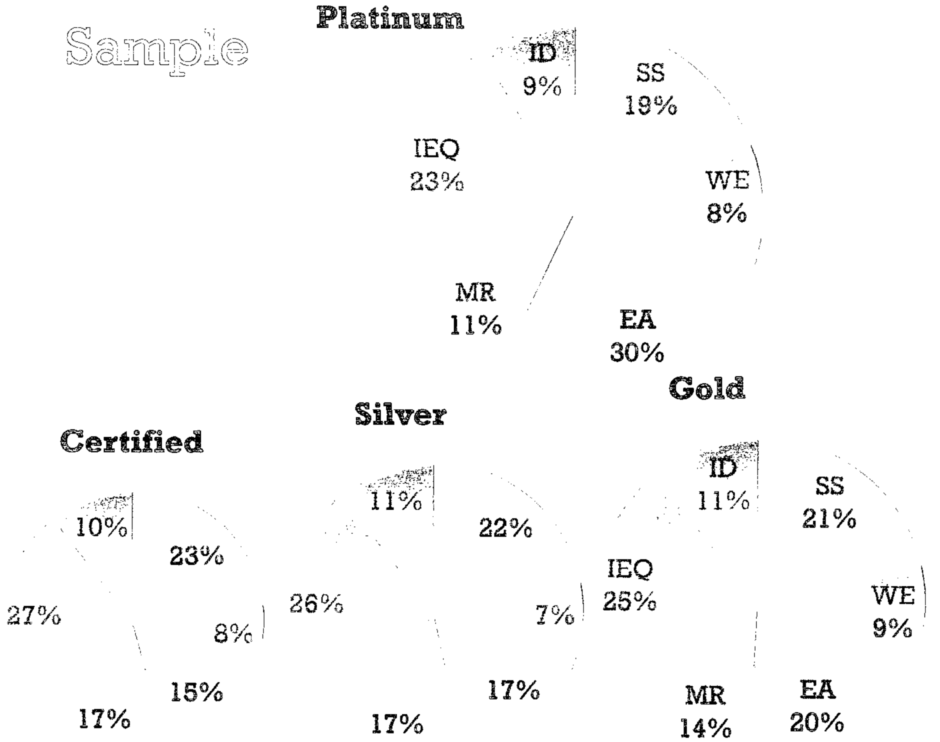



Figure 23: *Number of credits the sample earned in each category, by rating.*

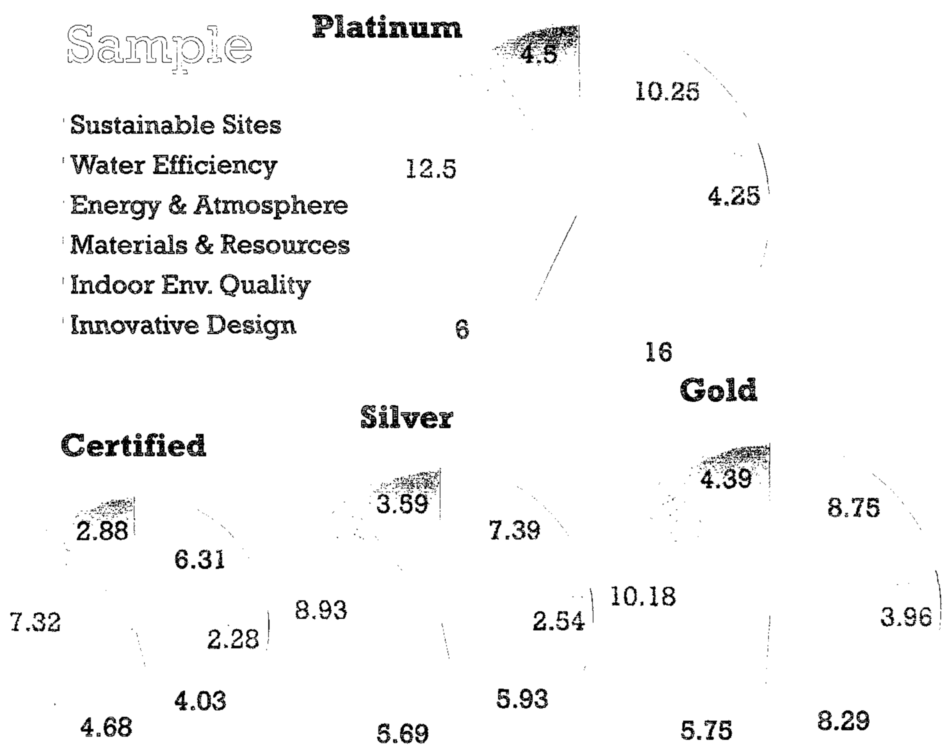


Figure 22 separates the sample into subsets (based on the four LEED ratings) to provide a visually weighted comparison. It shows that buildings with basic Certification relied most heavily on IEQ points. They earned 27% of their overall points in Indoor Environmental Quality which reflects an average of 7.32 IEQ credits (see Figure 23). As rating increased, however, so did the proportion of credits earned in Energy and Atmosphere (EA). This was not the case for IEQ, MR, or SS, where the share of overall point earnings decreased as rating increased. The portion earned in EA climbed from 15% among Certified earners, to 17% at the Silver level, and to 20% at Gold. Platinum buildings earned 30% of their credits in EA. The sample group as a whole used EA (as well as MR) at a lower rate than would be expected based on the number of points offered in these categories (see Table 6, p. 135). In other words, most applicants in the sample underutilized the Energy and Atmosphere category.

Platinum and Gold earners used five of the six categories in fairly similar ways. The number one factor propelling Platinum earners beyond Gold was their score in Energy and Atmosphere. It is clear that applicants who do not utilize EA points restrict their opportunities to earn high ratings. The effect will be even more dramatic under LEED v3.

Like EA, use of Sustainable Sites will undoubtedly grow under v3 as well. Regression analysis showed that past achievements in Energy and Atmpsphere did not tend to overlap those in Sustainable Sites. The two categories do not appear to share a great deal of variance with each other. As such, focusing on both of these categories simultaneously may help institutions secure high ratings.

Alternately, patterns in WE credit earnings were quite similar to EA within the given sample. This suggests that focusing on WE may not yield the advantages that focusing on SS does, even though both categories contribute significantly to rating. This is not soley due to the currently small size of WE, as will be explained later.

Analysis of the sample shows a high degree of variability in the use of both EA and SS. Since this variability did not overlap, it is clear that EA and SS each contributed to ratings in unique ways. Differences in Energy and Atmosphere were most dramatic because they were significant at each and every rating level. Certified buildings averaged 4.03 points in Energy and Atmosphere. Silver buildings earned almost one point higher (5.93 EA credits). At 8.29 EA credits, Gold earners exceeded Silver's average by well over two points. Yet, the four Platinum buildings excelled far beyond the others in the area of Energy. They earned an average 16 of the 17 possible EA points. With 35 EA credits available in LEED v3, variability in the use of EA is very likely to expand further. This could raise the category's predictive value even more. Competition from IEQ, ID, and MR will level off, although SS will remain a primary contender. With point offerings in WE expanded from five to ten, variability and predictive power of this category is also likely to rise under v3.

These trends suggest a myriad of possibilities for future research. It would be interesting to study correlations using EA scores as dependent variables. One might also be able to create prediction models for various ratings, or to achieve a similar type of understanding by conducting discriminant function analysis. Such analysis could seek to identify characteristics that differentiate groups of earners at each rating.

Within the sample, ratings were heavily dependent on energy, site, and indoor qualities. According to Malin (2009) "Maverick NYC mechanical systems designer Henry Gifford has long been a critic of LEED, arguing that it encourages the wrong things, and doesn't go far enough to ensure that certified buildings really save energy or provide good air quality" (¶ 1). Due to applicants' high use of the categories identified by Gifford and Malin, this study finds good reason for additional research on performance outcomes in both EA and IEQ. And with LEED v3's renewed focus on EA and SS, the USGBC has the obligation to ensure the best possible results in these areas as well. Experts need to make certain the measures used in these categories do as much good for the environment as possible.

The triangle at the center of Figure 21 illustrates the optimal order for loading scores in each category in order to predict rating it is based on data about early LEED v2 users. A visual comparison of pie charts for each rating (see Figures 22 and 23) with the order of predictors identified using regression (EA, SS, IEQ, ID, MR, and WE) proves interesting. It reveals that categories with the least variation from one rating to the next also offer the least predictive value.

The *number* of points available in each category limits the degree of influence each individual category can have on ratings. It is clear, however, the degree of *variance* in the sample's scores in each category has had much greater influence on rating than its size. In fact, when the Regression was controlled for size (i.e., when each category was given equal weight in the Regression), the loading sequence for predictions was identical.

To further illustrate, ID is a much smaller category than MR. Yet, the Multiple Regression and MANOVA conducted in Step 2 both indicated that Innovative Design exerted more force on rating than Materials and Resources did. ID shared 20.1% of its overall variance with rating while MR shared just 8.7%. As rating rose, so did the number of ID credits earned. Higher ratings also reflected slightly higher numbers of MR credits, but there was very little variation in the number of MR points from one rating group to the next. Of the 13 points available in Materials and Resources, institutions in this sample all clustered together in the number of MR credits earned. None of the rating groups earned a high percentage of the points offered in MR. Certified buildings averaged 4.68 MR points; Platinum buildings earned just a sliver more, averaging only 6 points in MR.

Innovative Design had much less potential to influence rating than Materials and Resources, because the ID category offers only five points while MR offers 13. In this sample however, ID was a bigger predictor of rating than MR because there was much more variation in its use. The ID category actually had remarkable influence on rating given its very small size.

And, although Water Efficiency (WE) and Innovative Design (ID) each offer five possible points, these two categories did not exert equal influence on the sample's ratings. Figures 23 and 24 indicate that every rating group earned a higher percent of its overall score using ID than WE. The "share of the pie" earned in WE changed more across the certification levels than the share earned in ID. This indicates there were bigger differences in the way the rating groups used WE than ID. The lower degree of variance in ID results, in part, from the fact that all but one member of the sample earned an ID credit for hiring a LEED Accredited Professional. This credit is considered a "freebie" among LEED users. The number of points earned in WE was highly correlated with rating, but this relationship was mirrored (and thus overshadowed) by the EA category.

Upon initial inspection, the results of the Multiple Regression and MANOVA appear to conflict, but upon closer analysis they actually make a great deal of sense. Comparing the results of these two different procedures helps identify and isolate effects. To better understand the difference between EA and WE (mentioned above), it is helpful to consider that Energy and Atmosphere independently accounted for 46.9% of the overall variance in rating. When measured independently using MANOVA, Water Efficiency accounted for a full 31.1%. A comparison with the results of the Regression Analysis reveals that Water shares much of it influence over ratings with Energy. Both categories vary in direct relation to rating, but Water Efficiency adds little new information to the prediction model because its patterns are so similar to Energy and Atmosphere.

As such, the Multiple Regression did not list Water Efficiency as a primary predictor because all categories were considered cumulatively by that procedure. WE is a small category and most of its variability overlaps more powerful categories. When the stepwise regression method was used, WE got muscled out of the way by categories that have bigger point allotments *and* greater variability in their use.

Another apparent anomaly is that Indoor Environmental Quality (IEQ) independently accounted for 29.9% of the overall variance in rating. Sustainable Sites (SS) independently accounted for 24.8%. However, SS was found to be the second most important predictor of rating when assessed as one component of the complete set of categories (using Multiple Regression). These results indicate that SS does not share as much of its variability with Energy and Atmosphere (as mentioned previously) but they also imply that IEQ shares more variability with EA than SS does. In other words, the Sustainable Sites category has more features that stand alone. Moreover, use of SS was more stable and predictable within the sample group than the use of IEQ.

Point totals in SS were found to relate to several institutional characteristics (including endowment, enrollment, and type). As such, it might be interesting to explore relationships among characteristics and ratings using Path Analysis.

**Implications for LEED Users**

The USGBC's stated intention was to develop a system that encouraged incremental improvement by offering incentives within reach of many applicants. The idea was to encourage participants to reach beyond contemporary building standards, and for USGBC to periodically raise the bar. Such change is evident with the release of LEED v3 (Cheatham, 2009a, 2009b; Stephens, 2008; USGBC, 2009d, 2009e). The new version has been tweaked based on observation and experience. USGBC (2009c) asserts that changes are also based on scientific research, although the research does not appear to be accessible to the general public.

Results of this particular study, however, do lend support to the USGBC's claims of continual upgrade. Patterns in the past use of LEED indicate evolution and provide insight for the future.

**Past trends in credit use.** The sample group represents early applicants. It had proportionally fewer Gold and Platinum awards than the population. Within both the sample (Figure 24) and population (Figure 25) postsecondary buildings have most

Figure 24: *Number of credits earned by sample.*

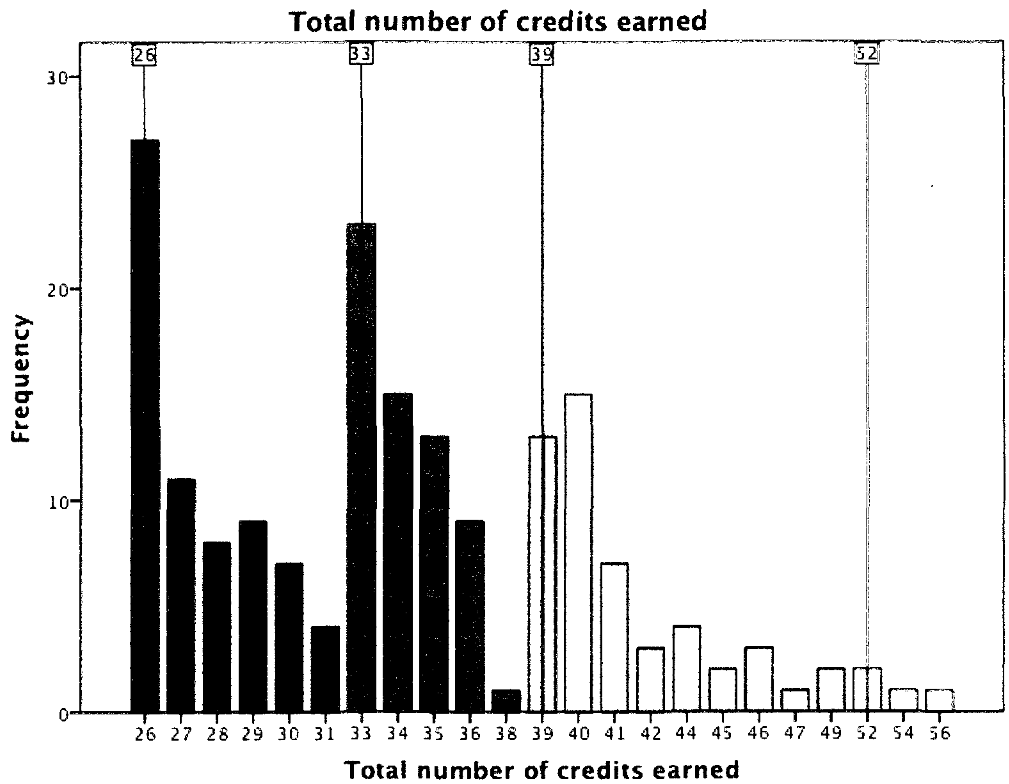
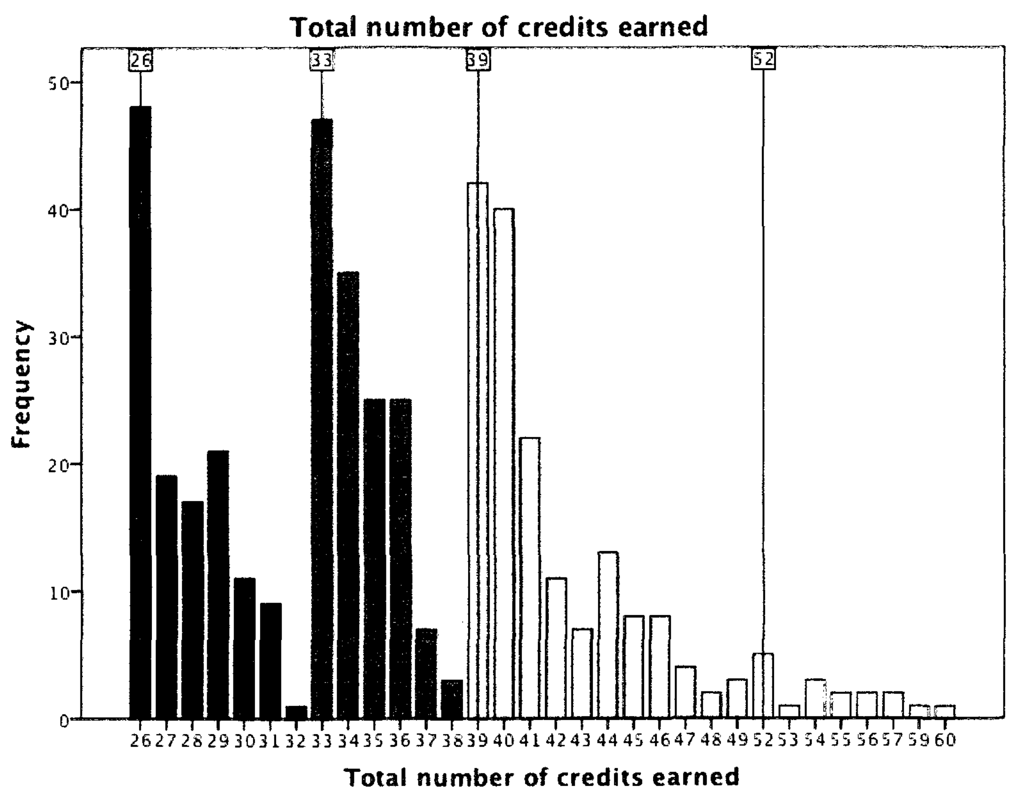



Figure 25: *Number of credits earned by population.*



frequently achieved point totals just over the threshold for the LEED rating they secured. In other words, there is a spike in frequency that falls precisely at each rating threshold. Figure 24 shows that the sample's credits spiked at basic Certification (at 26 points), Silver (33 points), and Gold (39 points).

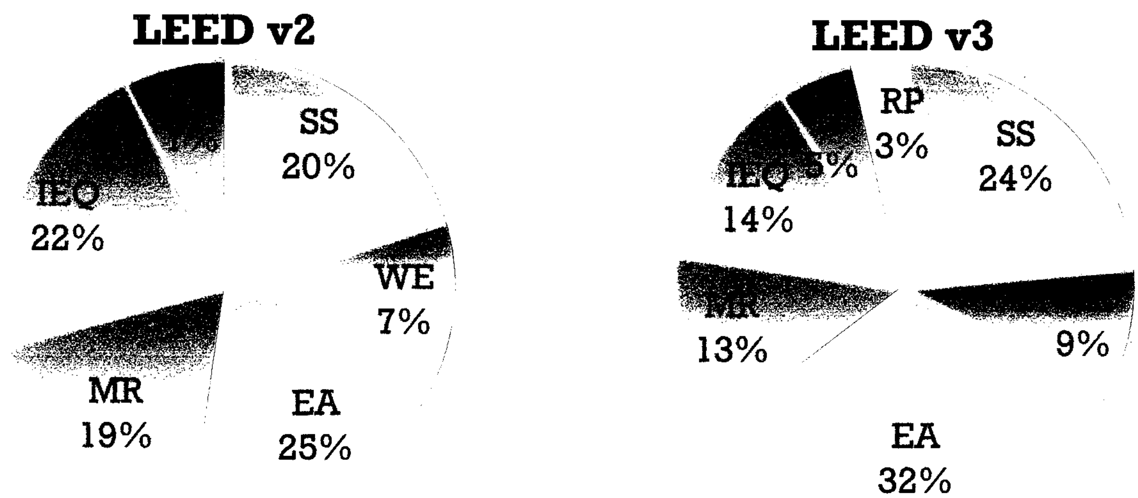
Figure 25 indicates this phenomenon has become even more pronounced over time. Within the overall population, spikes have become even more distinct at the levels of Gold (39 points) and Platinum (at 52 points). There has been a complete absence of earners at 50 and 51 points. Postsecondary applicants within two points of Platinum have all apparently managed to pull across the 52-point threshold.

This study looked at use of credits only by category. It might be interesting to investigate how applicants use each specific credit as well. Future research could investigate which credits applicants most often employ. It might also be interesting to conduct Confirmatory Factor Analysis (using the sample's credit tally data) to see if individual items fall into the same clear categories the USGBC uses. Factor Analysis could also be used to explore the synergies that the USGBC (2007) describes as occurring among credits in various categories. Individual credits in site design and water conservation are thought to correlate, for instance.

**Emerging changes.** The newest version of LEED, unveiled in the fall of 2009, reflects a number of meaningful policy changes. LEED v3 boasts a range of programs tailored to active user groups. The system is more rigorous; point thresholds are much higher and additional standards have been introduced. Using v3 will require greater commitment and this will, in turn, require more leadership from the people who organize and finance construction.

LEED v3 shifts its focus decisively toward Energy. Figure 26 shows the number of credits v2 offered in each category and compares them with v3. The pie charts facilitate visual comparison. Under v3, point offerings have greatly expanded in three different categories: Sustainable Sites, Water Efficiency, and Energy and Atmosphere. The overall proportion of available points (or share of the overall pie) is also larger for SS, WE, and EA. A new category is included. Regional Priority (RP) accounts for 3% of points available in LEED v3. Three categories (Materials and Resources, Indoor Enviromental  Quality, and Innovative Design) now have smaller overall shares, even though two of these categories have each gained a point.

Figure 26: *Comparison of v2 and v3 point offerings by category.*




| LEED-NC Categories | Credits in v2 (2.0-2.2) | Credits in v3 |
|---|---|---|
| SS Sustainable Sites | 14 | 26 |
| WE Water Efficiency | 5 | 10 |
| EA Energy and Atmosphere | 17 | 35 |
| **MR** Materials and Resources | 13 | 14 |
| **IEQ** Indoor Environmental Quality | 15 | 15 |
| **ID** Innovation & Design Process | 5 | 6 |
| **RP** Regional Priority | n/a | 4 |
| Total Points Available | 69 | 110 |

Compiled from: USGBC (2001, 2002, 2008b, 2009a)

Although Energy was a distinguishing feature among rating groups in the sample, earning energy credits was clearly not a focus for each and every applicant. It has, in fact, been possible to earn a LEED rating without accruing *any* EA points (beyond the mandatory pre-requisites). Four members of the sample did exactly that – three of them received basic Certification and one received Silver certification – despite earning zero points in EA. All told, 29% of the sample earned four or fewer of the 17 available Energy and Atmosphere credits.

A policy to address this problem was enacted three years ago. USGBC (2008b) now requires that projects (registered after June 26, 2007) earn a minimum of two points in Energy and Atmosphere. These points must be earned under credit EAc1, which involves optimizing energy performance (see Appendix A). New EA point offerings and higher rating thresholds indicate that applicant's avoidance of addressing Energy is likely to change. With the phase out of v2 programs, it will be increasingly difficult to achieve certification without investing in Energy.

New USGBC policies also promote higher levels of innovation. Although LEED v3 offers six ID points – one more than offered in v2 – this category's share of the overall point offerings has decreased from 7% to 5%. In seeking to encourage the generation of new knowledge under LEED v3, the USGBC has reserved two ID credits specifically for *new* innovations (see Appendix A). One ID credit is still reserved for hiring a LEED AP. However, the non-AP point offerings now have limits so that they cannot all be earned for exemplary performance (EP) as had been permitted in the past. Under v2 the non-AP credits were completely interchangable; they could each be earned for either Innovative

Design *or* Exmplary Performance. Now, two of the non-AP credits *require* innovation. The other three can be used for either IP or EP.

Thus, to earn all credits in the Innovation in Design category under LEED v3, an applicant will be required to make innovative contributions. USGBC (2009c) explains this was "an effort to encourage more innovation.... This step was taken in order to return to the original intent of the credit, to encourage projects to pursue innovation in green building" (p. 4).

Figure 26 shows that the USGBC has expanded categories of SS and EA most. With the introduction of LEED v3, the number of points available in Energy and Atmosphere has more than doubled. Sustainable Sites expanded by 186%. These changes promote greater focus on energy, carbon footprint, and issues related to the building's immediate site and its ties to the larger community.

All told, more points must be earned to achieve any rating using v3. It appears that earning any rating under v3 will require more of a stretch. This supports USGBC's stated intention the raise the bar over time.

Figure 27: *Portion of ratings earned in LEED v2.0, 2.1, and 2.2, by the population.*

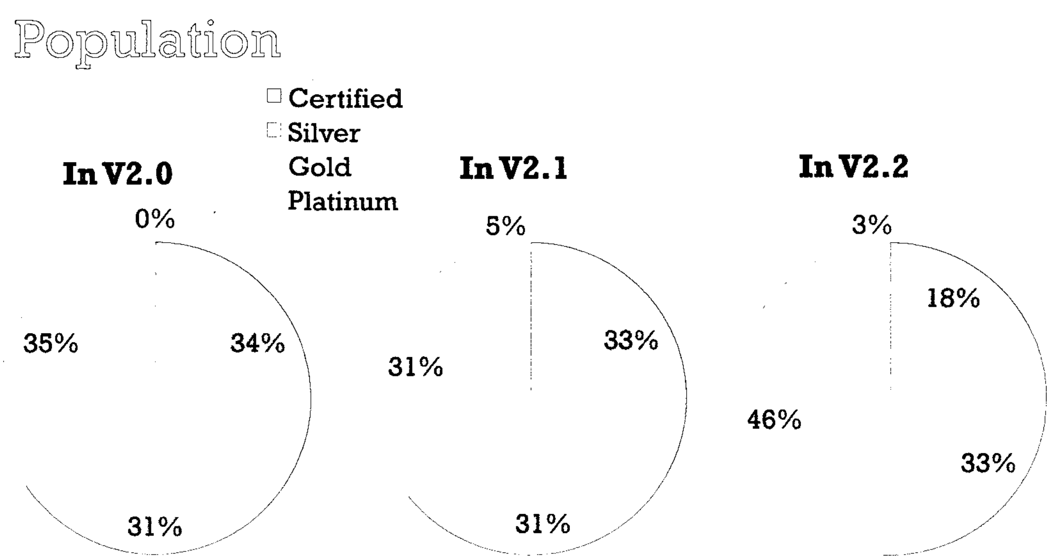


Figure 27 shows that across the past nine years, an increasing number of insitutions have been able to achieve Gold. Under v2.2, 46% earned Gold as compared with 31% under v2.1. These gains suggest that learning had occurred over time – that the system has been tweaked and LEED users now have the capacity to meet higher thresholds. The pattern of systematic improvement over time is likely to continue, despite the likelihood that ratings will initially drop as applicants begin using LEED v3 with its higher thresholds. The bar for reaching Gold has been raised from 39 to 60 points (see Table 4, p. 125). In the past, only 52 points were needed to obtain a rating of Platinum. This is well below the 80 points required for Platinum under v3.

Higher thresholds, combined with the expanded number of credits available in EA, SS, and WE, will change patterns of use signficantly. Appendix A provides a table of LEED v2 and v3 credit values and titles that reflects clear change over time. Because of changes incorporated into LEED v3, patterns of use under LEED v2 cannot be assumed to transfer directly to v3. It appears, for instance, that v3 users will have to reach further into EA, SS, and WE to earn ratings. They will not be able to rely on IEQ as heavily as postsecondary institutions have in the past.

**Organizational Leadership**

Within both the sample and the population, Platinum awards have been very rare. Earning Platinum requires high-level commitment, particularly within the category of Energy and Atmosphere. This supports USGBC's claim that LEED constitutes leadership in energy and environmental design. It also helps justify the USGBC's claims about "What LEED Measures" (see Table 1, p. 5). The organization asserts that *energy savings* and *carbon footprint* are primary measures of LEED. Both issues fall within the category of Energy and Atmosphere – the category that contributed the most predictive value toward the sample's various ratings.

Although it was not possible to measure leadership as a construct independent of rating, it does appear that leadership is a critical component of the LEED program. USGBC implies that the degree of leadership provided by an applicant is directly linked to the level of the certification the applicant earns. The USGBC associates market transformation with transformational leadership. The organization has not operationalized the construct of leadership in any way other than rating. The overarching assumption that certification reflects leadership is embedded in the program's name "Leadership in Energy and Environmental Design."

In any case, it is clear that universities are providing leadership in the LEED green building movement. Fedrizzi (2009) asserts that higher education accounts for 14% of all LEED users. The population of this particular study included 256 different postsecondary institutions in the United States. Hundreds more institutions are in the process of earning certification, and the number of postsecondary LEED buildings will undoubtedly soar. Of the 248 institutions in this study whose identities were known, 169 had obtained LEED certification for a single building at the time data were obtained. The other 79 institutions had earned multiple LEED certifications. Forty institutions in the population had two LEED-rated buildings as of December 7, 2009. Sixteen institutions had three, 8 had four, and 7 had five. One private university owned six LEED-certified buildings. Four public institutions had seven LEED buildings each and two private universities had 12 each. A public institution led the pack with sixteen LEED ratings.

The 248 institutions that own LEED-rated buildings enroll approximately 2.2 million students on a full-time basis each year. Imparting social and environmental values to these students is an important aspect of green building. The teaching aspect of postsecondary LEED buildings has been far under-utilized to date.

LEED participation highlights a university's environmental values to stakeholders in and outside the organization. The LEED Green Building Rating system also provides mechanisms to help participants expand society's knowledge base on green building. These include formal ways to develop and share innovative techniques. Helping shape the way the nation conceptualizes environmental issues and constructs buildings provides the type of leadership recommended by Kerr (1995), Levin (2003), and Rhodes (2001). Universities, they insist, are well suited to lead such efforts.

The USGBC asserts that its rating system is shifting the way the nation builds and that USGBC member organizations and LEED earners are the force behind this transformational movement (USGBC, 2009a). LEED rating is the USGBC's primary way of gauging and recognizing leadership. Higher LEED ratings imply higher levels of environmental leadership. The USGBC typically measures its own leadership success by the number ratings it confers.

Transformational change of this sort requires leadership at many scales. Leadership is needed at the level of the society, system, institution / organization, and individual person. The USGBC's claim that members and LEED participants are collectively leading market transformation refers to leadership at the system and society levels.

***System level.*** System level leadership is quite evident through LEED. There is no doubt that the United States Green Building Council is the nation's leader in promoting green construction (Gifford, n.d.; Malin, 2009). USGBC leads the country in creating incentives to go green and in expanding the nation's capacity with regard to green power, green technologies, and green industries. The USGBC is emerging as a world leader as well, with LEED-rated buildings in more than 103 countries (McEnery, 2009). The USGBC was not the first organization to offer such programs, but it is the most prominent today. McEnery indicates that the organization's current focus is "capacity development" (¶ 9) in North America, China, the Middle East, India, Brazil, and Italy.

***Institutional level.*** Every educational institution that has participated in LEED has been part of the leading edge of transformation. Each one has contributed to the green movement financially and, to various extents, intellectually as well. Most LEED earners do appear to be providing leadership in the area of green building. Applicant teams that achieve Platinum clearly deserve high leadership ratings. On the other hand, it appears to have been possible to have obtained low-level certification in recent years without providing much more leadership than required for a typical building project. Because the knowledge base necessary for obtaining basic Certification has become well established, it has become much easier to secure one. By following the lead of others and picking low-lying fruit, a project team could garner basic Certification without forging new territory. LEED v3 changes this. It requires all applicants to extend their reach in order to be recognized as green building leaders.

A common criticism of LEED is that its point system over simplifies complex issues. Some critics assert that in quantifying its measures, the USGBC has neglected several critical issues (thus shifting focus away from them). The system's definitions and calculations may still include faulty assumptions. And some applicants may, in fact, focus on point-chasing rather than the larger goal of environmental preservation (Malin. 2003). In response to such criticisms, the USGBC has put forth extraordinary effort to refine its policies and improve its measures.

Leadership experts agree that without clear vision and clear measures, it is very difficult for the various parts of an organization to work together toward a common goal (Fullan, 2001; Hannan & Silver, 2000; Holcomb, 2001). Although the LEED checklist has drawbacks, Malin (2003) says this format is also a primary strength of the program. "The system walks a fine line between ease of use and integrity," Malin explains. "If it is too complex, no one will use it, but much of the challenge in quantifying LEED performance comes from the need to verify achievements that are inherently difficult to measure" (¶ 7). Many building owners are not able to visualize complex environmental synergies without the aid of such tools. LEED provides a framework that is comprehensive, that is easy for people to understand, and that continually integrates emerging findings. Regardless of how an applicant approaches the system, implementing LEED should yield a building that taxes the natural environment less than a conventional building. It is the USGBC's job to ensure that measures are calibrated to produce positive results, and the organization appears dedicated to this cause.

***Individual level.*** Most applicants trust that by following LEED guidelines, their buildings will outperform standard buildings and will conserve natural resources. Although building owner/applicants do not always know exactly how each LEED measure works, their past performance indicates that they are willing and eager to learn as individuals and as organizational leaders. They expend energy and money supporting this effort. In doing so, they expand their own capacity and lead the way for others.

LEED has been designed to allow various players to make their own unique contributions. Owners contribute financially, designers contribute ideas and plans, builders construct the end product, manufacturers produce new components to support the cause, and specialists calibrate the system and its measures. The system provides a range of incentives necessary to engage such a diverse spectrum of participants and move them toward a common goal.

The system's primary tools are credits, ratings, and definitions. Its highly criticized checklist format, Malin (2003) argues, can actually help experienced designers optimize the team's efficacy. "In the hands of inexperienced designers, the checklist can result in a piecemeal approach to sustainability, with green features piled onto a conventional design" (¶ 9). On the other hand, "Experienced green designers can use it to organize a team around the task of designing a green building, while integrating selected strategies with little or no additional cost" (¶ 9). Malin suggests that leadership is critical to both how the system is used and how well its buildings are likely to perform.

LEED requires a high level of individual initiative and leadership from various participants. The design and construction process have changed considerably under LEED and participants must stay vigilant throughout the process. Owners, architects, LEED Accredited Professionals, and contractors must all pay close attention to detail and work together in new ways. LEED assessment is based on what is actually constructed, not just what was designed. Participation requires active and informed engagement from all parties – and a much higher level of collaboration (Browning, 2002; Huff, 2007; Mazza, 2007).

Individual members of an applicants' team have new incentive to put stereotypical rivalries aside and to work as a team, galvanized by the goal of environmental stewardship. Securing LEED certification requires higher levels of leadership from specific members of the design and construction team (Bilec & Ries, 2007). It also requires higher levels of commitment and involvement from the Owner, the Owner's various representatives (who frequently include college administrators), and the Contractor who is now accountable on more measures (USGBC, 2007). Contractors must understand the intended outcomes and be full collaborators in order to secure points. The reward is being acknowledged as a part of a team that is helping transform the way society builds… being recognized as a part of the leading edge of green design.

**Organizational Learning and Evolution**

The changes evident within LEED v2 indicate that the USGBC and LEED participants are, indeed, learning and that the system is evolving. The data used in this study indicate that applicants have had increasing success over time. Analyses show that the system has integrated feedback in effective ways. These findings support USGBC's claims of evolution. They show that the USGBC has moved quickly to address initial implementation dips. Patterns of change suggest individuals are learning new content and mastering new roles, applicant teams are learning to integrate new strategies, USGBC is learning from experience and analysis of data, and the system is adapting over time to facilitate higher levels of achievement.

Figure 28: *Weighted comparison of ratings using LEED v2 by the sample.*

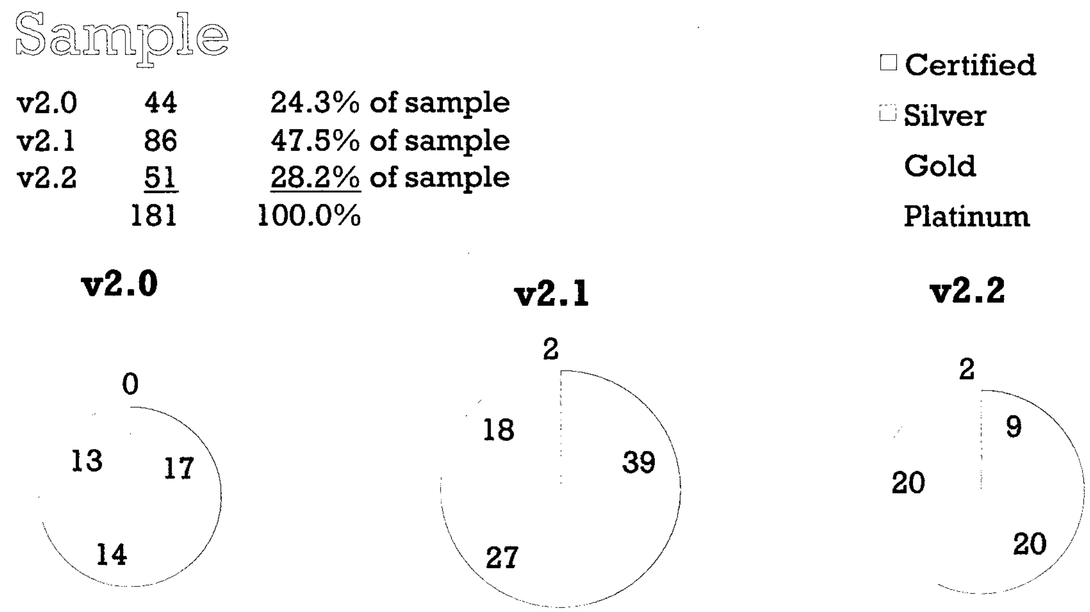
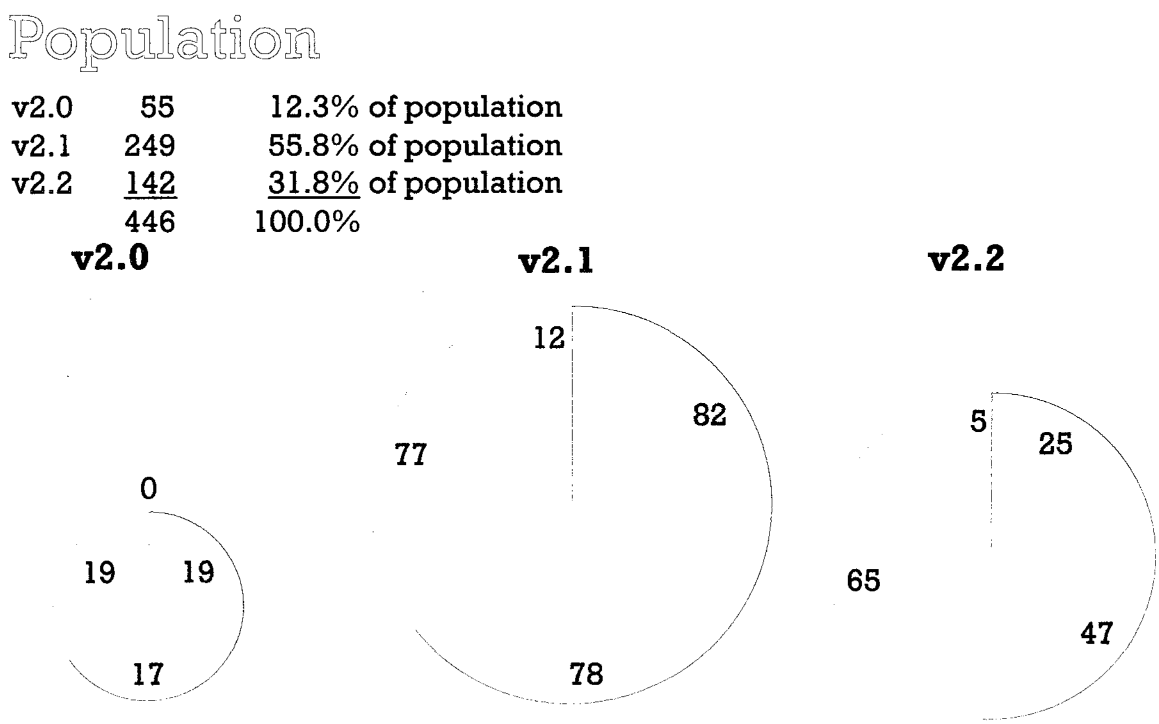



Figure 29: *Weighted comparison of ratings using LEED v2 by the population.*




In making these determinations, this study investigated three types of variables (institutional characteristics, credit earnings, and ratings) and assessed change over time. It used two different longitudinal measures, comparing groups based on version and time-in-system. It first compared v2.0 users to v2.1 and v2.2 users. It then compared early applicants (those with credit tally data) with later applicants and considered how well the sample represented the population.

In these analyses, institutional variables held fairly steady over time. The sample group (early applicants) did not vary characteristic-wise from the population. The sample group did, however, include notably fewer Associates colleges than the balance of the population. The sample's average endowment was higher than the balance of the population ($190,000 per student, as opposed to $146,000). These results suggest that LEED v2 has become accessible to a wider range of participants, and to participants with fewer financial resources.

Creating sub-groups based on the version made it possible to identify how the ratings earned by colleges have shifted over time. Institutions that used the earliest version were less successful in garnering Platinum (see Figure 27). In the population, LEED v2.2 yielded a higher level of overall success among users than the versions that preceded it. Achievement of Gold has swelled while reliance on basic Certification dropped substantially under v2.2.

Figures 28 and 29 illustrate evolution over time. They suggest that applicants who use v2 in the coming years are likely to garner increasingly high ratings. The increasing level of success does not appear to be a result of instrument decay. In this high-stakes, high-scrutiny program, review of each credit is remarkably standardized. Expectations and scrutiny have actually increased over time. Assessment of applications appears to be reliable and consistent. As such, increased success can be attributed to two primary sources: (1) refinement of definitions and formulae and (2) continual learning on the part of LEED organizers and applicants (President and Fellows of Harvard College, 2010; USGBC, 2009c). It appears that users have learned to use the system more effectively. They have made inroads toward addressing specific environmental issues defined by the USGBC.

Attaining Gold and Platinum is not likely to be commonplace in the early years of v3. Now that new technology and know-how is in place (making what was once difficult to achieve easier to reach today), the bar has been moved. This process facilitates incremental improvement of the entire system over time. Point thresholds are now much higher. This alone should help address under-performance issues of the sort Turner and Frankel (2008) found regarding energy.

Figures 29 and 30 provide weighted comparisons of the ratings earned by the sample and the population using various versions of LEED. The figures illustrate some chronological changes. Users of v2.2 have most frequently earned Gold. On the other hand, applicants who used v2.1 have been increasingly successful at earning Platinum in recent years. As more data becomes available on individual credits earned, it may be possible to identify more patterns, including characteristics that describe applicants who earn the highest ratings. The data used in this study suggest some differences among LEED applicants, but future studies might be able to achieve higher confidence levels by using larger pools of data.

Figures 28 and 29 show that higher education has used LEED v2.1 most frequently. This makes sense because v2.1 was primary from 2002-2006. It was main program for twice as long as v2.0 and a year longer than v2.2. Many users are still working toward certification under v2.1 and v2.2. However, applicants who joined the system since the summer of 2009 have been required to register under v3. They will be held to the new point thresholds and higher standards of measurement.

Applicants who registered under an earlier version of LEED may choose (a) to use the version under which they registered or (b) to shift to the new version. Registered applicants are likely to stick with v2.1 and v2.2, due to the lower thresholds. If, however, they find the definitions, rationale, and/or calculations in v3 superior, they may opt to use the new version. Doing so has some clear advantages (Tim Cole, personal communication, October 3, 2009). Although it means using new definitions and formulae, many of these have been refined to correct bugs detected in earlier versions. They are more transparent and they tend to make better sense (Cole; USGBC, 2009c).

It would be interesting to know more about which types of organizations use LEED as a teaching tool. Appendix E provides a case study of a high school designed to teach students about the environment. Among all LEED applicants, K-12 design teams have taken the greatest initiative to use LEED as a pedagogical tool. LEED for Schools has been customized for educational users. It is a sub-component of both LEED v2.2 and v3. LEED for Schools requires buildings to include features that support learning in direct and indirect ways (Building Operating Management, 2005). Under LEED for Schools, educational buildings must serve as didactic teaching tools. Today, all academic organizations are encouraged to use the LEED for Schools program. This tailored system is mandatory for K-12 applicants who register with LEED from this point forward. This program is also recommended, but not yet mandatory, for universities seeking LEED certification.

Future research could track the implementation and performance of pedagogical features. Such research could help determine if didactic features should be mandatory for all LEED certified buildings. This is an area where the USGBC could extend its reach. Today, sensory and cognitive experience is not necessarily enriched through an occupant's interaction with a LEED building. If the USGBC were to implement new pedagogical standards, people who use any LEED building could walk away from their experience with a higher level of awareness about the environment.

Institutions like Oberlin College (2007a) have achieved success in this realm. It is clear that more universities could enhance their educational offerings by exposing students to buildings embedded with environmental values. In addition, users of all ages could benefit from having educational clues embedded in the retail, office, health care, and assembly buildings they encounter each day. All LEED buildings could aim to educate individuals. The USGBC has successfully enhanced learning at the system and organizational level. It is time to expand its reach to individual learners. The USGBC has the potential to create sweeping change in society and to foster a nation-wide learning community steeped in environmental awareness. By making buildings more interesting, informative, and stimulating, LEED could help focus more peoples' attention on environmental ethics and conservation.

Although universities have not yet tapped the underlying pedagogical potential of their buildings, many institutions are cultivating and sharing green building know-how in other ways (AASHE, 2009b). They are sharing advice with each other and growing their own capacity to meet emerging LEED standards. Harvard publications offer suggestions to others, based on the university's prior experience with LEED. The institution proudly advertises that it has earned 24 certifications and registered 40 more projects to date (President and Fellows of Harvard College, 2010). It unabashedly challenges other institutions to follow its lead.

**LEED Supports Institutional Goals**

Today, many institutions are approaching LEED in ways similar to Harvard – celebrating it as a knowledge-generating, money-saving, performance-enhancing, marketing tool (President and Fellows of Harvard College, 2010). LEED provides a system of accountability and it helps universities demonstrate their value to society. LEED certification represents one way to gain credibility, measure success, and shift public focus toward green thinking. It raises the visibility of environmental stewardship and sustainability on campus.

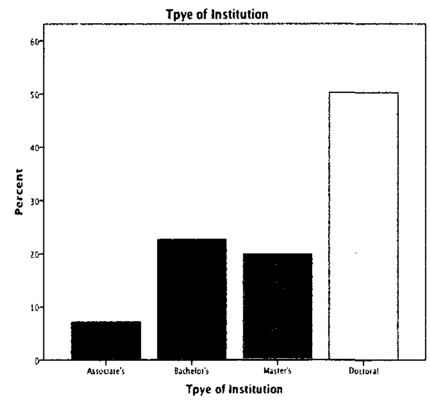
A major focus of "land grant" and research-intensive institutions is generating new knowledge and transferring knowledge from abstract theory into applied practice (Kerr, 1995; Levin, 2003; Rhodes, 2001). The results of this study indicate that innovation and knowledge-generation are important components of LEED and that they carry weight in ratings. A clear relationship exists between the number of Innovative Design credits earned and the level of certification achieved. Institutions at all rating levels typically earn 9-11% of their total points in Innovative Design (see Figure 23). Gold and Platinum earners in the sample cashed in on most of the points offered in ID. They accrued 88-90% of all points available for innovation, earning a higher portion of ID than any other category.

With the data provided for this study, it was not possible to differentiate credits earned for exemplary performance (EP) from those earned for other design innovations.

As such, the study could not measure innovation as precisely as desired. This constitutes a critical issue for a future quantitative and qualitative study.

"Building green" represents a way to apply new knowledge and incorporate new technologies – and to foster the evolution of both. This is a cause that clearly appealed to research institutions in the sample under investigation. The lure of LEED is evident across public and private institutions alike, and ones at all levels of size and wealth.

Figure 30: *Investigations regarding type of institution.*




| | | | | |
|---|---|---|---|---|
| **Control** | | | | |
| Public | 88 | (48.6%) | | |
| Private | 93 | (51.4%) | | |
| | | | | |
| **Type** | **LEED Sample** | | **All US Colleges** | |
| Associate's | 13 | (07.2%) | 1814 | (41.3%) |
| Bachelor's | 41 | (22.7%) | 767 | (17.5%) |
| Master's | 36 | (19.9%) | 636 | (14.5%) |
| Doctoral | 91 | (50.3%) | 283 | (06.4%) |
| | | | 891 | (20.3%) |
| Total | 181 | | 4391 | |

Clear relationships surfaced between LEED participation and institution type. Doctoral and research-intensive institutions employ LEED at much higher rates than teaching-focused institutions (see Figure 30). According to The Carnegie Foundation for the Advancement of Teaching (2005), Doctoral and research-intensive universities represent just 6.4% of all institutions. They own 50.3% of the LEED-rated buildings sampled, however, and they secured 49% of all ratings awarded in the postsecondary population (see Table 10, p. 156).

Doctoral universities in the sample were significantly larger and wealthier than other types of institutions. However, it is interesting to note that a vast majority of LEED ratings were secured by very small schools and by institutions with little to no endowment (see Appendix C). It also appears that over time LEED has become accessible to an increasingly diverse group of institutions. The number of Associates colleges participating in LEED is rising; these colleges tend to have extremely small endowments although they serve large groups of students. Based on these trends, it seems likely that the mean endowment of LEED earners will continue to drop.

As a group, universities have earned progressively higher ratings over time. In addition, Doctoral institutions have enthusiastically embraced the system. Interestingly, however, this study found nothing linking *type of institution* with the specific LEED *rating* an institution earns. It appears that an institution's capacity to achieve high ratings increases with experience (President and Fellows of Harvard College, 2009) but not necessarily with wealth. Future research could track ratings, to see if individual institutions earn successively higher ratings over time and to identify factors associated with various levels of success.

It is important to note that the lack of relationship between *type of institution* and *rating* does not imply that relationships do not exist between *type of institution* and *other* institutional characteristics. There were, in fact, clear links between institutional type and (1) region, (2) control, (3) enrollment, and (4) endowment within the sample group (see Appendix C). The largest enrollments and endowments were at research-intensive institutions. Although Doctoral universities reflected public and private control in nearly equal portions, this was not the case for Bachelors and Associates colleges. The Bachelors institutions in this sample were overwhelmingly private. The Associates colleges were strictly public. The portion of Associates colleges using LEED increased over time, while the proportion of Bachelors colleges decreased.

**LEED has Demonstrated Effectiveness as a Planning Tool**

LEED has demonstrated success in several quantifiable ways. This stands in contrast to Presley and Leslie's (1999) findings that the outcomes of most educational plans go un-assessed. As such, LEED provides new insight into organizational learning and the outcomes of strategic planning. Much of this is a result of the high level of scrutiny the system and its applicants face. Measures are precise and they are periodically updated in a way that provides continuity to users. The reporting mechanisms used to assign ratings also generate data that helps facilitate ongoing analysis.

Many scholars have cited the need to verify that educational planning yields measurable results (Holcomb, 2001; Presley & Leslie, 1999; Rowley et al., 1997; Wilson, 1997). This study documents change over time among institutions that have used the LEED Green Building Rating System and it shows positive results. Although it does not provide evidence that building performance is improving, it does show that institutions are achieving higher levels of success over time using a variety of LEED measures. Their success in earning LEED points and LEED ratings has risen. Buildings in the sample had increased success within Sustainable Sites and Indoor Environmental Quality under the recent LEED v2.2. And, within the broader population, awards of Gold and Platinum have been even more prevalent than in the sample… indicating that categories (such as EA) that contributed heavily to high ratings in the sample are likely to have gained momentum among recent LEED earners.

Within the measures of success developed by the United States Green Building Council, postsecondary institutions that use LEED as a planning tool are clearly excelling. LEED represents an effective method for integrating sustainability into university buildings. The system provides measures that can be used to track improvement over time. The measures incorporated into this study indicate gains in achievement over time.

The demonstrated success of LEED should help provide assurance to university leaders who place their trust in the system and in their practices of green facilities planning. What planners learn from using LEED and observing its results can help them calibrate other planning activities and refine their traditional planning practices. Future research can enhance society's understanding of organizational learning and of outcomes of campus planning efforts.

The unit of analysis for this particular study was the *building* rather than the *organization* applying for LEED certification. Future research could investigate the cumulative effect of constructing multiple LEED buildings on a single campus. Doing so could explain even more about leadership, innovation, and evolution through LEED.

**Implications for Research, Policy, and Practice**

This study explored how LEED has been used within American higher education. It built upon the university traditions of research, service, and innovation. It did this to understand an environmental stewardship program that is growing in popularity and influence. Teaching and learning are core values of this study.

The study reflects knowledge sharing and scholarship as defined by Boyer (1990). It aimed to help various LEED stakeholders evolve their practices over time. The hope was to generate knowledge that could help key stakeholders understand and refine the LEED system and their use of it. Such stakeholders include: USGBC organizers and members, design and construction professionals, universities that participate in LEED (and their administrators, faculty, staff, and students), and all users of LEED-rated buildings.

The practices that LEED encourages have tremendous influence over the future of building construction in the United States and, indeed, around the world. Conscientious evaluation of the system – and the consequences of its policies and procedures – is crucial to its ongoing success. Assessment can help the system advance environmental stewardship. It can identify opportunities for expansion and development.

The results of this study highlight LEED's growing focus on energy, site, and water conservation. LEED v3 reflects a shift away from past applicants' heavy reliance on Indoor Environmental Quality and toward macro-scale issues. Within the given sample, Energy and Atmosphere already had the most significant influence over rating. The influence of EA is likely to grow even more under LEED v3, since the number of points more than doubled in this category. Such policies underscore USGBC's focus on energy and carbon control. In recent years, the sample's use of SS and IEQ expanded faster than its use of EA. Under LEED v3, SS and EA will undoubtedly continue to grow; however, IEQ point offerings have been capped at v2 levels.

Overall, this study finds that LEED is evolving in both policy and practice and that research has contributed to change over time. It shows that Innovative Design has been an important category for LEED users. It indicates that the construct of leadership carries value in the green building movement – that the system has been designed to learn and grow, and that it is, in fact, doing so.

**Research.** Findings do suggest, however, that feedback loops and data collection practices could be expanded and further refined. New policies could be implemented to facilitate deeper analysis of results, increasingly effective program evolution, and better understanding of how LEED facilitates innovation and provides leadership. Such work could yield additional findings regarding organizational learning and other positive outcomes of planning.

The USGBC can enhance its efficacy by refining its feedback mechanisms and making its change process clearer to the public. Although the USGBC (2009c) asserts it has used "the best available science" (p. 3) to determine changes, most of this research is not available for review. The literature review identified a few studies, funded by the USGBC and conducted by third party organizations (universities and other non-profits), which have been distributed publically and exposed to peer review. Much more of this work needs to be done.

Peer review and public dissemination are crucial components of valid science. The USGBC has not utilized standard scholarly research mechanisms to the extent that it could. On the other hand, the USGBC has created an open forum for debate where many different perspectives are represented. The USGBC fosters active dialogue and reports findings at regional meetings, at its annual Expo, and though its website and press releases. The organization also appears to be aligning its resources to conduct more research (Cheatham, 2009a, 2009b; Stephens, 2008; USGBC, 2009d, 2009e). Additional research and transparency can enhance the USGBC's stature and better inform policy formation. Future research could help assess (and thereby help ensure a higher level of) validity and reliability of LEED and its measures. This type of work is necessary to rigorously advance knowledge.

The following sections will explore specific ideas for research. Some of the ideas expand the current study and could be conducted with existing datasets. Some suggest new directions for research and require additional data. Others explore implications for validity and reliability of LEED.

***Institutional Characteristics.*** All told, this study was not very successful in identifying applicant characteristics related to LEED participation. It appears that institutional qualities that influence both the decision to use LEED and how the categories are used were not selected for study. It is also possible that (a) the instrumentation and datasets employed were too weak to yield significant results and/or (b) the linear model used to detect differences was unable to deal with these particular datasets. Future research could seek to identify more pertinent variables. It might also refine the definitions of region, enrollment, and endowment and/or the instruments used to collect these particular data. Multiple Regression was not an effective tool to use for this part of the study because variation was limited in each of the five categories regarding characteristics. Two of the categories had floor effects (see Appendix D) and three represented categorical data. The overall level of variability was too low for Multiple Regression to gauge. The following passages discuss ways to enhance investigation in cases where region, endowment, and enrollment are studied.

*Region.* Results discussed in Chapter 4 suggest a link between an applicant's location and its point earnings in Sustainable Sites. There also appears to be some correlation between location and institutional types (see Appendix C). Unfortunately, these results were not particularly helpful in understanding LEED use. The results were not easy to interpret. This was due, in part, to the way region was defined for this study.

The accreditation regions used in this study appear to be based on population density rather than climate or geography.

Because green building practices are heavily dependent on climate, it would make sense to use climatic regions in future studies of LEED. Coding the location of buildings by climate (using established zones defined as cold, temperate, hot humid, and hot dry) or latitude would make it possible to arrange LEED buildings in a meaningful hierarchy.

*Enrollment and Endowment.* In this study, IPEDS data on enrollment and endowment did not yield many meaningful findings. Some relationships were located by using a log function of endowment. However, that procedure is not as appropriate for use with population indicators like enrollment. Some relationships probably do exist between LEED participation and an institution's enrollment or endowment. However, if they do exist, the models used to conduct this study were unable to detect them.

Data regarding enrollment and endowment for sampled buildings were not normally distributed. As illustrated in Appendix D, most institutions in the sample had little or no endowment. Using linear statistics to investigate non-linear distributions can lead to Type II errors. This happens when the results suggest there are no significant differences, but differences actually do exist. The likelihood of making Type II errors with these datasets was very high. Using a log function of endowment helped overcome this limitation in some tests; doing so increased the size of endowment numbers proportionate to one another. It thus supplied the degree of variability necessary for linear calculations. This procedure enabled the linear model to detect some existing differences. Results indicate that researchers who are interested in using the general linear model to study institutional endowments should consider using the log function.

In order for future research to identify existing patterns, it may be necessary to employ entirely different measures of endowment. Researchers who wish to utilize IPEDS endowment data should consider using datasets other than endowment per student. Using *total* endowment instead of endowment *per student*, for instance, would provide a higher level of variability. It would also require, however, making comparisons within two different sub-groups, since FASB and GASB endowments are calculated differently. On the other hand, it might be possible to develop a way of weighting IPEDS endowment data that would support comparison between FASB and GASB data. This could start with a review of the procedure NCES used in 2005 and 2006 when it attempted to derive standardized datasets (the sets employed in this study).

Alternatively, future studies could code endowment categorically in order to facilitate Chi-Square Analysis (which is not based on the linear model and which does not rely on variability the same way). This could, for instance, help detect patterns among institutions with (a) no endowment, (b) moderate endowment, or (c) extremely high endowment. Such a coding system was used to classify LEED credit earners into ratings groups, and this practice facilitated Chi-Square and Multiple Regression analysis.

***Validity and external reliability.*** It is critical for the USGBC to address validity and reliability issues soon, particularly the ones identified by Gifford (n.d.) and Navarro (2009). In this effort, the USGBC has already instituted new requirements for applicants to submit energy and water data for several years of their buildings' operation. This data will facilitate Life Cycle Analysis. The mandate has, however, raised legal concerns among designers, contractors, and building owners (Cheatham, 2009a, 2009b).

As such, the USGBC has decided to conduct performance analysis in a way that maintains confidentiality (Post, 2009). "Whether or not LEED-rated buildings are really performing is an extremely important issue for us" says LEED senior vice president, Scot Horst (cited in Post, 2009). The organization is "taking the concept of green building and making sure it is real" (¶ 4). In doing so, it faces challenges to meet the needs of all sorts of stakeholders.

A number of issues regarding the validity and reliability of LEED were highlighted in the methods chapter. The findings of this study have relevance in the areas of *consequential*, *predictive*, and *content* validity.

The study indicates that LEED has been increasingly successful with garnering buy-in in the area of Energy and Atmosphere and this helps confirm its *content validity* (since Energy is part of the program's name). LEED promises to measure energy and carbon footprint (see Figure 1, p. 5). This study found that Gold and Platinum earners made Energy and Atmosphere a high priority. Point totals in the EA category directly influenced the sample's ability to secure high ratings. Results also indicate that the number of Gold and Platinum earners is on the rise. LEED is an instrument for measuring environmental success, and it is apparent that the *content* of LEED is aligned with USGBC's promise to track energy and carbon footprint.

It also appears that LEED is fostering incremental improvement. However, because this study does not address the reliability of the calculations and models used to predict building performance, *predictive validity* remains a prominent source of concern. The USGBC must find ways to ensure that the energy, water, and air quality predictions are accurate and that they yield results.

Recent studies have found that Energy Star and LEED instruments do not align (Navarro, 2009). The lack of parity raises concern for both the *concurrent validity* and *external reliability* of LEED. These issues require additional study.

Many of the *consequences* of using LEED are positive. Today, the general public recognizes the importance of green building. Society has visible reminders of sustainability. LEED applicants and their constituents know new ways to enhance environmental sustainability. Through LEED, the design and construction industries have developed a broad base of green building knowledge and capacity. Organizations are building green more frequently today because of LEED. Nevertheless, there are questions to be answered about potentially negative consequences of LEED. Careful, ongoing assessment must be made to ensure all LEED buildings perform well.

***Performance outcomes of LEED.*** The consequences of ignoring under-performance could have disastrous results. If LEED is promoting techniques that are inherently inefficient, problems need to be identified and addressed immediately (Gifford, n.d.; Malin, 2008; Udall & Schendler, 2005). An example involves building envelopes. Critics note that many LEED-rated buildings are sheathed almost entirely in glass. Such building techniques have not yet been shown to conserve energy (Navarro, 2009). The predictive tools and construction techniques being promoted through LEED warrant careful assessment.

This study investigated performance of the system rather than its buildings. It used a literature review and statistical analyses to examine ways LEED has been meeting the goals of innovation, energy savings, carbon reduction, and corporate responsibility. Increased levels of environmental awareness, stewardship, and responsibility are evident across the United States today. Some of this ties to the high visibility of green buildings and the LEED program (Gifford, n.d.; Goleman, 2009; Malin, 2003). The results of this study indicate that LEED and many of its users do, indeed, focus their effort on energy conservation, carbon footprint, and innovation.

Newly expanded point offerings in EA and new policies for innovation will enhance these efforts. It is clear that the ID category is popular with LEED applicants, but the degree of new knowledge that has been generated through the system remains unknown. Since the USGBC could not provide data on ID credit titles, this study was not able to provide solid evidence that innovative techniques (rather than exemplary performance) are being contributed at high rates.

Performance reporting requirements adopted in 2009 reflect a move to generate additional knowledge about the performance of LEED buildings. These requirements will simultaneously generate data that can help building owners maintain and operate their buildings more effectively. The primary goal, however, is to allow the USGBC to track progress over time and to adapt policies in response to performance.

LEED already involves extensive data management. However, the USGBC has not yet made adequate use of the decade worth of data it has collected (Tom Dietsche, personal communication, November 20, 2009 & March 3, 2010). New policies and expansion of USGBC's research staff should help address these issues (Cheatham, 2009b; USGBC, 2009d). To allow the USGBC to focus on research as well as program development, the responsibility for assessing applications and collecting project data has been moved out of USGBC. Transferring certification and accreditation to the newly formed Green Building Certification Institute (GCBI) should allow the USGBC to focus on innovation and upgrade.

The findings of this study suggest that harvesting and analyzing existing LEED data can have tremendous benefit. Software is now being developed to facilitate data harvesting (Tom Dietsche, personal communication, March 3, 2010). The USGBC (2009c) has outlined a plan "to move LEED in to a continuous improvement cycle" (p. 4). This is intended to "ensure that LEED maintains its leadership position in the market" (p. 4). Using new and existing data can help the system learn faster and evolve better.

***Researching who chooses LEED.*** Future research could help determine what qualities LEED applicants share. It would be interesting to know if organizational characteristics have an identifiable relationship to *which* postsecondary institutions choose to use LEED. Tracking how characteristics change over time, or comparing characteristics of institutions that have used LEED with those that have not, might yield insight.

***Researching the cost to use LEED.*** University administrators and many other LEED applicants are curious about the up-front cost involved with earning LEED ratings. They often ask: How much cost does earning LEED-certification add to a construction project? What is the cost per square foot? What are the true cost savings over time? Some work of this type has already been done in the realm of green building (Scheuer & Keoleian, 2002).

In the specific area of higher education, research could compare the construction costs of LEED and non-LEED facilities based on formal classifications (such as building type, occupancy, and use). It is not clear if the USGBC has collected construction cost data for institutional buildings. However, capital expenditures for construction at public universities are generally included in annual reports that are available to the public. Since extensive data collection may be required to study this, however, case studies might be the best way to proceed.

***Estimating overall use of EA and ID.*** The results of this descriptive, exploratory study provide a basis for further analysis. This study focused on a single subset of users but its methods could be used to analyze the entire universe of LEED earners. It would be interesting to compare postsecondary institutions (their LEED ratings, credit earnings, and choice of version) with other, non-academic, LEED users. This type of analysis might show, for instance, if universities use particular categories at higher or lower rates than other organizations. It might help reveal if universities use Innovative Design more often than organizations that do not claim to have a research focus. It might also show which types of organizations achieve the most in Energy and Atmosphere.

***Predicting individual ratings.*** Data used in this study could be used to create additional prediction models for each rating level. Prediction models of how to achieve Gold and/or Platinum ratings would be of great interest to LEED users. As mentioned earlier, this type of investigation could be done using discriminant analysis (although securing additional data would make the findings more robust). In addition, the regression equations produced in this study could be used to develop Path Models and test them for validity. Such models could describe relationships among all known variables and present them in graphically.

**Policy and practice.** The USGBC (2009c) has been working to enhance transparency in decision-making. This is something that leadership expert Daniel

Goleman (2009) says is essential to improving green systems and making them more effective. Increased transparency can enhance both the performance and prestige of LEED. The USGBC (2009c) recently recalibrated its point system using what the organization calls *transparent weighting*:

> the process of redistributing the available points in LEED so that a given credit's point value more accurately reflects its potential to either mitigate the negative or promote positive environmental impacts of a building. Until now, the LEED Green Building Rating System has not used an overarching, consistent framework for allotting point values to credits. Though ample anecdotal explanation for those choices is available – i.e., consensus of a large pool of talented and experienced individuals in the buildings industry – LEED 2009 goes a step further by weighting LEED according to a logical, transparent framework that incorporates the best available science. (p. 3)

Studies like this one help promote understanding and facilitate purposeful change. The results of this study indicate that energy and carbon emissions have been, and will almost certainly continue to be, critical factors in earning high LEED ratings. However, the changes that this study identifies still have to do with the system's achievements and *predictions* of future building performance. Research clearly needs to be conducted regarding *actual* performance of LEED buildings. This was difficult to do in the past. However, the USGBC has begun collecting data on energy and water use in LEED-rated buildings. The fact that LEED now requires building owners to provide data for several years of operation will support future research and it can enhance decision-making.

## Conclusions

This exploratory study represents a new branch of research in that it investigates one specific group that has enthusiastically embraced LEED. Similar work seems to have been done by the USGBC as a part of ongoing development, but research of this nature has not been published. The scholarly community does not know how change has occurred, what has been discovered, or how research findings have been integrated into practice.

In order to improve any program, it helps to engage people from both inside and outside the system. This ensures that diverse perspectives are voiced in the effort to refine various aspects of performance. Such a process is evident within USGBC, an organization that relies heavily upon dialogue and debate.

One of the first studies on the energy performance of LEED buildings was conducted through collaboration between the New Building Institute and USGBC (Turner & Frankel, 2008). Findings were published and openly critiqued by experts in the field and other external reviewers (Gifford, n.d.; Malin, 2009). It was one of a number of studies conducted by non-profit organizations with funding from the USGBC. Several universities have also conducted studies with financial support from the USGBC.

This particular study provides an example of how universities are engaged in research and evaluation of LEED. This study comes from outside the LEED system but it could not have happened without the USGBC's consent and contribution of data. The individual who conducted this study contributed it as part of her scholarly undertakings while employed by a Masters level university and seeking a degree from a Doctoral level institution. She did not receive funding from the USGBC to conduct this study. The scenario illustrates ways in which individuals' scholarly interests drive research in the academic arena and how the process helps generate new understanding and new knowledge (Balderston, 1995; Boyer, 1990; Leslie, 2002; Levin, 2003, Rhodes, 2001).

This study sought to harness existing data in order to enhance practice. It aimed to help the system evolve, make it more transparent, and make green construction a little easier for applicants. A small degree of success was achieved even prior to the publication of this dissertation study. The author presented emerging findings to audiences of aeronautical researchers and university administrators. She also worked with USGBC to locate Data Use Agreements that were in common use. Her request for data prompted the USGBC to begin developing formal agreement procedures (Tom Dietsche, personal communication, November 20, 2009). This should make it easier for other researchers to secure access to data and enhance the transparency of the system.

This study shows that universities and their constituents can be part of moving programs like LEED forward. It contributes (a) new understanding of how applicants use various credit categories, (b) new knowledge on one substantial user group, and (c) an additional level of transparency regarding outcomes of the LEED program. It also provides a template for future study.

Findings indicate that 446 postsecondary institutions earned ratings using LEED-NC v2 before the end of 2009. Studying this population – and the credit categories that a portion of this population achieved in the process of earning LEED certification – yielded the following broad conclusions.

**LEED encourages environmental responsibility.** Participation in this new and innovative incentive program requires a high level of engagement in the construction process. It also requires a higher level of commitment than standard building methods. It focuses an applicant's efforts on targeted environmental issues. It elevates crucial issues of green building among, and far beyond, the immediate users of the system.

**LEED focuses on energy.** Energy is a primary concern of LEED organizers and of applicants who secure high ratings. Success in Energy and Atmosphere has risen over time and LEED v3 places even greater emphasis on this category. Point totals in Energy and Atmosphere will undoubtedly increase even more because rating thresholds have been raised. Applicants will need to earn more credits in this category in order to secure any level of certification. Based on past trends and new policy changes, Energy and Atmosphere is likely to remain the strongest single predictor of rating. If, in the early years of LEED v3, variability of use increases within SS and drops in EA, the prediction order could change. In the long run, however, EA will provide the most opportunity for variation in use.

**LEED promotes innovation.** Institutions in the sample used Innovative Design at the highest rate of any category. They cashed in on 71.6% of the points it has been possible to earn in the ID category. Recent policy changes will help ensure that future effort is directed toward generating new techniques and applying new knowledge, rather than simply exceeding standards that have been defined by others. Research about the past use of ID to generate innovation could substantiate the importance of this work, which could lead to refining and expanding the category.

**USGBC and many LEED users are leading the green building movement.** Propelling the green building forward requires extensive leadership. Those who have orchestrated the development of this system over a period of just 12 years are clear leaders in the field. Innovators and applicants who forged the initial path provided essential leadership. Each LEED certified building has contributed momentum to the cause, although the level of contribution does appear to vary among applicants.

**LEED can do more to teach building occupants.** The opportunity for buildings to serve as learning tools has been under-realized up to this point. Green buildings can, and should, impart new values and teach users about the natural world. USGBC's focus has been on educating specific sectors of society; design and construction professionals have clearly been learning and expanding their capacities to produce green buildings through their participation in LEED. Universities appear to have been expanding their capacity as well. However, universities and the USGBC could both do more to teach the public through the buildings their work creates.

**LEED is evolving.** The USGBC is actively engaged in improving its programs and refining its feedback mechanisms. This study identifies areas where the USGBC is succeeding (such as in focusing attention on Energy and Atmosphere) and areas where it can improve (such as in disseminating its own scientific research).

This descriptive, exploratory study was designed to be part of the evolution process. It tapped existing data to answer the question: *To what degree have institutions of higher education used LEED® to earn certification, provide leadership, and foster innovation in environmental sustainability?* The study ultimately shows that postsecondary institutions constitute a significant user group. The members of this group have provided leadership and innovation to the green building movement. Their leadership contributions are currently measured by the ratings they earn. Their innovation and knowledge-generation is gauged through Innovative Design credits. They have demonstrated effectiveness in both measures.

By persistently assessing outcomes and continually refining the system, the USGBC and individual researchers can help ensure that the investments made in green buildings yield positive results. This is done in the hope of achieving long-term environmental sustainability and of passing a healthy planet on to future generations.

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## Appendix A: Table of Points Available in Each LEED Category

| LEED Credit | Name | Points in v2 | Points in v3 |
|---|---|---|---|
| **Sustainable Sites (SS)** | | *Italics denote major changes* | |
| SS Prereq 1 | Construction Activity Pollution Prevention | Required | Required |
| SS Credit 1 | Site Selection | 1 | 1 |
| SS Credit 2 | Development Density & Community Connectivity | 1 | *5* |
| SS Credit 3 | Brownfield Redevelopment | 1 | 1 |
| SS Credit 4.1 | Alternative Transportation, *Public Transportation* | 1 | *6* |
| SS Credit 4.2 | Alternative Transportation, *Bicycle Storage & Changing Rooms* | 1 | 1 |
| SS Credit 4.3 | Alternative Transportation, *Low-Emitting & Fuel Efficient Vehicles* | 1 | *3* |
| SS Credit 4.4 | Alternative Transportation, *Parking Capacity* | 1 | *2* |
| SS Credit 5.1 | Site Development, *Protect or Restore Habitat* | 1 | 1 |
| SS Credit 5.2 | Site Development, *Maximize Open Space* | 1 | 1 |
| SS Credit 6.1 | Stormwater Design, *Quantity Control* | 1 | 1 |
| SS Credit 6.2 | Stormwater Design, *Quality Control* | 1 | 1 |
| SS Credit 7.1 | Heat Island Effect, *Non-Roof* | 1 | 1 |
| SS Credit 7.2 | Heat Island Effect, *Roof* | 1 | 1 |
| SS Credit 8 | Light Pollution Reduction | 1 | 1 |
| | **Total Points Available in SS** | **14** | ***26*** |
| **Water Efficiency (WE)** | | | |
| WE Credit 1.1 | Water Efficient Landscaping, *Reduce by 50%* | 1 | *2* |
| WE Credit 1.2 | Water Efficient Landscaping, *No Potable Use or No Irrigation* | 1 | *2* |
| WE Credit 2 | Innovative Wastewater Technologies | 1 | *2* |
| WE Credit 3.1 | Water Use Reduction, *20% Reduction* | 1 | *Now a Prequisite (WEp1)* |
| WE Credit 3.2 | Water Use Reduction, *30% Reduction* | 1 | *2* |
| | Water Use Reduction, *35% Reduction* | *n/a* | *+1* |
| | Water Use Reduction, *40% Reduction* | *n/a* | *+1* |
| | **Total Points Available in WE** | **5** | ***10*** |
| **Energy and Atmosphere (EA)** | | | |
| EA Prereq 1 | Fundamental Commissioning of the Building Energy Systems | Required | Required |
| EA Prereq 2 | Minimum Energy Performance | Required | Required |
| EA Prereq 3 | Fundamental Refrigerant Management | Required | Required |

| | | | |
|---|---|---|---|
| EA Credit 1 | Optimize Energy Performance | 2-10 | *2-19* |
| EA Credit 2 | On-Site Renewable Energy | 1-3 | *1-7* |
| EA Credit 3 | Enhanced Commissioning | 1 | *2* |
| EA Credit 4 | Enhanced Refrigerant Management | 1 | *2* |
| EA Credit 5 | Measurement & Verification | 1 | *3* |
| EA Credit 6 | Green Power | 1 | *2* |
| | **Total Points Available in EA** | **17** | ***35*** |
| **Materials and Resources (MR)** | | | |
| MR Prereq 1 | Storage & Collection of Recyclables | Required | Required |
| | Building Reuse, *Maintain 55% of Existing Walls, Floors & Roof* | *n/a* | *1* |
| MR Credit 1.1 | Building Reuse, *Maintain 75% of Existing Walls, Floors & Roof* | 1 | +1 |
| MR Credit 1.2 | Building Reuse, *Maintain 95% of Existing Walls, Floors & Roof* | +1 | +1 |
| MR Credit 1.3 | Building Reuse, *Maintain 50% of Interior Non-Structural Elements* | 1 | 1 |
| MR Credit 2.1 | Construction Waste Management, *Divert 50% from Disposal* | 1 | 1 |
| MR Credit 2.2 | Construction Waste Management, *Divert 75% from Disposal* | 1 | 1 |
| MR Credit 3.1 | Materials Reuse, *5%* | 1 | 1 |
| MR Credit 3.2 | Materials Reuse, *10%* | 1 | 1 |
| MR Credit 4.1 | Recycled Content, *10% (post-consumer + 1/2 pre-consumer)* | 1 | 1 |
| MR Credit 4.2 | Recycled Content, *20% (post-consumer + 1/2 pre-consumer)* | 1 | 1 |
| MR Credit 5.1 | Regional Materials, *10% Extracted, Processed & Manufactured* | 1 | 1 |
| MR Credit 5.2 | Regional Materials, *20% Extracted, Processed & Manufactured* | 1 | 1 |
| MR Credit 6 | Rapidly Renewable Materials | 1 | 1 |
| MR Credit 7 | Certified Wood | 1 | 1 |
| | **Total Points Available in MR** | **13** | **14** |
| **Indoor Environmental Quality (IEQ)** | | | |
| IEQ Prereq 1 | Minimum IAQ Performance | Required | Required |
| IEQ Prereq 2 | Environmental Tobacco Smoke (ETS) Control | Required | Required |
| IEQ Credit 1 | Outdoor Air Delivery Monitoring | 1 | 1 |
| IEQ Credit 2 | Increased Ventilation | 1 | 1 |
| IEQ Credit 3.1 | Construction IAQ Management Plan, *During Construction* | 1 | 1 |
| IEQ Credit 3.2 | Construction IAQ Management Plan, *Before Occupancy* | 1 | 1 |
| IEQ Credit 4.1 | Low-Emitting Materials, | 1 | 1 |

| | | | |
|---|---|---|---|
| | *Adhesives & Sealants* | | |
| IEQ Credit 4.2 | Low-Emitting Materials, *Paints & Coatings* | 1 | 1 |
| IEQ Credit 4.3 | Low-Emitting Materials, *Carpet Systems* | 1 | 1 |
| IEQ Credit 4.4 | Low-Emitting Materials, *Composite Wood & Agrifiber Products* | 1 | 1 |
| IEQ Credit 5 | Indoor Chemical & Pollutant Source Control | 1 | 1 |
| IEQ Credit 6.1 | Controllability of Systems, *Lighting* | 1 | 1 |
| IEQ Credit 6.2 | Controllability of Systems, *Thermal Comfort* | 1 | 1 |
| IEQ Credit 7.1 | Thermal Comfort, *Design* | 1 | 1 |
| IEQ Credit 7.2 | Thermal Comfort, *Verification* | 1 | 1 |
| IEQ Credit 8.1 | Daylight & Views, *Daylight 75% of Spaces* | 1 | 1 |
| IEQ Credit 8.2 | Daylight & Views, *Views for 90% of Spaces* | 1 | 1 |
| | **Total Points Available in IEQ** | **15** | **15** |
| **Innovation & Design Process (ID)** | | | |
| ID Credit 1.1 | Innovation in Design | 1 (ID or EP) | 1 (ID or EP) |
| ID Credit 1.2 | Innovation in Design | 1 (ID or EP) | 1 (ID or EP) |
| ID Credit 1.3 | Innovation in Design | 1 (ID or EP) | 1 (ID or EP) |
| ID Credit 1.4 | Innovation in Design | 1 (ID or EP) | *1 (ID only)* |
| | Innovation in Design | *n/a* | *1 (ID only)* |
| ID Credit 2 | LEED Accredited Professional | 1 | 1 |
| | **Total Points Available ID** | **5** | **6** |
| **Regional Priority (RP)** – *This category is new in LEED Version 3* | | | |
| | **Total Points Available in RP** | ***n/a*** | ***4*** |
| | | | |
| | **Total Points Available in Version** | **69** | ***110*** |

Compiled from: Aarons-Sydnor and Miller (2009), Nexus Green Building Resource Center (2009), and USGBC (2008b, 2009a).

## Appendix B: Obtaining IPEDS Data

The institutional data needed to conduct this study was obtained using the IPEDS Data Center, which recently replaced the Data Cutting Tool (NCES, 2009d). All institutions in the sample were located using the IPEDS Peer Analysis System. A list of institutional variables was then entered into the Peer Analysis System.

It is possible to replicate this list of variables using IPEDS. However, it would not be a simple matter to replicate the list of institutions, since many of them have chosen to remain anonymous and are thus not listed in this report. Obtaining that list would require permission from the USGBC.

Pertinent variables are listed below to facilitate replication of this study. To begin obtaining data, go to <http://nces.ed.gov/ipeds/datacenter/> and click "Download Custom Data Files." Select "continue" if prompted and then enter each institution in the sample using the "Select Institutions" tab.

Now chose the "Select Variables" tab. A list of survey years should appear. Under 2008, select "Frequently used/Derived variables" and click the box beside "Carnegie Classification 2005: Basic." *The data that will be downloaded through this operation will indicate how the Carnegie Foundation for the Advancement of Teaching classifies the institution.*

While still under 2008, select "Institutional Characteristics" twice, then select "Institutional control or affiliation," next check the box beside "Institutional control or affiliation." *The results will indicate whether the institution was publicly or privately held in academic year 2008-09.*

Next click 2007 to obtain data related to survey year 2007. Select "Frequently used/Derived variables" and then "Enrollment and retention rates: Fall 2007." Click the box beside "Full-time equivalent enrollment: Fall 2007." Next, scroll down the list to find and select "Revenues and expenditures: Fiscal year 2007." Now select "Endowment assets (year end) per FTE enrollment" and check the boxes beside both choices: "Endowment assets (year end) per FTE enrollment (GASB)" and "Endowment assets (year end) per FTE enrollment (FASB)." *The results will indicate the institution's endowment, in dollars, divided by the number of students the intuition enrolls on a full-time basis or its equivalent.*

The next steps involve selecting similar data for additional years, to provide a back up in instances where data are missing. To do this, proceed to survey year 2006. Select "Frequently used/Derived variables" and select "Revenues and expenditures: Fiscal year 2006." Now select "Endowment assets (year end) per FTE enrollment" again and check the boxes beside both choices (GASB and FASB). Now go to survey year 2005 and select "Frequently used/Derived variables" and then "Enrollment and retention rates: Fall 2005" and check "Full-time equivalent enrollment: Fall 2005." Next select "Institutional Characteristics" and then "Institutional Characteristics" again. Now select "Institutional control or affiliation," next check the box beside "Institutional control or affiliation."

The following explanation of how GASB and FASB financial data were derived, was copied directly from the IPEDS Data Center:

> Endowment assets (year end) per FTE enrollment for public institutions using GASB 34/35 standards is derived as follows:

Endowment assets (year end) (F1H02) divided by 12-month FTE enrollment (FTE12MN). Endowment assets are gross investments of endowment funds, term endowment funds, and funds functioning as endowment for the institution and any of its foundations and other affiliated organizations. Endowment funds are funds whose principal is nonexpendable (true endowment) and that are intended to be invested to provide earnings for institutional use. Term endowment funds are funds which the donor has stipulated that the principal may be expended after a stated period or on the occurrence of a certain event. Funds functioning as endowment (quasi-endowment funds) are established by the governing board to function like an endowment fund but which may be totally expended at any time at the discretion of the governing board. These funds represent nonmandatory transfers from the current fund rather than a direct addition to the endowment fund, as occurs for the true endowment categories.

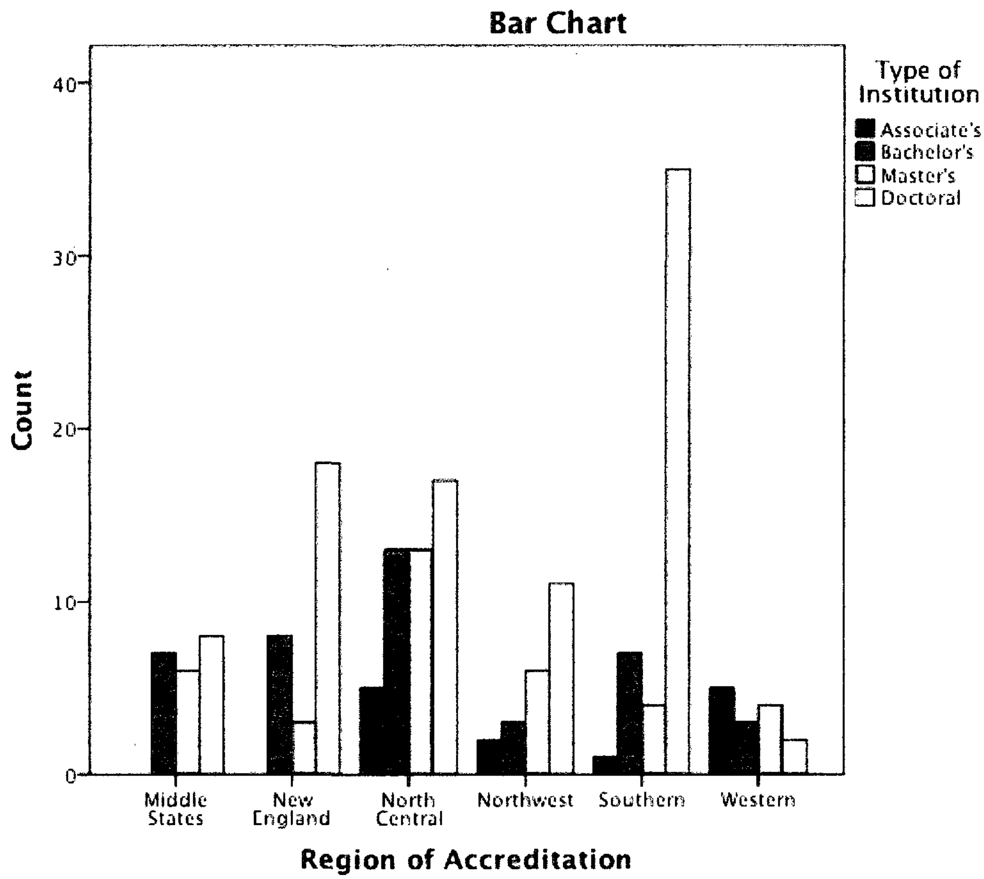
The full-time-equivalent (FTE) enrollment used is the sum of the institutions' FTE undergraduate enrollment and FTE graduate enrollment (as calculated from or reported on the 12-month Enrollment component) plus the estimated FTE of first-professional students. Undergraduate and graduate FTE are estimated using 12-month instructional activity (credit and/or contact hours).

Endowment assets (year end) per FTE enrollment for public and private not-for-profit institutions using FASB standards is derived as follows: Endowment assets (year end) (F2H02) divided by 12-month FTE enrollment (FTE12MN) Endowment assets are gross investments of endowment funds, term endowment funds, and funds functioning as endowment for the institution and any of its foundations and other affiliated organizations. Endowment funds are funds whose principal is nonexpendable (true endowment) and that are intended to be invested to provide earnings for institutional use. Term endowment funds are funds which the donor has stipulated that the principal may be expended after a stated period or on the occurrence of a certain event. Funds functioning as endowment (quasi-endowment funds) are established by the governing board to function like an endowment fund but which may be totally expended at any time at the discretion of the governing board. These funds represent nonmandatory transfers from the current fund rather than a direct addition to the endowment fund, as occurs for the true endowment categories.

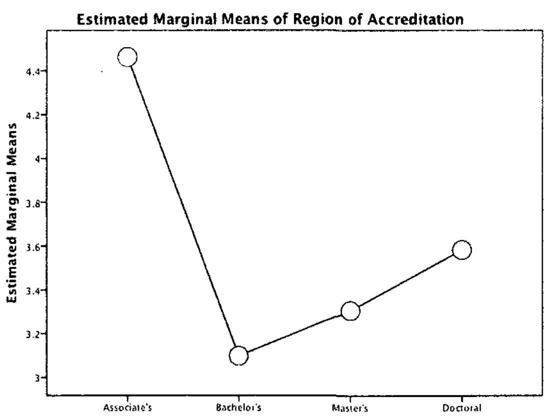
The full-time-equivalent (FTE) enrollment used is the sum of the institutions' FTE undergraduate enrollment and FTE graduate enrollment (as calculated from or reported on the 12-month Enrollment component) plus the estimated FTE of first-professional students. Undergraduate and graduate FTE are estimated using 12-month instructional activity (credit and/or contact hours).

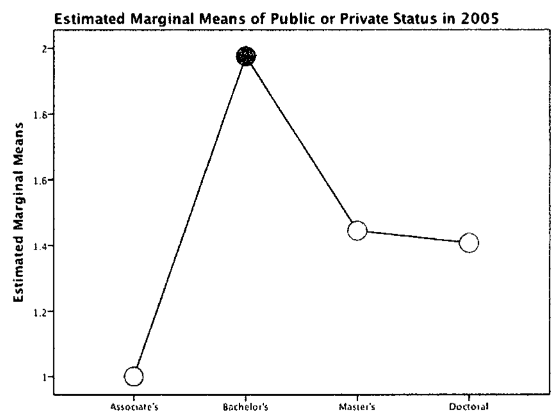
**Appendix C: Tables for Findings Regarding Type of Institution**

All of the analyses described below involve the sample group. Pearson Chi-Square analysis, $\chi^2$ (1, N=15) = 45.950, $p<.01$, indicated significant differences in region. Location is illustrated in the bar chart below.

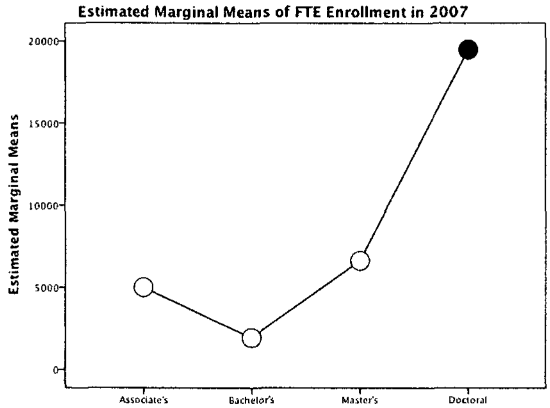


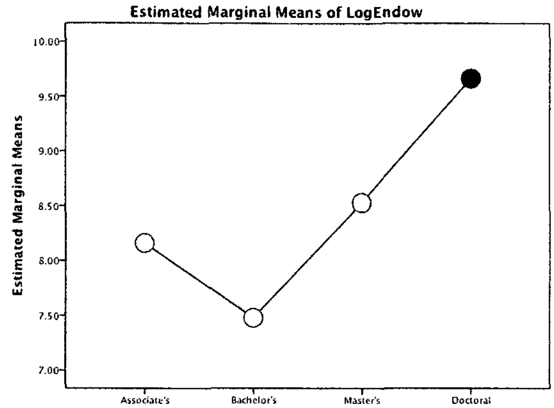

*Means plots for region (left) and control (right), based on type of institution.*



*Means plots for enrollment (left) and endowment (right), based on type.*




A MANOVA was run for region, control, enrollment, and endowment with institutional type as the dependent variable. The overall assumption of equal variances was not met: Box's M=377.885, $F$=18.09, df1=20, df2=41742.72, $p$<.01. However, a Pillai's Trace test confirmed that the overall model was significant: $F$ (12, 528) = 21.911, value = .997, $p$<.01. Each of the four relationships was found to be significant at the $p$=.05 level or better.

| Levene's Test of Equality of Error Variances for Type | | | | |
|---|---|---|---|---|
| | **F** | **df1** | **df2** | **Sig.** |
| Region of Accreditation | .204 | 3 | 177 | .894 |
| Public or Private Status | 257.810 | 3 | 177 | .000 |
| FTE Enrollment | 27.372 | 3 | 177 | .000 |
| Log of Endowment | 5.619 | 3 | 177 | .001 |
| Tests the null hypothesis that the error variance of the dependent variable is equal across groups. | | | | |

| Tests of Between-Subjects Effects | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Source** | **Dependent Variable** | **Type III Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** | **$R^2$** |
| Type | Region | 20.571 | 3 | 6.857 | 3.139 | .027 | .051 |
| | Control | 13.395 | 3 | 4.465 | 24.836 | .000 | .296 |
| | FTE Enrollment | 1.093E10 | 3 | 3.644E9 | 45.013 | .000 | .433 |
| | Log of Endowment | 147.537 | 3 | 49.179 | 101.133 | .000 | .632 |
| $R^2$ and Partial Eta Squared were identical in the MANOVA tests in this study. As such, the $R^2$ reported also indicates the Effect Size of each individual measure. | | | | | | | |

| Public or Private Status in 2005 | | | | |
|---|---|---|---|---|
| Type of Institution | N | Subset | | |
| | | 1 | 2 | 3 |
| Associates | 13 | 1.00 | | |
| Doctoral | 91 | | 1.41 | |
| Masters | 36 | | 1.44 | |
| Bachelors | 41 | | | 1.98 |
| Sig. | | 1.000 | .987 | 1.000 |
| Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square(Error) = .180. Uses Harmonic Mean Sample Size = 28.555. Alpha = .05 using Tukey HSD. | | | | |

| FTE Enrollment in 2007 | | | |
|---|---|---|---|
| Type of Institution | N | Subset | |
| | | 1 | 2 |
| Bachelors | 41 | 1943.83 | |
| Associates | 13 | 5013.23 | |
| Masters | 36 | 6638.78 | |
| Doctoral | 91 | | 19498.79 |
| Sig. | | .203 | 1.000 |
| Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square(Error) = .180. Uses Harmonic Mean Sample Size = 28.555. Alpha = .05 using Tukey HSD. | | | |

| Log of Endowment | | | | |
|---|---|---|---|---|
| Type of Institution | N | Subset | | |
| | | 1 | 2 | 3 |
| Bachelors | 41 | 7.4770 | | |
| Associates | 13 | | 8.1605 | |
| Masters | 36 | | 8.5279 | |
| Doctoral | 91 | | | 9.6645 |
| Sig. | | 1.000 | .195 | 1.000 |
| Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square(Error) = .180. Uses Harmonic Mean Sample Size = 28.555. Alpha = .05 using Tukey HSD. | | | | |

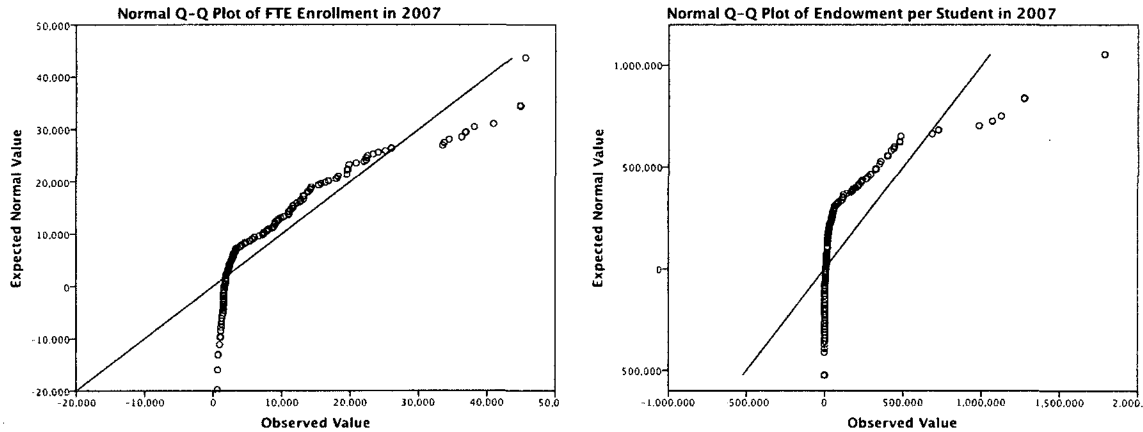
| Equal Variances Not Assumed | | | | | | |
|---|---|---|---|---|---|---|
| (I) Type | (J) Type | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
| | | | | | Lower Bound | Upper Bound |
| Associates | Bachelors | 1.36* | .454 | .031 | .10 | 2.62 |
| | Masters | 1.16 | .462 | .086 | -.12 | 2.43 |
| | Doctoral | .88 | .415 | .189 | -.31 | 2.07 |
| Bachelors | Associates | -1.36* | .454 | .031 | -2.62 | -.10 |
| | Masters | -.21 | .349 | .933 | -1.13 | .71 |
| | Doctoral | -.48 | .283 | .324 | -1.23 | .26 |
| Masters | Associates | -1.16 | .462 | .086 | -2.43 | .12 |
| | Bachelors | .21 | .349 | .933 | -.71 | 1.13 |
| | Doctoral | -.28 | .296 | .786 | -1.06 | .51 |
| Doctoral | Associates | -.88 | .415 | .189 | -2.07 | .31 |
| | Bachelor's | .48 | .283 | .324 | -.26 | 1.23 |
| | Masters | .28 | .296 | .786 | -.51 | 1.06 |

Based on observed means. The error term is Mean Square(Error) = .486. The mean difference is significant at the level indicated in the Sig. column.

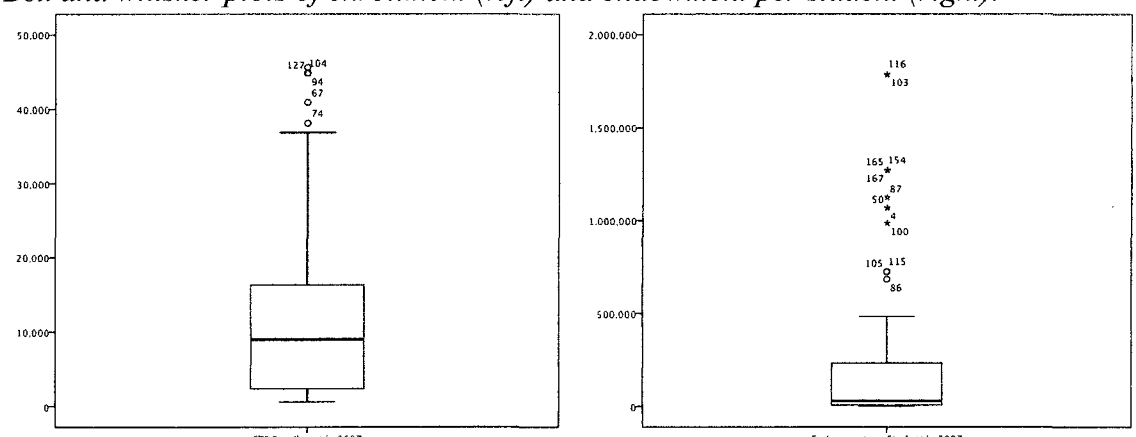
## Appendix D: Tables for Findings Regarding Enrollment and Endowment

The Q-Q plots below illustrate that the sample's endowment and enrollment distributions had restricted variance. The restriction in variance limited how well the general linear model could detect relationships regarding endowment or enrollment. Both endowment and enrollment reflect a floor effect. Many LEED-earning institutions had small student enrollments and relatively small endowments per student. Box and whisker plots provide another way of visualizing these effects. The bulk of cases fall in the tan boxes, the others represent outliers of sorts. The median endowment (indicated by the bold horizontal line) falls near zero.

*Q-Q plot of FTE enrollment (left) and endowment per student (right).*




*Box and whisker plots of enrollment (left) and endowment per student (right).*

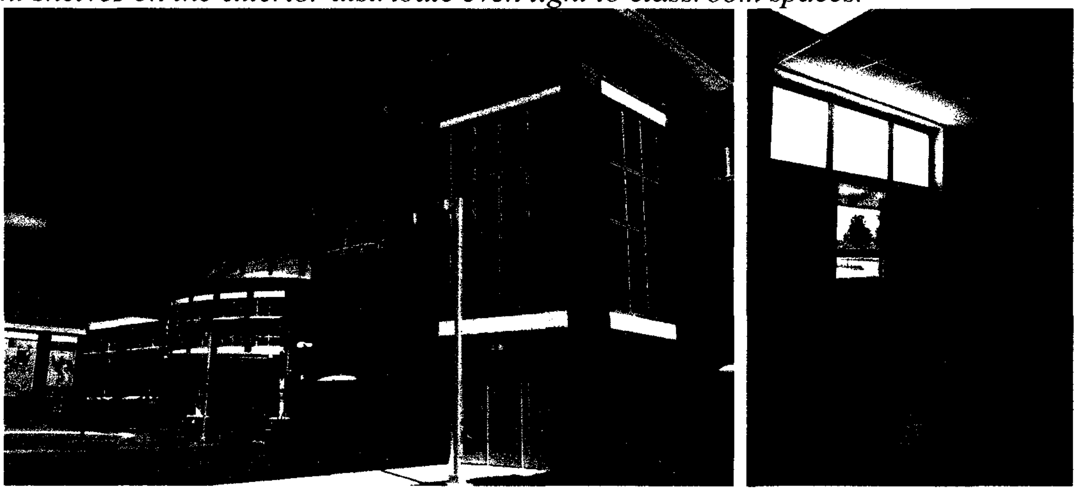



Descriptive statistics indicated that the distributions (for both sample and population) on endowment were extremely leptokurtic (i.e., peaked). They were also positively skewed. One-Sample Kolmogorov-Smirnov tests (at the $p<.01$ level) confirmed that enrollment and endowment were *not* normally distributed in the sample nor the population. The chance of randomly selecting a sample that deviates from the normal Gaussian distribution as much as this one on these factors is less than 1%. With so many institutions clustered at the small end of the spectrum, the linear model could detect other differences. This model relies on the existence of a normal curve, but the data on endowment and enrollment for these institutions do not follow a normal curve.

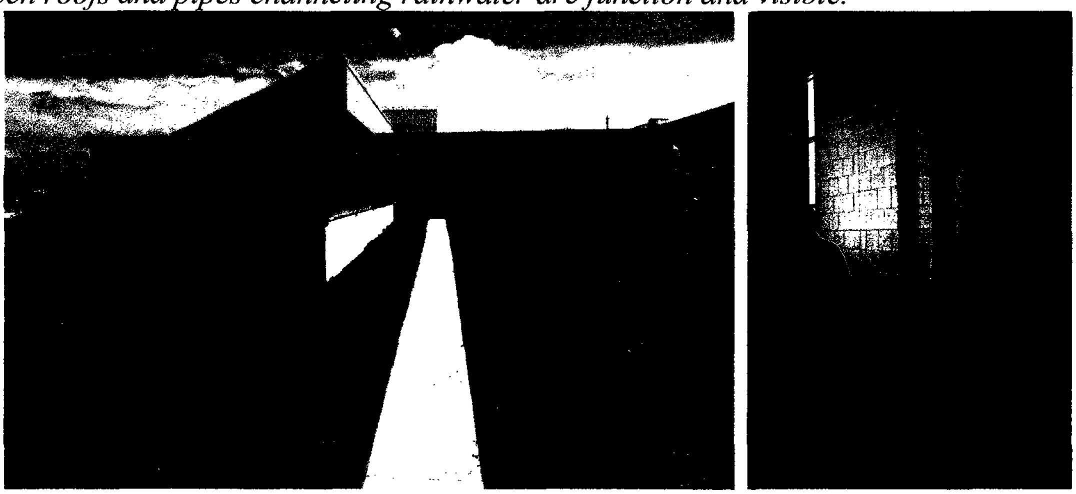
## Appendix E: Case Study of LEED-Rated High School

Primary and secondary schools are providing a great deal of leadership in green building. As of September 2009, there were 1,521 registered K-12 projects and 185 schools had achieved LEED certification (USGBC, 2009i). LEED promotes a range of tangible benefits for schools. For instance, many LEED buildings provide natural daylight. Daylighting has been shown to improve worker and student productivity (McDonough & Braungart, 2002). A study by the Heschong Mahone Group found that students working under the best lighting conditions "progressed 20 percent faster on math tests and 26 percent on reading tests in one year than students with the worst daylighting" (cited in Building Operating Management, 2005).

*Light shelves on the exterior distribute even light to classroom spaces.*



*Green roofs and pipes channeling rainwater are function and visible.*



The Renaissance Academy being built by Virginia Beach Public Schools (VBPS) provides an example. It uses a holistic approach to design that includes, but also exceeds, LEED requirements (Tim Cole, personal communication, October 5, 2009). The three major sustainability goals of Virginia Beach Schools are: (1) constructing sustainable buildings, (2) integrating sustainable practices throughout the school system, and (3) educating the general public about environmental issues.

The Renaissance Academy includes a middle school and a high school. It will serve students who do not fit the traditional educational setting for various reasons. The school district consulted with behavioral psychologists as well as sustainability experts in its design. The building and the curriculum integrate sustainability and help meet the educational needs of the students who will attend. The culinary arts program will include a sustainable aquaponics program where the students will raise tilapia. They will use effluents from the fish to fertilize plants in the school's greenhouse. Students specializing in culinary arts will prepare meals using ingredients from the aquaponics program.

Students studying building trades will learn construction techniques that apply to LEED. This will help prepare students to go into green construction, filling a workforce need in the region. The USGBC claims "reorientation of K-12 and higher education programs toward sustainability and green building is critical to preparing students for a broadening green marketplace" (USGBC, 2009g, ¶ 2).

VBPS directly supports LEED. Its Renaissance Academy is one of five VBPS projects registered with LEED. One of its elementary schools was the first LEED certified school in the state. VBPS is aiming for a LEED rating of Silver or better on all future renovation and construction projects (Tim Cole, personal communication, October 5, 2009).

VBPS's Director of Sustainability, Tim Cole, has been actively engaged in LEED since its earliest days (personal communication, October 3, 2009). He worked on the development of a building certified under LEED Version 1 (the pilot program that certified a total of 20 buildings). VBPS is serving as a catalyst for sustainability within the larger community. Cole indicates that as a client, VBPS encourages local architects, engineers, and contractors to learn and integrate sustainable approaches.

The Renaissance Academy uses solar heated water for the cafeterias. A rainwater harvesting system supplies water for toilets, urinals, and landscape irrigation. The day lighting system can be supplemented as necessary with artificial lighting. The school has windows that allow the building's users to see mechanical and rainwater systems in action. Students and visitors also have access to an interactive kiosk, where they can retrieve data about the geothermal and photovoltaic systems. Light shelves on the south face of the Academy block direct sunrays from passing through the glass and heating interior spaces (see Figure 39, left). The light shelves bounce indirect light deep into classroom spaces (see Figure 39, right). Light monitors (see Figure 40, far left) channel light into a cafeteria. Green roofs collect and filter water and insulate the Renaissance Academy. Pipes channeling rainwater are visible in both cafeterias (see Figure 40, right).

These pedagogical components were optional under LEED-NC Version 2.2, but are integral to the new LEED for Schools program (Building Operating Management, 2005). Tim Cole indicates that the cost of constructing this Academy was about $3.50 less per square foot than similar schools in the region. VBPS also supports an extensive recycling system, and uses only Green Seal certified cleaning supplies. Cole says that administrators see the 15,000 employees and 69,000 students in the system's 87 schools as a "great platform for directing change locally and on a larger scale" (personal communication, October 5, 2009). VBPS is trying to implement proven strategies, but the fact that it is introducing these strategies into a region of the country where they have not been used reflects leadership in environmental sustainability. It helps spur innovation and the generation of knowledge at the local level.

## Appendix F: Tables for MANOVA for Question 2b

In Question 2b, Levene's Test of Equality of Error Variances (directly below) was used to test the null hypothesis (that the error variance of the dependent variable was equal across groups). Results of this test determined which charts to use fro post hoc analysis. The three categories with unequal variance (WE, MR, and ID) are described in the charts below the Levene's results. The three that had equal variances (SS, EA, and IEQ) are described in the table at the end of this Appendix.

| Levene's Test of Equality of Error Variances for LEED rating | | | | |
|---|---|---|---|---|
| | **F** | **df1** | **df2** | **Sig.** |
| Credits earned in Sustainable Sites | 1.607 | 3 | 177 | .189 |
| Water Efficiency | 7.318 | 3 | 177 | .000 |
| Energy & Atmosphere | 1.722 | 3 | 177 | .164 |
| Materials & Resources | 5.133 | 3 | 177 | .002 |
| Indoor Env. Quality | 1.055 | 3 | 177 | .370 |
| Innovative Design | 2.999 | 3 | 177 | .032 |

The post hoc tests for Water Efficiency, Materials and Resources, and Innovative Design are based on observed means. Means for groups in homogeneous subsets are displayed. The error term is Mean Square (Error) = 1.225. These three post hoc tests used Tukey HSD, with Harmonic Mean Sample Size = 13.272 and $p$=.05.

| Post hoc test for Water Efficiency | | | |
|---|---|---|---|
| **LEED Rating earned** | **N** | **Subset 1** | **Subset 2** |
| Certified | 65 | 2.28 | |
| Silver | 61 | 2.54 | |
| Gold | 51 | | 3.96 |
| Platinum | 4 | | 4.25 |
| Sig. | | .927 | .907 |

| Post hoc test for Materials and Resources | | |
|---|---|---|
| **LEED Rating earned** | **N** | **Subset 1** |
| Certified | 65 | 4.68 |
| Silver | 61 | 5.69 |
| Gold | 51 | 5.75 |
| Platinum | 4 | 6.00 |
| Sig. | | .171 |

| Post hoc test for Innovative Design | | | |
|---|---|---|---|
| LEED Rating earned | N | Subset | |
| | | 1 | 2 |
| Certified | 65 | 2.88 | |
| Silver | 61 | 3.59 | 3.59 |
| Gold | 51 | | 4.39 |
| Platinum | 4 | | 4.50 |
| Sig. | | .455 | .240 |

The post hoc analysis for the categories without equal variance (SS, EA, and IEQ) also used rating as the dependent variable. The table below is based on observed means. The error term is Mean Square(Error) = 1.553. The mean difference is significant at the level indicated in the Sig. column.

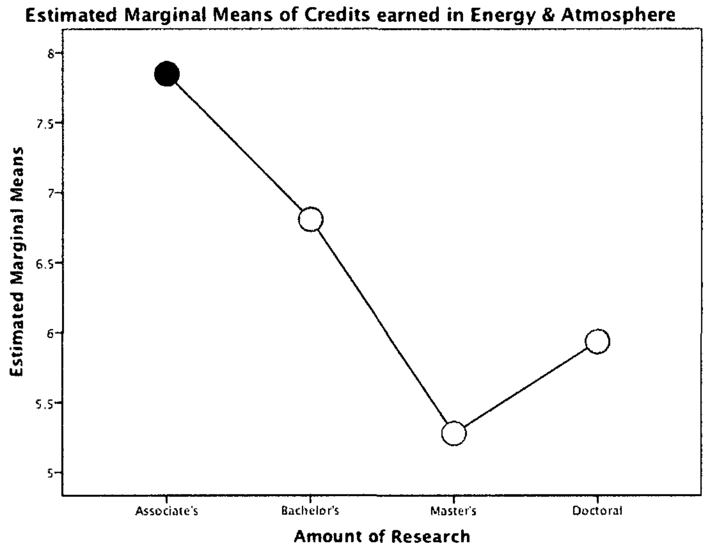
| Post hoc tests using Games-Howell with rating as dependent variable | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dependent Variable | (I) LEED Rating earned | (J) LEED Rating earned | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
| | | | | | | Lower Bound | Upper Bound |
| Credits earned in Sustainable Site | Certified | Silver | -1.09* | .339 | .010 | -1.97 | -.20 |
| | | Gold | -2.44* | .331 | .000 | -3.30 | -1.57 |
| | | Platinum | -3.94* | .524 | .004 | -6.00 | -1.88 |
| | Silver | Certified | 1.09* | .339 | .010 | .20 | 1.97 |
| | | Gold | -1.35* | .366 | .002 | -2.31 | -.40 |
| | | Platinum | -2.86* | .547 | .012 | -4.86 | -.85 |
| | Gold | Certified | 2.44* | .331 | .000 | 1.57 | 3.30 |
| | | Silver | 1.35* | .366 | .002 | .40 | 2.31 |
| | | Platinum | -1.50 | .542 | .131 | -3.52 | .51 |
| | Platinum | Certified | 3.94* | .524 | .004 | 1.88 | 6.00 |
| | | Silver | 2.86* | .547 | .012 | .85 | 4.86 |
| | | Gold | 1.50 | .542 | .131 | -.51 | 3.52 |
| Credits earned in Energy & Atmosphere | Certified | Silver | -1.90* | .434 | .000 | -3.03 | -.77 |
| | | Gold | -4.26* | .445 | .000 | -5.42 | -3.10 |
| | | Platinum | -11.97* | .493 | .000 | -13.65 | -10.29 |
| | Silver | Certified | 1.90* | .434 | .000 | .77 | 3.03 |
| | | Gold | -2.36* | .484 | .000 | -3.62 | -1.10 |
| | | Platinum | -10.07* | .528 | .000 | -11.75 | -8.38 |
| | Gold | Certified | 4.26* | .445 | .000 | 3.10 | 5.42 |
| | | Silver | 2.36* | .484 | .000 | 1.10 | 3.62 |
| | | Platinum | -7.71* | .537 | .000 | -9.39 | -6.02 |
| | Platinum | Certified | 11.97* | .493 | .000 | 10.29 | 13.65 |
| | | Silver | 10.07* | .528 | .000 | 8.38 | 11.75 |
| | | Gold | 7.71* | .537 | .000 | 6.02 | 9.39 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Credits earned in Indoor Env. Quality | Certified | Silver | -1.61* | .337 | .000 | -2.49 | -.73 |
| | | Gold | -2.85* | .384 | .000 | -3.86 | -1.85 |
| | | Platinum | -5.18 | 1.215 | .061 | -10.73 | .38 |
| | Silver | Certified | 1.61* | .337 | .000 | .73 | 2.49 |
| | | Gold | -1.24* | .378 | .008 | -2.23 | -.25 |
| | | Platinum | -3.57 | 1.213 | .158 | -9.13 | 2.00 |
| | Gold | Certified | 2.85* | .384 | .000 | 1.85 | 3.86 |
| | | Silver | 1.24* | .378 | .008 | .25 | 2.23 |
| | | Platinum | -2.32 | 1.227 | .373 | -7.80 | 3.15 |
| | Platinum | Certified | 5.18 | 1.215 | .061 | -.38 | 10.73 |
| | | Silver | 3.57 | 1.213 | .158 | -2.00 | 9.13 |
| | | Gold | 2.32 | 1.227 | .373 | -3.15 | 7.80 |

## Appendix G: Tables Related to Follow MANOVAs in Question 3

This MANOVA was significant using the Pillai's test: $F(18, 522) = 1.897$, value $= .184$, $p=.014$. Variances were equal across rating groups (Box's M= 72.134, $F=(63, 7449) = 1.020$, $p=.432$). Confirming the results of the prior Regression analysis, the ANOVAs for SS and EA both significant. The ANOVA for SS was: $F(3, 177) = 3.026$, MSE = 13.217, $p=.031$. The ANOVA for EA: $F(3, 177) = 2.731$, MSE = 28.863, $p=.045$. A means plot is provided directly below.

*Means plot for Energy and Atmosphere credits earned by institutional type.*




| Tests of Between-Subjects Effects for Type of Institution | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Source** | **Dependent Variable** | **Type III Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** | **$R^2$** |
| Type of Institution | Credits earned in Sustainable Sites | 39.650 | 3 | 13.217 | 3.026 | .031 | .049 |
| | Water Efficiency | 7.466 | 3 | 2.489 | 1.434 | .234 | .024 |
| | Energy & Atmosphere | 86.589 | 3 | 28.863 | 2.731 | .045 | .044 |
| | Materials & Resources | 16.556 | 3 | 5.519 | 1.899 | .132 | .031 |
| | Indoor Env. Quality | 10.233 | 3 | 3.411 | .621 | .602 | .010 |
| | Innovative Design | 6.091 | 3 | 2.030 | 1.063 | .366 | .018 |
| $R^2$ and Partial Eta Squared were identical in the MANOVA tests in this study. As such, the $R^2$ reported also indicates the Effect Size of each individual measure. | | | | | | | |

| Credits earned in Sustainable Sites | | |
|---|---|---|
| Type | N | Subset |
| | | 1 |
| Associates | 13 | 6.69 |
| Bachelor's | 41 | 6.80 |
| Masters | 36 | 7.42 |
| Doctoral | 91 | 7.86 |
| Sig. | | .155 |

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square(Error) = 4.368. Tukey HSD. Uses Harmonic Mean Sample Size = 28.555. Alpha =.05.

| Credits earned in Energy & Atmosphere | | | |
|---|---|---|---|
| Type | N | Subset | |
| | | 1 | 2 |
| Masters | 36 | 5.28 | |
| Doctoral | 91 | 5.93 | 5.93 |
| Bachelor's | 41 | 6.80 | 6.80 |
| Associates | 13 | | 7.85 |
| Sig. | | .289 | .121 |

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square(Error) = 10.570. Tukey HSD. Uses Harmonic Mean Sample Size = 28.555. Alpha =.05.

## Appendix H: Tables Related to Change Over Time for Step 4

The results below are also illustrated using means plots (included in the main body of the text). The follow post hoc test reported immediately below used Using Tukey HSD. It is based on observed means with Mean Square(Error) = .758.

| Post hoc test comparing sample and balance of the population based on version | | | | | | |
|---|---|---|---|---|---|---|
| (I) Version of LEED used | (J) Version of LEED used | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
| | | | | | Lower Bound | Upper Bound |
| 2.0 | 2.1 | -.08 | .130 | .827 | -.38 | .23 |
| | 2.2 | -.35* | .138 | .030 | -.68 | -.03 |
| 2.1 | 2.0 | .08 | .130 | .827 | -.23 | .38 |
| | 2.2 | -.28* | .092 | .008 | -.49 | -.06 |
| 2.2 | 2.0 | .35* | .138 | .030 | .03 | .68 |
| | 2.1 | .28* | .092 | .008 | .06 | .49 |

The following table provides the results of an ANOVA for the population. It shows that in the population, ratings under v2.2 were significantly different from the earlier versions.

| ANOVA for population, based on LEED rating earned | | | | |
|---|---|---|---|---|
| (I) Version | (J) Version | Mean Difference (I-J) | Std. Error | Sig. |
| 2.0 | 2.1 | -.076 | .130 | .827 |
| | 2.2 | -.352* | .138 | .030 |
| 2.1 | 2.0 | .076 | .130 | .827 |
| | 2.2 | -.276* | .092 | .008 |
| 2.2 | 2.0 | .352* | .138 | .030 |
| | 2.1 | .276* | .092 | .008 |

# VITA

Shannon Massie Chance

| | | |
|---|---|---|
| Birthdate: | February 7, 1970 | |
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| Education: | 2006-2010 | The College of William and Mary<br>Williamsburg, Virginia<br>Doctor of Education |
| | 1993-1996 | Virginia Polytechnic Institute and State University<br>Blacksburg, Virginia<br>Master of Architecture |
| | 1988-1993 | Virginia Polytechnic Institute and State University<br>Blacksburg, Virginia<br>Bachelor of Architecture |
| Registrations: | 2009-present | LEED Accredited Professional (LEED AP)<br>United States Green Building Council |
| | 2005-present | Registered Architect, Commonwealth of Virginia |
| | 2005-present | NCARB Certified Council Record Holder<br>National Council of Architectural Registration Boards |
| Employment: | 1999-present | Hampton University Department of Architecture<br>Hampton, Virginia – Tenured Associate Professor |
| | 1999-present | ReConstruct Architecture<br>Portsmouth, Virginia – Sole Practitioner |
| | 2005 | Fulbright-Hays Group Projects Abroad<br>Dar es Salaam, Tanzania – Program Director |
| | 1998-1999 | Tymoff+Moss Architects<br>Norfolk, Virginia – Intern Architect |
| | 1996-1997 | Studio Wagner<br>Carona, Switzerland – Architetto |
| | 1994-1995 | Virginia Tech College of Architecture & Urban Studies<br>Blacksburg, Virginia – Lecturer |