Fall 12-3-2015

CREATING HEALTHY SCHOOLS: IDENTIFYING THE POSITIVE IMPACTS OF PRACTICING SUSTAINABLE INTERIOR DESIGN IN EDUCATION FACILITIES

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by

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A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Major: Architecture

Under the Supervision of Professor Lindsey Bahe

Lincoln, Nebraska

December 2015

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University of Nebraska, 2015

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A significant amount of research identifies a relationship between the physical environment of educational facilities and how the design can positively or negatively impact teachers, staff and students. Evidence indicates that America's school facilities are outdated, decaying, and need repair. This presents an opportunity for interior design professionals to create high-quality learning environments through an emphasis on sustainable design practices.

This thesis examines interior spaces of two high school buildings in North Mississippi. Site A incorporated sustainable design principles while Site B did not. To limit influential variables, the two sites were selected because of the location and similar population size. The method of the research was a qualitative mixed method approach used to evaluate each school. The objective was to determine the positive and negative impacts each built environment had on the occupant's overall well-being, teaching, and learning activities.

The first phase was site observations to inventory the building's physical characteristics. The researcher had a primary focus on the indoor environmental qualities (IEQ), and documented the presence or absence of sustainable design elements. These findings were used for comparison after the second and third phase data collection, which

included electronic survey to faculty and staff, and interviews with each principal. The questions asked to all participants were used to understand their overall satisfaction with the school's built environment, and if it adequately supported their daily activities. These methods provided data which allowed the researcher to determine if sustainable design principles were perceived more positively than the non-sustainable design principles by the occupants of each school.

The research findings combined with literature review identifies benefits from integrating sustainable design in educational facilities. The findings offer a more specific study on the positive impacts of sustainable design, which is beneficial for design professionals, school administrators, and policy makers. In addition to the positive benefits, the findings also indicated that other variables outside of sustainability influenced the participant's overall satisfaction with their school environments. Due to the limitations, continued research is needed for occupants to experience the benefits of a sustainably designed and healthy school.

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CHAPTER I: Introduction

There is a significant amount of research indicating that the majority of America's public school facilities are in poor physical condition due to age, and inadequate maintenance work. This neglect is deteriorating the buildings at an accelerated rate (Filardo, Berstein, Eisenbrey 2011, 1). The buildings lack modernization of technology, adequate space, and healthy building materials, which are negatively impacting students, faculty, and staff. These poor physical conditions are negatively impacting occupants because they spend more time in their school environment than their homes. There are more than 62 million Americans spending an average annual of 1,016 hours in school buildings (National Research Council, 2007, 17). Therefore, there is a need for improving the physical features of these schools, and at the same time eliminate indoor hazards (Alexander, D., Lewis, L., Ralph J., 2014, 4).

According to the U.S. Department of Education's 2012-13 evaluation report for the National Center for Education Statistics' (NCES), a majority of America's public school facilities are on average 44 years old, or had been renovated 12 years ago (Alexander, D., Lewis, L., Ralph J., 2014, 4). These vast numbers of older school buildings are negatively impacting individuals caused by environmental factors. The problem is significant because there are more than 62 million Americans spending an annual of 1,016 hours of their time in these facilities (National Research Council, 2007, 17). The negative impacts consist of distractions from learning because of overcrowding, noisy conditions, poor air quality, and in proper lighting. The buildings are not only affecting the individuals, but they are also negatively impacting the environment by consuming 40% of the U.S. energy, and a large amount of raw materials (National Research, 2007, 16).

Research has shown that poor indoor environments can negatively affect the health and development of children and adults in school buildings (Uline, C., Tschannen-Moran, M., 2008, 55). These include building materials, systems, maintenance operations, and cleaning practices (National Research Council, 2007, 16). Therefore a strong valued base solution is needed to improve the indoor built environment within school buildings. This can be achieved through new and renovation construction with an emphasis on sustainable design.

By making sustainability a priority for school construction, new building designs will meet the needs of the present generation without compromising the needs of future generations (UN Brundtland Report, 1987). As a result, schools buildings integrated with sustainable design principles will encompass more of a global approach. This is achieved through better environmental strategies and by focusing on the health performance of occupants. The outcomes can provide better learning opportunities by allowing occupants to actively engage with their school buildings. This experience can enhance 21st century learning because it's both human and environmentally centered (Hon, 2010, 1).

One group of professionals that can significantly impact the design of school buildings with a focus on sustainability is interior designers. According to previous research conducted by the University of Salford's School of the Built Environment, researchers found after a yearlong study examining 751 students in 32 classrooms across

7 primary schools that classroom design significantly improved academic performance. The researchers indicated that environmental factors studied affected 73 percent of the changes in student scores. Students were assessed for academic performance, and classroom interiors were rated on environmental qualities of classroom orientation, natural light, acoustics, temperature, air quality, and color (The Huffington Post, 2013, p1). All of these components are part of the built environment where professional interior designers make decisions relative to the design of the space. This evidence supports that interior designers do have a vital role in improving the indoor environment of school buildings because of their multi-faceted responsibilities. These include solutions that are both creative and technical which are applied within a structure to achieve an interior built environment that solves the occupant's problems. The solutions are functional, enhance the quality of life and culture of the occupants, and are aesthetically attractive, and must adhere to code and regulatory requirements, and encourage the principles of environmental sustainability (Mazarella, F., 2011, p1).

Interior designers that practice sustainable design through a holistic approach can positively impact the building occupants, the community, and the environment. They achieve this by addressing the interrelating social, aesthetic and economic issues within a school building. This is a significant solution when designing school buildings because it is the interior designers' social and moral responsibility. The outcome of their school designs should create spaces that are functional, safe, comfortable, and healthy. By creating healthy school environments, interior designers are acknowledging the importance of health and learning. Health is a human right, and educational facilities where students, faculty, and staff occupy on a daily basis should support this right.

In order to understand the significance of sustainable design practices, it's important to define the history. According to the World Commission on Environment and Development, sustainable design is defined as, "Meeting the needs of today without compromising the ability of future generations to meet their own needs." It is a fully integrated building that provides optimal environmental and economic performance by saving energy, water, and natural resources; and is a product of quality indoor spaces using environmentally preferable materials (Ramli, N.H., Masri, M.H., Mohd, Z.H., Hamid, N.A., Hamid, T., 2012, 463).

The sustainable design movement is not a new solution. The United States Green building Council (USGB) was established in 1993, and is the practice of reducing environmental impacts of design, avoiding the depletion of natural resources, and led the transformation of the building industry to sustainable practices. In 2000, the organization created a measurable method to define and measure sustainable buildings, which was Leadership in Energy and Environmental Design (LEED). LEED's rating system has evolved since 2000. It now addresses project development, and offers rating systems for specific building types. The rating system has 80 base points, and they are distributed between seven topics including: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), Indoor Environmental Quality (IEQ), Innovation Design (ID), and Regional Priority (RP). A LEED project must meet the rating requirements by gaining points through credits. Each credit is allocated points based on the relative importance of the building-related impacts it addresses. Then LEED weights the credits by a third-party commissioning process in order to receive certifications. There are four levels of certification that include certified (40-49 points), silver (50-59 points), gold (60-79 points), and platinum (80 points and above) (USGBC 2013).

While LEED 2009 Green Building Rating System is a good guideline for designing and constructing school facilities, it is not the only method. Sustainability can be achieved through integrating the principles without choosing LEED certification. The goal is for the end result to provide a better building performance over its life cycle in lieu of having a certification. However, both methods require design professionals to design buildings that provide; clean fresh air, comfortable temperature ranges, abundant light, proper acoustics, minimal pollution, and a reduced consumption of energy. Another important aspect of sustainable design is to provide indoor environmental qualities. These are the components that help create a physically comfortable learning environment, and have a significant role in impacting school occupants.

An increase in research studies has indicated that sustainably designed schools can improve student health and academic performance. These school designs have also been found to be cost effective, more comfortable, and are both socially and environmentally responsible (Arthur, 2014, 21). This finding supports the proposed solution to update our nation's school buildings with a sustainable design emphasis. It also indicates sustainable design is a solution that not only creates a reduced environmental footprint, but also provides benefits to students, faculty, and staff by positively impacting their experience and performance. The positive impacts can be shown in a measurable way through improved test scores, attendance, reduced discipline reports, and less vandalism because the occupants have ownership in the school, community, and environment. While sustainable design within school buildings has been found to be a potential factor in measurable improvements of occupants, there are also additional variables that can contribute to the positive impacts. These include but are not limited to school culture and leadership.

The purpose of this thesis is to examine design aspects of both non-sustainable and sustainable schools (on site and through literature review) in order to identify the different outcomes between the two spaces. This information is significant because it can demonstrate how schools can specifically benefit from incorporating sustainable practices in their construction projects. The research will be valuable to school districts because it can provide them evidence to fund, support, and justify new construction and building renovations for their communities in order to create healthier environments for students, faculty, and staff.

The components selected to measure, review, and analyze in the study include: acoustic environment, air quality, lighting (artificial and Natural), and thermal comfort. The components were selected using LEED 2009 for Schools New Construction and Major Renovations rating system as a standard for measure, this thesis will specifically focus on six credits within that rating system. Those six credits include Indoor Environmental Quality (IEQ) Credit 9: Enhanced Acoustical Performance, IEQ Credit 2: Increased Ventilation, IEQ Credit 4: Low-Emitting Materials, IEQ Credit 6.1: Controllability of Systems – Lighting, IEQ Credit 8.1: Daylight and Views – Daylight, and IEQ Credit 7.1: Thermal Comfort – Design. By examining these seven areas, this thesis will report how the indoor built environment positively affects the performance, health, and wellbeing of students, faculty, and staff.

CHAPTER II. Literature Review

2.1: Research Problem – America's Public School Building's Physical Conditions

In recent decades, there has been a focus on examining the physical condition of the nation's public school buildings, and the quality and condition of these learning environments continue to be a topic of concern. According to the 1989 Education Writers Association report twenty one percent of U.S. schools were built in the 1950s and 60s (Uline, 2000, 442). In the U.S. alone, more than fifty five million students and more than five million faculty, staff, and administrators spend 6.7 hours on an average school day, and 180 days a typical year in buildings with poor physical conditions which include poor indoor air quality, inadequate lighting, inferior acoustics, decaying interior finishes, overcrowding of classrooms, and uncomfortable thermal conditions (Lumpkin, 2013, 1; Ford, 2007, 6). The disrepair exists because the average U.S. school building is at least forty years old or older, and there has been an under spending in preventative maintenance. The lack of repair has significantly increased the rate of decay, and the overall costs of maintaining buildings that allows them to function properly for occupants, and achieve their projected life expectancy (Filardo, Bernstein, Eisenbrey 2011, p1; Council of Great Schools Report 2014, 1).

According to the United States Accounting Office, 1995-1996, a comprehensive study was conducted on the condition of public school facilities throughout the United States from January 1994 through February 1995. A questionnaire was mailed to a representative sample of 9,956 schools across the country and received a 78 percent return rate. The participants in the study included district facilities directors and central office administrators. The results indicated one third of the schools were reported as needing extensive repairs and sixty percent indicated need for at least one major repair in order to restore the quality and condition of the building. Half the schools reported maintenance problems with lighting, ventilation, heating, or security issues. The study concluded that two-thirds of the nation's schools were adequate condition; but that the remaining third represented 25,000 schools serving 14 million students were in inadequate conditions (GAO, 1996). In addition, 28 million students attended schools needing one major repair (GAO, 1996).

Unfortunately, millions of students are attending schools, and reporting unsatisfactory conditions. This evidence supports the need for improvement among U.S. public school buildings. The built environments of schools should provide functional spaces that positively support learning, health (both human and environmental), and the well-being of its students, faculty and staff. The built environment of these our schools can be powerful protectors and promoters, and they matter in the education environment. A growing body of research is connecting the quality of school facilities to student performance, furthering accompanying recent efforts to improve the state of the educational infrastructure in the U.S (Uline, 2008, p55).

Despite efforts to improve buildings, schools continue to deteriorate because of poor maintenance, funding, and age. This problem continues within our schools because superintendents and school board members are putting a higher emphasis on raising tests scores and improving standards over upgrading or maintaining facilities (Ford, 2007, 6). With this strategy, school districts are having difficulty managing both facilities and raising test scores. According to the American Society of Civil Engineers' (ASCE) 2005 Report Card for America's Infrastructure, America's schools received a D rating. This current assessment of the condition of our nation's school buildings indicates the struggle to update facilities because of high construction costs and limited funding (ASCE, 2005). A lot of the blame for infrastructure inequity falls on our school finance system. Low-income districts often get less money from the state, and they have less wealth to tax locally. It can also be challenging for low-income districts to get their communities to support the school bonds that help fund infrastructure projects (Boser, U. 2015, p1).

This lack of support for improving our nation's school structures is potentially reducing the positive impacts a school building can have on occupants. That is why there is a need to improve these facilities, so they help support a student's testing and learning skills. This is significant because research indicates a correlation between the school's built environment and student's performance on test scores (Edwards, 2006, 21). If school administrators expect their students to do well, a built environment should be provided with the necessary infrastructure for them to do so (Boser, U. 2015, p1). Therefore, the repairs and modernization must come first in order to produce positive outcomes. A growing body of research provides evidence of a link between school building quality and student achievement, attitude, as well as teacher attitude and behavior (Uline, 2008, 56). Well-designed schools are created through a collaborative method with design professionals, teaching experts, and students working together to make the best use of the space.

Despite the vast amount of evidence indicating the desperate need of improvement, another problem hindering implementing sustainable schools is there is not an archival system in place that documents the current state and history of our school buildings infrastructure. Because this information is not available, it makes it difficult for school officials to adequately asses, measure, and define the current condition of school built environments (State of Our Schools, 2013, 4). Without this information, stakeholders (policymakers, parents, educators, and designers) can't make informed decisions about what school repairs are precedents over others. With a current report on the physical condition of educational facilities, school districts will be able to better understand their needs, and create a quality school environment (The State of Our Schools, 2003. 4). This report should be updated every 10 years in order to keep a current report (The State of Our Schools, 2003, 11).

2.1.1: Negative Impacts of School Building Conditions

The negative impacts of school buildings is a significant nationwide problem because the large amount of people being impacted on a daily basis, over an extended period of time, and a vulnerable sector of the population including children and adolescents. Older buildings are inadequate in their ability to cope with anticipated changes such as shifting pedagogy, curriculum and learning expectations (Cardellino, P; Leiringer, R.; Croome, C.D., 2009, 249). These school buildings that are 30 years old or older are barriers to the advancement of teaching and learning in 21st Century learning environments. One study indicated students in poor condition schools had standardized achievement test scores between five to eleven percentile points lower than students in modern buildings (Council of Great Schools Report, 2014, 5). A second research study indicated students in buildings without AC performed three to twelve percentile points lower on measures of student performance than students in AC buildings (Council of Great Schools Report 2014, 6; Earthman, 2004).

Another example of how poor environmental qualities and older school buildings have negative impacts is the case study on Thirman L. Milner elementary school that relates the building design to learning. Thirman L. Milner is located in urban Hartford, Connecticut constructed in 1924, and its physical condition is one of the worst in the city. Hartford is the state's capital and it's the poorest in the city, and the student's test scores are the lowest in the state. Only seven percent attained the state goal for reading performance in 1995, and eleven percent met the goal for math and thirteen percent for writing.

The poor environmental qualities within this school are asbestos flooring, lead paint that is cracking and peeling, roof leaks, and overcrowded classrooms. There is also a lack of modernization, and spaces that inspire learning. It is a traditional design with never-ending hallways. It lacks a balance between technical needs of function, and creativity, and it has fallen into a state of disrepair making it an unacceptable place learn or teach (Uline, 2000, 444). This building is a representation of many school buildings across the nation, and how their deteriorating conditions are negatively impacting learning, and are not safe to occupy.

One of the challenges for interior designers when designing a school building is creating a quality indoor environment. Defining what is considered a quality learning environment is multifaceted. Building characteristics associated with the quality of a space include both functional and aesthetic aspects (UNICEF, 2000, 7). Functional relates to the building performance and construction, and includes proper systems of lighting, mechanical, fire protection, and plumbing. These systems help create schools that are safe, healthy, secure, environmentally sustainable, and flexible. Functional quality also includes concepts associated with building use, access and space. It provides adequate size rooms, proper furniture, and equipment that support learning and teaching. Aesthetic qualities help create an emotion or experience for the occupants. By having an interaction with the school's infrastructure, this connection creates a quality environment that is peaceful, safe, supports learning and influences participation (UNICEF, 2000, 8).

There is not only a correlation between a quality designed school and student's performance, but can have impact on teachers and staff. There is a large amount of empirical literature that investigates how school facility quality impacts teacher retention in school districts across the U.S. The No Child Left Behind Act (NCLB) mandates that all teachers in core subjects be "highly qualified" by 2005-6. This mandate presents a challenge for school districts to attract and retain qualified teachers because research shows that one-quarter of all beginning teachers leave teaching within four years (Buckley, Schneider, Shang, 2004, 1; Benner, 2000; Rowan et al. 2002). The environment and quality of space may have impact on retaining qualified teachers in their profession longer. The consideration of the schools conditions are just as important as salary in retention decisions made by teachers (Buckley, Schneider, Shang, 2004, 2). Theoretically the design quality is an important aspect because the building can affect a teacher's ability to teach, their morale, safety and health.

One environmental component that can have negative impacts on occupants is poor indoor air quality (IAQ). IAQ refers to the presence or absence of air pollutants in buildings. Pollutants can impact the health of occupants, and if they are negative it can lead to “sick building syndrome.” This can also lead to increase absenteeism due to health related problems caused by the building. For example, two-thirds of Washington teachers surveyed reported poor indoor air quality in their schools (Buckley, Schneider, Shang, 2004, 3). To test the link between school facility condition and teacher retention Buckley, Schneider, and Shang researchers used data from a survey of teachers in Washington, D.C. Their main variable was reflected by the grade the teachers measured the school facility (Buckley, Schneider, Shang, 2004, 4). The results indicated an empirical analysis that suggested that the benefits from facility improvement for retention can be equal or greater than those from teacher pay increases (Buckley, Schneider, Shang, 2004, 7).

Overall the results from the literature review support a relationship between school building designs and their impact on the behavior and experience of their occupants. The impacts include academic performance, positive learning, improved levels of teaching, and improvements in morale, motivation, and attainment. The relationship between people and their built environment is multifaceted in nature. The physical environment that is constructed is a social phenomenon as it is a physical one (Cardellino, P.; Croome, D.J.; Leiringer, R.; 2009, 251). The research focused on in this thesis will isolate the component of sustainable design elements and there perceived effect on students, faculty, and staff’s level of satisfaction with their school environments. It also determined their perception of how the space supported their learning, and teaching activities.

The literature also indicated a significant need for building improvements across the U.S., further validating the importance and market for the design and re-design of school facilities across the country. Inadequate buildings are creating opportunities for school districts to build new and/or renovate structures into 21st Century Schools that provide a sustainable design environment and contribute to the criteria of a quality school. With a sustainable design approach, this new construction and remodels can have impact on our environment, as well as the behavior and experience of the students, teachers, and staff who occupy them.

2.2: Research Significance - School Building Opportunities

One key element designers can focus on when providing high-quality educational experiences is designing facilities that integrate sustainable design. The baseline when designing, or re-designing these learning environments should always be safety, and health. With this baseline, designers should also aim to elevate the design of space beyond the technical requirements, and focus on how it can improve the quality of ones experience in space. This can be achieved by creating spaces that are healthy and exciting, so people interact, thrive, and enjoy their school environments. Improvements should consist of social connections that encourage communication and participation within the school structure, and are conducive to learning (Kennedy, 2010, 12). Having a connection to the built environment allows learning and activities to take place throughout the entire school not just the classrooms.

An improvement to schools through an integrated design process doesn't just impact occupants, but has the potential to impact the community. By providing multi use spaces that support collaboration and flexibility, it creates improved school environments.

All t design aspects together can make a school a place that people want to be. In order for sustainably designed schools to be successful, all the elements must be integrated into each aspect of the project. However the elements cannot stand alone, they are part of the whole building. There can be no separation between sustainability and building because they are both one in the same.

With evidence strongly supporting an interconnection between school buildings, people, and community, as interior designers' they have a responsibility not only to create people's surroundings, but also to make sure the surroundings support activities and needs of the individuals who use the space. Therefore, a more focused initiative and value of improving our educational facilities using sustainable and LEED standards as a guide, we will not only improve learning, health, and satisfaction of our students and teachers, but will significantly impact our environment by reducing carbon footprints. Interior design strategies should focus on creating interiors that demonstrate environmentally responsible sustainable design. This type of design is different from traditional practices, and focuses on materials' intended application, aesthetic qualities, environmental, and health impacts, availability, ease of installment and maintenance, and initial and life cycle costs (Hayles, C.; 2015, 101)

One way to increase the practice of sustainable design is to eliminate confusion between "green building", "high-performance", and "sustainable design" through defining the distinction between terms. First, green design is a practice that reduces environmental impacts of design. It is associated with individual products, processes, and services that reduce health and environmental impacts when compared to similar products, processes, and services used for the same purpose (Mokhtar, Deng, 2014, 163).

It encompasses a focused approach on the building and individuals that are directly impacted by building materials at the present versus how the buildings and materials will impact the environment and individuals over a longer period of time (World Commission on Environment and Development, 1987).

A high-performance school is defined as a building varying in size, shape, and structure. It has similar characteristics of a green school because it incorporates healthier, more resource-efficient building materials that conserve energy and water. However, these building characteristics are not the main focus in creating a high performance school. A high-performance school's mission is to be a well-designed building that enhances performance and makes the education experience more enjoyable (CHPS). This type of school environment is enforced by CHPS (The Collaborative for High Performance Schools), which is a non-profit organization that is leading a national movement to improve student performance and the educational experience. CHPS is significant to design professionals and school officials because it provides a best practices manual to help with creating school designs. It also provides actual case studies of how high performance schools were constructed, and how they provided benefits to occupants. With this evidence based design, other school districts and design professionals can learn new methods of designing school facilities through a high performance approach.

The U.S. Green Building Council (USGBC) defines a sustainable school as "A school building or facility that is conducive to learning while saving energy, resources, and money." Sustainability encompasses a global approach being tied to whole systems by not only improving a school building infrastructure for occupants of the present, but making improvements that will not jeopardize future generations (UN Brundtland Report, 1987). This method of design seeks to reduce negative impacts on the environment, and the health and comfort of school building occupants by improving building performance. The basic objectives of sustainability are to reduce consumption of non-renewable resources, minimize waste, and create healthy and productive environments (World Commission on Environment and Development, 1987). These are achieved by design professionals incorporating low-impact materials of recycled content, which are non-toxic, and require little energy to process. Sustainable design principles also focus on energy efficiency and durable design by reducing the consumption of waste of resources and increasing durability (U.S. General Services Administration, 2015).

By comparing the terms; green design, high performance, and sustainable design, the findings clearly identified these are not interchangeable terms. While each design method focuses on creating buildings that are environmentally responsible, the design outcomes set out to achieve different focuses. Overall, a sustainable design school is a built environment that encompasses a variety of concerns and needs. It is a design that has incorporated sustainable design principles which focus on creating positive impacts on human health and the planet. The mission is to design for the health, safety, and welfare of the planet by practicing environmental responsible design.

Sustainable design principles are typically measured on how well they are integrated into the whole building design and build process through building components and systems. The finished product is measured to determine how well the sustainable design worked to save energy, and reduce environmental impact (Olson, S.; Kellum,S., 2003, 3). However, there is an additional need for this design method to expand its mission by focusing on the school's spatial configuration more critically and to further develop a creative indoor school environment Adler, T. (2009). A school should be a space that reinforces learning experiences, and impact how students acquire knowledge and develop skills to be successful citizens in our society. The schools can be used as learning tools in helping pupils understand how human impact can affect the planet and encourage them to weigh up the evidence themselves. A sustainable design approach creates school buildings that are used as models of good practice, and offer students the chance to contribute to sustainable living, and demonstrate good practices to others (DCF, 2008, p5). Sustainably designed schools have important roles in producing high-quality facilities that have minimal impact on natural resources. This responsive design approach would help interior designers create more innovative and sustainable learning environments that would shape learners, and allow them to be influenced by their school environment. This aspect transitions the sustainable learning environment from just a "green" school to a social development that enriches the 21st century education environment and learner (Lippman, P.C.; 2010, 1).

There is an opportunity to improve learning even more. By establishing the theory of interaction between the learners and the built environment, interior designers and other design professionals are acknowledging a better design solution for improving education facilities. The built environment shapes the learner, and the learner will influence the learning environment; this understanding creates student motivation in their physical environment with more engagement and active learning. Sustainability is an important component in innovative design because it balances three factors; these factors include social, environmental, and economic interests (Lippman, P.C.; 2010, 3). By designing school buildings that address these factors through a collaborative process among design professionals, the process better insures the growth of sustainable design in a positive direction for the long term. This process should include identifying the sustainable design goals, objectives, and benefits achieved through improving a school building. This approach is beneficial because it will bring awareness to our society about the importance of driving school improvements through sustainable design. In return sustainable design practices will gain public support because our society will have a better understanding about this method of design, and the interrelationships among diverse stakeholders of design professionals, school officials, and the community (Lee, 2014, 161).

2.2.1: Defining Indoor Environment Quality Factors

In order for sustainably designed schools to provide better opportunities for students, teachers, and staff, the building improvements should not only reduce environmental impacts, but the design should also support learning and teaching. One method to achieve this goal is for interior designers to provide indoor environment quality (IEQ) factors to a new school project. IEQ factors are important for a sustainably design school because they can help reduce distractions, which can help improve the occupants' comfort levels. Sustainable building practices with an emphasis on IEQ factors provide optimally safe, healthy, comfortable, and productive learning environments for students, faculty and staff. This design method specifically benefits students because if they are not uncomfortable or distracted by poor lighting, heating, cooling, and ventilation noise their ability to learn will not suffer (Olson, S.; Kellum,S., 2003, 3). As interior designers, it is important to consider good IEQ in schools throughout the design and construction process because the benefits include a profound impact on students' ability to learn and teachers' ability to teach.

IEQ creates positive impacts for sustainable schools. One impact is through creating superior indoor air quality that reduces exposure to chemicals and environmental toxins, which can contribute to building related illnesses (Ford, 2007, 6). Another benefit includes increasing student performance. Research has indicated that people work better in places they feel comfortable (Samani, Samani, 2012, 129; Oneworkplace, 1999; Monteiro, 2012). The two IEQs that have had a profound effect on comfort and performance are daylighting versus artificial lighting and indoor air quality (IAQ.).

Daylighting is the use of sunlight to conduct specific tasks. This type of lighting strategy is beneficial because it can help lower utility costs by reducing the amount of energy consumed from electric/artificial light, while providing occupants a visual connection to the outdoor environment (Olson, Kellum, 2003, 7; Devolder 2002, 322). Lighting impacts people's life, health, productivity, and performance, and should be comfortable to all building users by supporting human needs of visibility, task performance, communication, and social behavior, health, and safety(Samani, Samani, 2012, 129). The design should aim to supply appropriate luminance, color temperature, and meet requirements the building's occupants.

In 1999 the Heschong Mahone Group (HMG) conducted a research study for Pacific Gas & Electric (PG&E), and focused on the effect of daylighting had on student performance. The data was collected from three elementary schools across the nation, and looked for a correlation to the amount of daylight provided by each classroom environment. They analyzed results for over 21,000 students, retrieved architectural plans, aerial photographs, and maintenance records, and site observations that classified the daylighting conditions in the classrooms. The results indicated that the students exposed to the most daylighting within their classrooms progressed 20% faster on math tests, and 26% faster on reading tests in one year than those with the least. The study found that skylights improved the daylighting by 19-20% than those classrooms without a skylight (Heschong Mahone Group, 2003, p2). The lessons learned about daylighting in this study established a positive correlation between higher test scores and the presence of daylight in classrooms due to many variables of improved visibility due to higher illumination levels, and improved light quality, which helped lead to improved student performance (Heschong Mahone Group, 2003, p29). These results affirm that daylight is significant for improved student performance.

Another important IEQ factor is creating good indoor air quality (IAQ), which is evaluated by the chemicals, and airborne impurities or toxins that have negative effects on occupants, including increased respiratory and asthma symptoms (Olson, Kellum, 2003, 7; EPA, 2000). Evaluating IAQ involves measuring for appropriate levels of airborne contaminants of volatile organic compounds (VOCs), and other pollutants. Good IAQ can be accomplished by eliminating VOC emitting building materials, which are typically found in adhesives, sealants, paints, coatings, carpet, composite wood, and agrifiber products (Hon, 2010, 9). According to the U.S. Environmental Protection Agency, air quality is magnified for indoor environments, and pollutants many are two to five times and even one hundred times higher than the air outdoors (Olsen, Kellum, 2003, 9; EPA, 2000).

According to *Greening America's Schools: Costs and Benefits,* a Capital E Report for U.S. Green Building Council, providing good IAQ in school building can contribute to improving health and educational settings for students, faculty, and staff. Currently in conventional school environments, poor indoor air quality can cause occupants to be 30% to 50% more likely to have respiratory problems such as asthma and allergies that lead to increased absenteeism, and diminished learning an test scores (Kats, G.; 2006, 19). This evidence supports the reason why it's important for interior designers and design professionals to provide school designs with good IAQ; this is significant for student achievement because "well maintained schools can reduce asthma 40% and upper respiratory infections 70% by utilizing best practices of IAQ," (Lumpkin, 2013, 2). If students and faculty are healthier, they will be present in class instead of being absent due to building-related illnesses; this increases their ability to perform and learn more successfully.

A research study was conducted by Diana Haigh of Martin Centre at Cambridge University, where she investigated various environmental conditions within fifty-four sustainable and non-sustainable designed school buildings in Hamphire and Essex, England. The purpose of the study was to determine if sustainable schools provided teaching and learning benefits, if these aspects within the classroom enhanced educational performance, and what was the perception of sustainable schools by the major stakeholders (Edwards, 2006, 16). The research measured user performance in both types of school designs and focused on the IEQ factors that were either present or not present in the classrooms. The IEQ factors included natural light, ventilation, and locally sourced building materials. The researcher investigated five performance indicators;

these included student tests, student satisfaction, teacher turnover, and teacher satisfaction. The research method included interviews with the student and teacher participants (Edwards, 2006, 20). The research findings were significant because they suggested that school buildings designed on sustainable principles offered more benefits for students and teachers. Productivity improved 4%, test scores were 3%-5% higher, and bullying incidents were reduced when compared to the non-sustainable schools (Edwards, 2006, 21).

Despite previous literature identifying both the physical problems with America's school buildings, and the value of integrating sustainable design, there is still limited research providing design guidelines and explanations of how interior designers can make sustainable design choices more frequently when designing school buildings. As a result from lacking this research, a majority of school administrations are not applying sustainable design principles to their school construction projects. These findings are significant to identify in order to create more sustainable school buildings in the future (Marchman, Clarke, 2011, 1). Therefore, this thesis will focus more in-depth on four IEQ factors of acoustic quality, indoor air quality, artificial lighting versus daylighting quality, and thermal comfort quality to further develop a comprehensive understanding of what constitutes sustainable interior design practice for school building projects.

Figure 2.2. A: The whole sustainability framework. (Barr, S.K., Cross, J.E., Dunbar, B.H., 2014, *Center for Green Schools at USGB*, 2)

TABLE A

Financial Benefits of Green Schools ($/ft²)	
Energy	$9
Emissions	$1
Water and Wastewater	$1
Increased Earnings	$49
Asthma Reduction	$3
Cold and Flu Reduction	$5
Teacher Retention	$4
Employment Impact	$2
Total	**$74**
Cost of Greening	**($3)**
Net Financial Benefits	**$71**

Figure 2.2.B:. The financial savings are about $70 per square foot, 20 times as high as the cost of going green (Kats, G., 2006, *Greening America's Schools Costs and Benefits*, 2)

2.3: Acoustic Quality

School buildings are complex learning environments where students learn and practice extracurricular activities, teachers educate, coaches instruct athletes, and staff members work on specific tasks such as counseling, nursing, and maintenance. It is also a place where principals, assistant principals, and superintendents perform administrative duties of planning curriculum, school budgets, and meeting with parents or other members of the community to achieve goals for their school system. Many of the tasks conducted by the occupants involve concentration and communication modes of speaking and listening. Therefore, good acoustical quality is essential for student learning and adult productivity.

Research has shown that noise exposure affects educational outcomes and provides evidence of mechanisms that explain the effects of noise on learning. Managing the acoustical environment within school facilities can be difficult with excessive background noise from outdated mechanical systems, and significant noise levels transmitted through walls and windows from the exterior or adjacent indoor spaces (National Research Council 2007, 92). If spaces do not contain a proper balance of sound absorbing materials and volume within the space, generated noise is uncontrollable. This is caused by increased reverberation noise times, which is the amount of time it takes for a loud sound to die away after the source is turned off. Reverberation sounds are distracting because they are competing with ambient noise, the level of the total noise in the space (National Research Council 2007, 93).

Having excessive noise interferes with learning, affecting memory and speech development; it creates distractions that impair students' ability to pay attention, causing an interference with their performance of various tasks. It also causes vocal impairment for teachers because they have to raise their voices to be heard over sounds, which negatively impacts their health, causing increased absenteeism (National Research Council 2007, 97, 100). According to Earthman and Lemasters' (1997) report evaluating fifty-three studies pertaining to school facilities, student achievement, and student behavior, a link exists between acoustics and learning. The report findings included that good acoustics are fundamental for good academic performance and high levels of excessive noise caused stress in students. Additionally, 70% of Washington, D.C. teachers reported that their classrooms and hallways were so noisy it affected their ability to teach (Buckley, Schneider, Shang 2004, 4).

There is evidence that excessive noise and reverberation, uncontrolled by classrooms' design features, negatively impact students and teachers. A solution to this problem is under the Indoor Environmental Quality (IEQ) of LEED for Schools New Construction and Major Renovations Rating System, Prerequisite 9: Enhanced Acoustical

Performance. This credit attempts to reduce noise in education facilities to levels that previous studies have shown to be universally supportive to students' and teachers' abilities to perform and communicate effectively in the classroom.

Interior designers have the capability of effecting noise pollution by the selecting of finishes, types of lighting fixtures, and adjacencies of certain room types. Because interior designers have a responsibility to design the indoor environment, accommodating practices to meet good acoustics is adding value in learning environments. Design strategies include using sound-absorbing materials such as ceiling tiles, acoustical wall panels, and carpet. All these materials reduce the amount of hard surfaces and provide better sound absorption to effectively reduce noise levels.

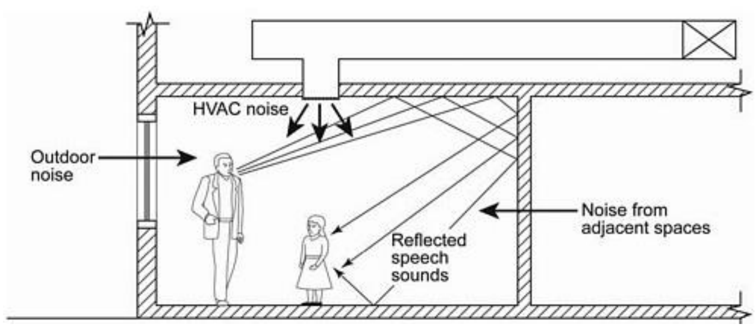


Figure 2.3. A: Key noise and reverberation in classrooms (National Research Council 2007, 93).

2.3.1: IEQ Prerequisite 9: Enhanced Acoustical Performance

IEQ Prerequisite 9: Enhanced Acoustical Performance can earn the building one point toward achieving LEED (Leadership in Energy and Environmental Design) certification. LEED is a rating system that is recognized as the international mark of excellence for green building in one-hundred-fifty countries (USGBC). This LEED prerequisite refers to the classroom acoustical environment with the intent to create quiet classrooms, in order to provide classrooms that facilitate better teacher-to-student and student-to-student communications through effective acoustical design. This allows the teachers to speak without straining their voices, and students can learn effectively by communicating with each other and the teacher. The credit requires the design of the building shell, classroom partitions, and other core learning space partition to have an STC rating of at least 35. It also requires a reduced background HVAC noise level to 40 dBA (USGBC 2009). Another prerequisite that focuses on acoustics is IEQ Prerequisite 3 — Minimum Acoustical Performance, which requires a limited background noise from HVAC systems in classrooms and other core learning spaces to 45 dBA, and limits reverberation time in learning spaces with sound-absorptive finishes (LEED 2009 For Schools New Construction and Major Renovations Rating System, 2009, 83). See Appendixes A and B for the specific requirements.

2.4: Indoor Air Quality

The indoor air quality (IAQ) is the function of outdoor and indoor air pollutants. Research indicates that air quality concerns are magnified for indoor environments; the U.S. EPA studies claim that indoor air pollutants may be two to five times higher than air outdoors. Due to the significant amount of time students, teachers, and staff spend indoors, IAQ can affect the health of children and adults. Poor indoor air quality can cause negative health symptoms including: headache, fatigue, shortness of breath, sinus congestion, cough, sneezing, eye, nose, and throat irritation (Olson, S.; Kellum, S., 2003, 9). These negative health impacts associated with IAQ can also influence student learning and teacher productivity (National Research Council 2007, 54). In the United States (U.S.), more than one-half of our nation's 115,000 schools have problems linked to indoor air quality. IAQ is impacted by mold, dust, pollen, and indoor toxins, which can have negative effects on asthma resulting in increased illness and absenteeism among students and teachers.

There is evidence that ventilation rates in the majority of schools do not meet the current standards of the American Society for Heating, Refrigeration, and Air Conditioning (ASHRAE) standards (Karliner, J., 2005, 5). Key causes of illness symptoms of indoor air pollution include sick building syndrome, combustion of products (space heaters, furnaces, etc.), biological pollutants (molds, dust mites, animal dander, etc.), volatile organics (formaldehyde, pesticides, solvents, cleaning agents), heavy metals (airborne lead and mercury), and environmental tobacco. School occupants being exposed to poor indoor air quality are typically in deteriorating school buildings; these building characteristics include: roof leaks, damp smells, lack of fresh air, high relative air humidity, and a frequency in maintenance repairs. Additional signs include new and or renovated school buildings not being properly ventilated, which contributes to negative side effects from off gassing from building products (Healthy Schools Network, 2012, 2-3).

The U.S. General Accounting Office conducted a random survey in 1994 of 10,000 schools and reported that one third of the schools had at least one building in its entirety in need of extensive repair or replacement. The report also indicated that 37% of the facilities had inadequate heating, ventilation, and air-conditioning; inadequate ventilation was 28%, and poor indoor air quality was 21 %. These environmental pollutants existing in outdated facilities have negative health and learning impacts on occupants due to breathing high volumes of contaminated air consisting of dampness and mold. The health problems include, but are not limited to, upper and lower respiratory symptoms, cough, wheezing, shortness of breath, asthma symptoms, development of asthma, fatigue, headache, eye irritation, and skin irritation (Sahakian, N.M., White, S.K., Park, J.H., Cox-Ganser, J.M., Kreiss, K.; 2008, 33).

A solution to poor indoor air quality is a sustainable design approach that addressing indoor air quality, including natural ventilation, solar chimneys, displacement ventilation, wind walls, and use of low-volatile organic compounds (VOC) materials (Ford, 2007, 11). Sustainable schools have superior indoor air quality, and expose occupants to fewer chemicals and environmental toxins. Good IAQ is a significant sustainable design feature because it can protect 20% of school buildings occupants' health. Previous research has linked good IAQ within school designs with lower asthma rates, fewer allergies, and reduced sick days (Ford, 2007, 6).

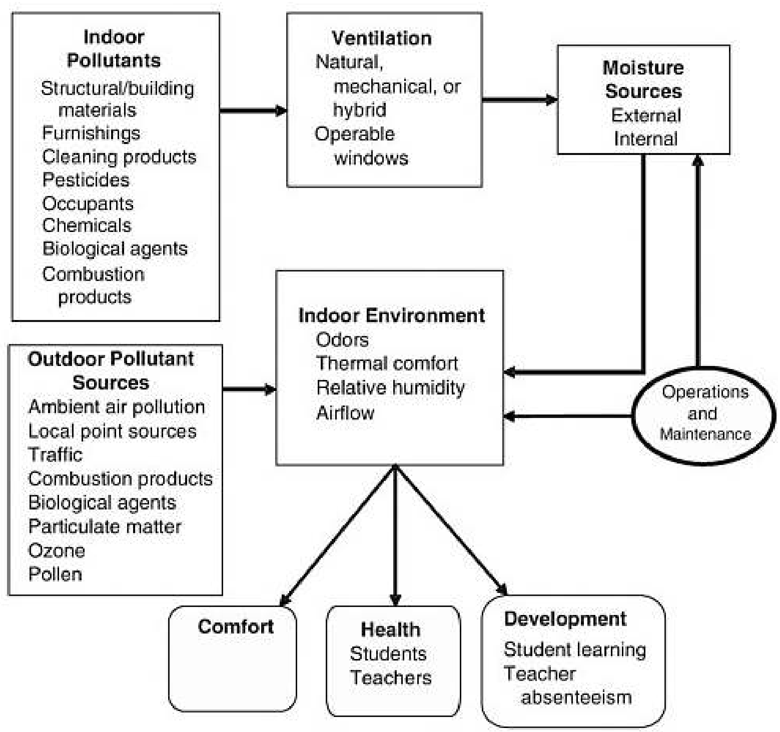


Figure 2.4. A: Relationships between pollutants, moisture, and ventilation and human comfort, health, and development (National Research Council 2007, 56).

According to *Greening America's Schools: Costs and Benefits,* many large scale studies have found evidence that correlates green or high performance features, specifically improved IAQ, with increased productivity and performance in academic institutions. There were 17 separate studies analyzing the built environment and health impacts, and all found positive health impacts from improved indoor air quality, ranging from 13.5% up to 87 % improvement (Kats,C., 2006, 10). Another review conducted by Carnegie Mellon, researched five separate studies evaluating the impact of the improved indoor air quality on asthma found an average reduction of 38.5% in asthma in school buildings with improved air quality.

Good IAQ starts by eliminating pollutant sources by the use of low-emitting materials and furnishings. There should be proper operations and maintenance strategies established by interior designers and other design professionals to maintain good IAQ through proactive building operation plans. These guidelines would provide detailed and practical guidance on how school districts can plan and implement enhancements to their operations and maintenance programs, which will help the districts properly, maintain their facilities. This strategy includes educating maintenance staff on proper cleaning procedures of low or zero VOC's in cleaning products. Another solution is to minimize air pollutants by air filtration systems when windows open and close.

2.4.1: IEQ Credit 2: Increased Ventilation

One aspect that is related to indoor air quality (IAQ) is proper ventilation, specifically natural ventilation. Fresh air is associated with creating healthier buildings. This is accomplished by fresh air intakes to ensure the exhaust of pollutants from outside. Walk off mats and grills remove outside dust and other pollutants from shoes. The guidelines also focus on clean ventilation pathways that use ducted returns and high-efficiency filters with MERV of 10 or higher. They discourage exposed fibrous insulation in ducts because it absorbs VOCs and dust (National Research Council 2007, 75). Key factors in good air quality are the ventilation rate; ventilation effectiveness; filter efficiency; the control of temperature, humidity, and excess moisture; and operations maintenance and cleaning practices (National Research Council 2007, 77). According to the USGBC, providing adequate ventilation and keeping relative humidity below 60% inhibits mold growth, which helps prevent serious health concerns (Adler, T., 2009, 451).

The IEQ Credit 2, Increased Ventilation, can earn the building one point toward achieving LEED certification. The intent is to provide additional outdoor ventilation to improve indoor air quality and promote occupant comfort, well-being, and productivity. There is a mechanically vented space, which increases the breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE 62.1-2007 (with errata but without addenda) as determined by IEQ Prerequisite 1: Minimum Indoor Air Quality Performance. For this credit, the ventilation must increase by 30% to all occupied spaces. The rates cannot be averaged.

Another requirement to follow that provides good indoor ventilation, is the Chartered Institution of Building Service Engineers (CIBSE) Applications Manual. This list of requirements determines if natural ventilation is an effective choice. It uses calculations and diagrams to show how a system meets the list of requirements established by the CIBSE Manual 10: 2005. It also uses an analytic, multi-zone macroscopic model to show how airflow in each room will work and meet rates per

ASHRAE 62.1-2007 for a minimum of 90% of the occupied spaces (LEED 2009 For Schools New Construction and Major Renovations Rating System, 2009, 66-67). See Appendix C for the specific requirements.

By addressing these problems, increased ventilation can help mitigate occupant health problems. In addition to preventing illness by improving air quality, studies have also linked healthy schools to improved learning and test scores. One study in Illinois analyzed two school districts, and found attendance rose by 5% after integrating indoor air quality improvements (Kats, G.; 2006, 11). With research indicating that school occupants can benefit significantly from improved IAQ that follows a sustainable design approach, this environmental factor should be integrated more frequently when interior designers and design professionals are improving school buildings (Kats, G.; 2006, 8).

2.4.2: IEQ Credit 4: Low-Emitting Materials

School facilities should strive to be toxic free environments. Therefore, building materials should not emit toxic gases or odorous compounds, as do dirty air filters and ducts, cleaning agents, kitchens, bathrooms, gymnasiums, art rooms, moldy surfaces, computers and copy machines. Other indoor objects that demonstrate sensory pollution are from chemically formulated and synthetic building products which are found in paint, carpet adhesives, sealants, ceiling tiles, wall systems, and furniture that have toxic containing materials (National Research Council 2007, 66). According to the U.S. Environmental Protection Agency (EPA), there are many volatile chemicals in many cleaners, floor sealers and waxes, disinfectants, and other custodial supplies that cause distracting side effects to students and teachers. When presented with this research, many sustainable schools are switching to nontoxic cleaning products that produce less indoor air pollution, which helps students and teachers perform tasks better (Adler, T., 2009; 451). It is also important, once these measures are in place, to train the building maintenance staff in order to maintain the finishes properly, according to the rating system or the preventative pollutant method that was adopted.

One guideline is the IEQ Credit 4: Low-Emitting Materials; this credit can earn the building a maximum of four points toward achieving LEED certification. The intent is to reduce the quantity of indoor air contaminants that are odorous, irritating, and/or harmful to the comfort and well-being of installers and occupants. There are six different credit options to choose from, but only four points can go towards LEED certification. The six credits are 4.1 Adhesives and Sealants, 4.2 Paints and Coatings, 4.3 Flooring Systems, 4.4 Composite Wood and Agrifiber Products, 4.5 Furniture and Furnishings, and 4.6 Ceiling and Wall Systems. See Appendix D for the specific requirements.

2.5: Lighting Quality

The visual environment is one of the most important factors that contribute to the learning process. It affects students' mental attitude, class attendance, and performance (Heschong, Mahone Group, 1999). The lighting design is a fundamental feature of the built environment; that is why the design strategy is complex and requires integrating both artificial and natural light systems. It is important for interior designers and other design professionals to practice design refinement when coordinating design components that impact lighting a space. This process includes designing a learning environment with adequate windows, shading systems, lighting systems, occupancy sensors, and controls. This holistic design approach helps produce healthier and brighter learning environments.

Proper lighting is important in schools because occupants spend a majority of their time indoors. Children reportedly spend 15,000 hours in school environments during their formative years, and up to 90% of this time is spent indoors, so the lighting should be designed comfortably for the users (Future Proofing Schools, 2011, 5). Because school buildings are expected to support multiple activities, this requires the infrastructure to be accommodating for occupants' learning, performance, and engagement in productivity needs.

Interior designers, electrical engineers, and lighting consultants are qualified professionals that have experience with designing lighting systems that are adequate for reading, communicating with others, and performing visual tasks associated with learning, teaching, and school administration responsibilities (National Research Council 2007, 81). A significant amount of research exists to indicate that indoor lighting has an influence on students, teachers, and staff in school environments. Research indicates there is a direct relationship between lighting a school environment and improvements in performance, health, and well-being among school occupants (Samani, S.A., Samani, S.A., 2012, 127; Oneworkplace, 1999). Higher illumination levels are recommended for specialized task areas for reading and writing. While public spaces need lower illumination levels. Overall, the lighting design varies between spaces within a school environment to support specific functions and tasks that is why design professionals are needed to accommodate this need (National Research Council 2007, 88).

There are two types of lighting found in school buildings: electric (artificial) and daylight (natural); sustainably designed school buildings combine the two methods of lighting. Daylighting refers to the wide use of natural sunlight for task illumination, which is normally provided by artificial light fixtures (electrical light). Daylighting is achieved by incorporating skylights and large windows that allow daylight to filter in the spaces; this design strategy reduces energy costs and improves student concentration and performance (Olson, S.L.; Kellum, S., 2003, 7). For this method to be successful the daylighting needs to be controlled. Lighting control methods include tinting and insulating glass, window treatments, and light shelves. These design features help reduce heat gain and glare, and provide an even distribution of light within the interior space (Adler, T., 2009, 450). Daylighting is important because recent studies reveal students in classrooms with natural light had improvements in performance and health (Olson, S.L.; Kellum, S., 2003, 3).

Artificial lighting represents the largest portion of a school's electricity use, impacting the environmental "footprint" of the school. Specifying highly efficient fixtures and effective controls can reduce this footprint (LiteControl, 2009, 4). According to the two lighting associations, the Illuminating Engineering Society of North America (IESNA) and the International Association of Lighting Designers (IALD), sustainable lighting is defined as a, "lighting design that meets the qualitative needs of the visual environment." For a school facility, the lighting must provide a high-quality visual environment that supports the learning needs of the teachers and students (Haran, S.K., 2010, 18). Electric light should not only focus on energy conservation, but balance the environmental impacts. These include supporting human comfort, which can enhance productive learning and providing light that supports specific functions within a space that are essential for operating a school building. This includes designing light fixtures with lamps of minimum consumption of mercury and operates in two modes: general

(35-50 footcandles) and AV (10-20 footcandles). The lights should also have both indirect and direct light distribution that produce clear diffused light and reduces glare and shadows for classrooms and libraries (Davis, R.G., 2007, 4).

There is a problem that a majority of America's buildings are older and do not contain sustainable lighting features. School facilities constructed during the 1960's have little daylighting because the design trend used was black out glass. This type of glass allowed a view out, but did not allow the natural light to filter into the space (Olson, S.L.; Kellum, S., 2003, 7). Black out glass, and other insufficient lighting controls can lead to problems that directly impact school occupants, which include: eyestrain, musculoskeletal injuries, decreased attention spans, and increased body temperature in students, teachers, and staff (Samani, S.A., Samani, S.A., 2012, 131; John; Timothy, 2005). For non-sustainable electrical lighting systems, the largest environmental impact is caused by the consumption of energy, which can account for as much as 50% of the electricity used to operate a school building. In order for school buildings to minimize their energy used to operate lighting systems, the design should accommodate the following design features: adequate lighting levels, highly efficient light fixtures, daylight harvesting method, and implementation of occupancy controls to reduce electric light in unoccupied spaces (Davis, R.G., 2007, 1).

2.5.1: IEQ Credit 6.1: Controllability of Systems – Lighting

One of the goals of a sustainable lighting design is to supply appropriate luminance, color temperature, and lighting to accommodate the users' needs. Learning spaces acquire the lighting to meet varying types of uses from digital presentations where lights are dimmed, to brighter lighting situations for reading and communicating. If the lighting system is designed inadequately, it has noticeable psychological effects on students', teachers', and staffs' well-being; it can also negatively influence their performance (Samani, S.A; Samani, S.A., 2012, 132). Lighting controls include occupancy sensors, multilevel switching, programmable lighting control systems, daylight harvesting, and intelligent systems.

The LEED rating system guideline IEQ Credit 4: Low-Emitting Materials; can be used to develop a more efficient lighting design that is both environmentally responsible and meets the needs users'. This credit can earn the building a maximum of one point toward achieving LEED certification. The intent is to provide an energy efficient, and flexible lighting system that can be controlled by individuals or groups within the indoor school environment (e.g., classrooms or conference areas). This type of lighting system is beneficial to both the natural environment, and to school occupants; it is creating a comfortable indoor environment, which has been linked to promoting an increase in productivity and well-being for students', teachers', and staff. There are two specific requirements to meet this credit requirement, which include: CASE 1 Administrative Offices and Other Regularly Occupied Spaces, and CASE 2 Classrooms. See Appendix E for the specific requirements.

2.5.2: IEQ Credit 8.1: Daylight and Views – Daylight

Daylighting is another goal of a sustainable lighting system. It is a significant component because it reduces the need for electrical light, cooling, and can reduce energy expenses by 30 to 70 percent (Olson, S.L.; Kellum, S., 2003, 7). It's best to minimize direct sunlight by installing shades and other fins outside to reduce glare from the sun, reduce eye fatigue, and still provide a mental break from a confined space (Davis, R.G., 2007, 3). Thee LEED rating system guideline IEQ Credit 8.1: Daylight and Views –

Daylight can be used to incorporate daylighting in school building construction. This credit can earn a maximum of 3 points towards LEED certification. The intent is to provide building occupants with a connection between indoor and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building. There are 4 options to achieve daylighting credit, and through 1 of the 4options must achieve daylighting in the following spaces: classroom and core learning spaces (75% = 1 point, and 90% = 2 points), and other regularly occupied spaces (75% = 1 point). The options include: Option 1 Stimulation, Option 2 Prescriptive, Option 3 Measurement, and Option 4 Combination. See Appendix F for the specific requirements.

2.6: Thermal Comfort Quality - IEQ Credit 7.1: Thermal Comfort – Design

Thermal comfort is a building component that contributes to the building performance. Thermal comfort in a sustainable design school building has been found to be a factor in improving learning, health and productivity among occupants.

A research study was conducted by Turner Construction, one of the largest construction management companies in the United States, surveyed schools in in Illinois; Washington, D.C.; Washington state; Oregon; Pennsylvania; and North Carolina found that: student attendance rose by 5% after cost effective thermal comfort improvements (Hon, D.E.G., 2010, 3).

Thermal comfort can be a challenge to create properly because many environmental factors contribute to poor thermal comfort, which include: heat from electrical light levels and poor performing building envelopes. It is a challenge for design professionals to design and coordinate building systems that balance clean air, energy efficiency, and low background noise. This need for balance reintroduces sustainable design concepts that incorporate operable windows and radiant heating (Hon, D.E.G., 2010, 3). The success of thermal comfort depends on four parameters: air temperature, radiant temperature, relative humidity, and air speed. Thermal comfort standards are based on a set of air and radiant temperatures and relative humidity levels that can better satisfy up to 80% of school building occupants at specified metabolic rates and clothing values. Thermal comfort is an important component that contributes to indoor environmental qualities within school building designs. Research indicates that productivity levels can decline if temperatures are too high in a school built environment (National Research Council 2007, 65; Kwok, 2000).

The LEED rating system guideline IEQ Credit 7.1: Thermal Comfort – Design; can be used as a guideline to help develop a better thermal environment that is comfortable for the users'. This credit can earn the building a maximum of one point toward achieving LEED certification. The intent is to provide a comfortable thermal environment that promotes occupant productivity and well-being. The requirements include efficient designs of building systems which include: the thermal barrier, heating, ventilation, and air conditioning (HVAC). These building systems that make-up the building envelope, must meet either one of the following options: ASHRAE Standard 55-2004 or Non-U.S. Equivalent, or ISO 7730: 2005 & CEN Standard EN 15251: 2007. See Appendix G for the specific requirements.

ASHRARE stands for the American Society of Heating, Refrigerating, and Air-Conditioning Engineers. It is a global society advancing human well-being through sustainable technology for the built environment. The society focuses on building systems, energy efficiency, indoor air quality, refrigeration and sustainability. ASHRAE publishes a series of standards and guidelines relating to HVAC systems and building components and systems that are found within built environments. ASHRAE requirements are often referenced in building codes, and used by design professionals (ASHRAE, 2015).

CEN stands for Comite Europeen de Normalistation (European Committee for Standardization). It is an association that brings together National Standardization Bodies of 33 European countries. It provides a platform for development of European Standards and other technical documents in relation to various kinds of products, materials, services and processes (USGB, 2007). The CEN Standard EN 15251-2007 focuses on the indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics (CEN, 2015).

2.7: Literature Review Conclusion

The initial literature review included a body of previous research that identified key points including: point one; our nation's school buildings are deteriorating, and point two; a healthy school environment can be produced through sustainable design practices. There has been a great interest in evidence based design as it pertains to the effects of sustainable design on the overall performance of school facilities including but not limited to the economic benefits, financial benefits, and occupant benefits. This evidence, supported by the researchers, identified several environmental factors with an emphasis on sustainable design. These environmental factors contributed to positive outcomes of improved productivity, health, and well-being among school occupants' (Hon, 2010, 1), and included the following: acoustic quality, indoor air quality, lighting quality, and thermal comfort quality (Marchman, Clarke, 2011, 1). The factors were found to be significant because they helped create better indoor environmental qualities within school environments.

Although the research results indicated positive outcomes associated with sustainable design school buildings, many studies revealed a strong pattern that sustainable design was not being integrated within our nation's school buildings (Filardo, Berstein, Eisenbrey, 2011, 1). This strong evidence is creating awareness that a school's built environment is an important component in creating positive learning experiences. It also reveals indoor environmental qualities (IEQ) have serious impacts on students, teachers, and staff (National Research Council, 2007, 16).

The purpose of the initial literature review provided evidence that a majority of America's schools are not supporting positive outcomes for learning. Therefore, there is an opportunity to construct new and or renovate school projects to address this problem. Additional evidence demonstrates that sustainable design can be used as a guideline to create positive outcomes among school occupants'. This information helped structure the proposed study by establishing the four indoor environmental qualities (IEQ) that were found to have an integral part for creating sustainable design schools. These include the following: acoustic quality, indoor air quality, lighting quality, and thermal quality. By using these factors as guidelines, the researcher will be able to measure and assess the school built environments that were selected to study in this thesis. The factors will be used to support the assumption that sustainable design schools add value through creating healthier indoor environments.

Chapter III: Proposed Study

The ultimate goal of this proposed study is to identify and study specific Indoor Environmental Quality (IEQ) credits of sustainable design as outlined by LEED 2009 For Schools: New Construction and Major Renovations Rating System and gauge each selected credit's influence on occupants' satisfaction levels for their school environments. The four IEQ selected to evaluate were the following: acoustic quality, indoor air quality (IAQ), lighting quality, and thermal comfort quality. These were selected by the researcher to determine if they will have an influence on the participating school building occupants' productivity, health, and wellbeing. Through the literature review process, multiple research questions were raised and the hypothesis with various subsets was extrapolated.

This leads to research questions:

1. Should the solution for improving our nation's school building infrastructures have an emphasis on sustainable design?
2. Does sustainable design create spaces that allow school occupants, students, teachers, and staff, to actively engage with their school buildings and community to enhance the learning experience?
3. Do sustainable design principles, specifically indoor environmental qualities (IEQ), affect school occupant's productivity, learning, and wellbeing?

Research Objectives:

1. Determine the need for new and or renovated school construction across the United States.
2. Identify what a sustainable school means, and why it is a significant solution.
3. Identify how other school districts and design professionals have been successful in creating a sustainably designed education facilities in order to establish better design guidelines for future school construction.

Hypothesis:

1. There are aspects of sustainable design that are beneficial to occupants in educational facilities, and create great success in schools. There are also limitations that prevent this type of design as a solution for new and/or renovated construction of educational facilities. Therefore, research should outline the existing barriers and benefits in order to identify strategies for increased use of sustainable design in educational facilities.

Chapter IV: Method

4.1: Research Design

A case study method was selected as a strategy of inquiry in which the researcher explores in-depth design characteristics of two high school buildings in North Mississippi. This method was the strategy of inquiry because the researcher could explore in-depth the physical environments using a variety of data collection procedures over an extended period of time. One high school (Site A) was selected because it was a newly constructed facility that integrated sustainable design principles, has a LEED Silver certification, and was built in 2014. The other high school (Site B) was selected because it did not incorporate sustainable design principles, and was an older facility built in 1998. The two high school facilities were carefully selected based on the incorporation and non-incorporation of sustainable design, and having similar student populations and locations. These characteristics among the two sites where significant to the validity of the study by limiting the potential of influential variables. It was essential to this study to identify the presence of both sustainable and non-sustainable design principles, so the researcher could determine which design components had an influence on the occupants' level of satisfaction with their schools' built environment.

This research was conducted through three different types of data collection methods. These included observational studies during site tours, survey questions to faculty and staff, and interviews with principals' at each site. Before the methods were conducted, the researcher used the four Indoor Environmental Quality (IEQ) factors that were chosen in the initial literature review as guidelines for measurement when evaluating each high school. These included acoustic quality, indoor air quality (IAQ), lighting quality, and thermal comfort quality. These were based on the LEED 2009 For Schools: New Construction and Major Renovations Rating System credits. Research supports that IEQ have a significant impact on the learning environment, and this was the reason they were the selected by the researcher to be used as guidelines for this study. The IEQ factors helped the researcher identify which building characteristics and spaces were going to be observed, and what types of questions were going to be asked to the participants at each site. This information was significant to the study, because it allowed the researcher to determine how the built environment correlated with the participants' perception of their schools' building, and then compare the results.

The initial framework for this research study was for the researcher to establish which spaces were going to be observed. The intent was for these spaces to be consistent at each site, and where learning took place the most. Therefore, the core learning areas were selected by the researcher, and included the following: standard classrooms, labs, libraries, cafeterias, gymnasiums, and corridors. This was also an organizational method so the researcher could observe similar building components, analyze the differences, and document the results, for each site. The researcher created a list of design aspects to be documented when observing each core learning space. These included the following: room dimensions, ceiling heights, quantity and size of windows, type of floor finishes, type of wall materials, type of ceiling materials, type of lights, presence of technology, and types of furniture. The purpose of this data collection method was to create consistency when documenting the building characteristics at each school building.

After establishing the framework for the observation method, the researcher conducted the site visits at each school building to gather inventory in order to gain an understanding of each high schools' built environment. The intent was to identify the presence of the selected IEQ factors associated with sustainable design principles. It was essential for the researcher to identify this information at each site to determine if these variables had negative or positive impacts on the occupants.

During the site visits the researcher evaluated and documented the physical conditions of the core learning spaces, but did not observe the occupants in the space. The visits were conducted at times where students, faculty, and staff were either not presents, or not in critical working modes to minimize the amount of disturbance and to protect their privacy. To protect the identities of the high schools' and the participants', each site was assigned the following codes: Site A incorporated sustainable design principles in the building design, and Site B did not incorporate sustainable design principles in the building design. The intent of the site visits, allowed the researcher to document and asses each schools' built environment, which established the independent variables in this study. The researcher identified the dependent variables during the second and third type of research methods. These research methods were conducted through surveys and interviews, and established the participants' perception of how their school building influenced their productivity, health, and wellbeing.

Another research method the researcher used when evaluating the two case studies was a unit of analysis, defined as the area of focus of the study (Merriam, 1988; Yin, 2009). For this study, this unit of analysis was a quantitative data collection method conducted through a distribution of electronic survey questionnaires sent to the teachers and staff. The survey website access was sent via email to the principals' at each site by the researcher. Then each principal sent the request to participate to their faculty and staff via email, and the survey was then self-administered by the participants' via the Internet. The purpose of selecting these two groups, faculty and staff, was to use a quantitative data collection method to explore the participants' own views on their schools' built environment, and other areas of discussion relative to the research topic. Prior to contacting participants, the researcher applied and was granted permission to engage in research with human subjects by the University's Institute Review Board (IRB). Before the participants could complete the surveys, they were asked to read and agree to the Informed Consensus Forms that explained the purpose of the study and participation regulations.

The data collection instruments for this study consisted of two self-administered electronic surveys with closed and open-ended questions. Both surveys were designed to gain a deeper understanding how the occupants perceived their learning environments. The intent was to understand how the occupants felt their school's physical environment impacted them on a daily basis to determine if the space met their needs or needed improvement.

After reviewing the data collection from the surveys, a majority of the results obtained had an inconsistent response rate. Therefore some of the data findings were inclusive from previous research identified in the literature review. With no explanation for these results, a follow-up explanation phase of qualitative themes was conducted through emailed interview questions to each principal. The following sections of the thesis provide more detailed information on the processes and methods used during each phase of this research study.

4.2: Documentation and Assessment of the Built Environment

The first step was for the researcher to obtain the floor plans of each high school building to locate the six core areas of learning being evaluated. The floor plans were used to develop a better understanding of the circulation patterns, square footages, adjacencies, windows placements, and basic layouts of the core areas of learning prior to the site visit. The next step was conducting the site visits' to gather the inventory of the schools' built environment at each high school. This was achieved through photographing, and documenting the findings observed by the researcher.

The documentation included identifying detailed information specific to the IEQ factors present or not present in each room. This information included the following: room dimensions, ceiling heights, quantity and size of windows, type of floor finishes, type of wall materials, type of ceiling materials, type of lights, presence of technology, and types of furniture. The researcher documented all design components through field notes, and photographs. During this phase, the researcher focused on design components that impact the acoustic environment (specifically focusing on flooring, ceiling, and wall finishes, and materials), air quality (date of HVAC System, and the condition of interior finishes and materials), artificial lighting (type of fixtures), natural lighting (amount of windows present, size, and view), and thermal comfort (date of HVAC System, type of HVAC, and if operable windows were present).

School Characteristics	Site A	Site B
Student Population	1000	728
Grades Served	9 to 12	9 to 12
Faculty Population	78	59
Staff Population	27	11
Year Built	2014	1998 (Original Building) 2004 (English Addition)
Square footage	220,000	84,000 (Original Building) 11,000 (English Addition) 95,000 (TOTAL SF original + addition)
Sustainable Design Principles		
Acoustics	Lay-in Acoustical Ceiling (majority of the ceilings) Acoustical wall panels (in areas with high ceilings) Carpet in some areas (library, staff suites) Meets LEED minimum requirements	Lay-in Acoustical Ceiling (majority of the ceilings) Carpet in some areas (library and staff suite) Does not meet LEED requirements
Indoor Air	2014 HVAC Unit Meets LEED requirements for energy and atmosphere Energy Recovery Units, which pretreats incoming fresh air to reduce humidity, and it has humidification equipment to control interior air	1998 HVAC Unit Does not Meet LEED requirements.
Lighting	LED Light Fixtures Occupancy Sensors Daylighting is used	Fluorescent fixtures No occupancy sensors Does not meet LEED requirements Daylighting is used
Thermal	Meets LEED requirements for energy and atmosphere Insulated glass with sun guard coating to reduce heat gain and glare. High albedo concrete reduces heat gain.	Single pane glass Non insulated glass No sun guard coating

Building materials and finishes	Polished Concrete Floors Wood Window Sills, floor base, and stair (local wood) CMU from recycled concrete from demolition Carpet Recycled Content	None

Figure 4.2.A: Comparison Chart of Site A & B's Building Characteristics

4.3: Documentation and Assessment of Survey to Teacher and Staff

This portion of the research study assessed the teachers and staff from each site. The goal was for the researcher to determine their attitudes and opinions toward the condition of their school buildings' built environment, and how it impacted their daily use of the facility. This research method was conducted through an online survey sent by the principals to all teachers and staff members at each site. This information was significant to determine for this study, because the researcher hypothesized that sustainable designed schools result in more positive experiences among students, teachers, and staff. There is potential for this insight to help provide sustainable design guidelines, so interior designers and other design professionals can integrate sustainable design more commonly in school building projects.

An electronic survey was chosen in order to reach the largest amount of participants, protect their privacy, and to ensure that the questions were answered in un-biased manner. The survey was compiled of questions based on areas of sustainable design that were addressed in the initial literature review in this thesis. The questions focused on IEQ factors in education facilities consisting of acoustical environment, indoor air quality, lighting, and thermal comfort.

The questions were intended to measure the participants' opinions. Therefore, the researcher used a nine point Likert scale ranging from a level of disagreed (1 highest level of disagreement) to agree (9 highest level of agreement), and not well (1 highest level of disagreement) to extremely well (9 highest level of agreement) on a specific topic. Other questions measured their attitudes were on a nine point Likert ranging from a level of dissatisfied (1 highest level of dissatisfaction) to satisfied (9 highest level of satisfaction). Answers to these questions determined whether participants had a positive or negative attitude and/or opinion toward their built environment. In addition, the answers allowed the researcher to identify if sustainable design was a factor that influenced the participants' perceptions of their school buildings, which was the primary focus for this research study.

Other questions asked required answers that were either yes or no to determine if the participants had an opinion about specific design features that were either present or not present in their space. The goal was to determine if certain design features impacted the participants positively, negatively, or not at all. These specific design features were selected to examine because initial literature review indicated they can impact occupants in learning environments (Edwards, 2006, 21). Some of the design features included, but were not limited to: physical comfort, adequate lighting, environmental responsibility, operable windows, climate control, interior finishes, and daylighting.

Overall the survey questions were created to measure the effect that sustainable design has on the overall attitude and opinion of a school being satisfied or not satisfied. The questions were constructed in a precise way to address the topics, while still providing enough information for participant comprehension. The Institutional Review Board (IRB) at the University of Nebraska, Lincoln, has approved this research (IRB#

14762). An example of the survey questionnaires to the teachers at site A & B are shown in Appendix J, staff at site A & B are shown in Appendix K.

4.4: Documentation and Assessment of Interview Questions to Principals

In order to explore each schools' principals' views and experiences with operating a school facility, interviews were conducted by the researcher. The intent of this qualitative research method was to provide a deeper understanding on how well they perceived their school building supported the students, teachers, and staff. The questions asked were intended to be open-ended, neutral, and easy to understand about topics relating to the IEQ factors found within their school buildings, and if they perceived these to have an impact on students, teachers, and staff. Due to their unavailability to meet, the questions were emailed after the site visits. This allowed the principals' to meet the researcher, and be introduced to the research study topic and objectives. An example of the site A and B principal interview questions are shown in Appendix L.

4.5: Assumptions and Limitations

This study entailed several assumptions. First, teachers, staff, and principals, as users' of school buildings, are the main focus of the study. Second, the study aims to investigate and analyze the influence of IEQ factors with an emphasis on sustainable design on the participants' level of satisfaction for their school buildings'. Any other levels of satisfaction found not associated with the IEQ factors held by the participants' are not a direct part of this study and do not impact the findings.

This study encountered several limitations. First, both superintendents were originally involved in the research study to discuss their personal view points about their schools' built environment, and how it impacted their schools' occupants. However, Site

A's superintendent was the only one who answered the interview questions. This information would have been a significant component to the study because of their involvement with school construction. Second, the combination of small sample size, and low response rate to survey questions limited the use of advanced statistics for analyzing the data. Thus, the findings in this portion of the study need to be cautiously interpreted.

Third, the two high schools were selected because of specific characteristics including both non-sustainable and sustainable design aspects integrated in the built environment. The researcher assumes that these sample populations are representative of the greater population of high school facilities across the nation. Although the results of this study cannot be generally applied to the overall population of high school facilities, the results of this study can be suggested as accurate to the larger population.

Fourth, Site B was an older facility and did not incorporate sustainable design principles. However, it was not in extreme deteriorating condition. Therefore, not reflect the severity of the aging school facilities discussed in the literature review.

Chapter V: Results and Analysis

5.1: Site A – Documentation and Assessment of the Built Environment

Site A was a newly constructed 220,000 square foot educational facility. According to the Superintendent the new high school, "Is an academic performing school that provides a successful learning environment for students, and it serves as a role model for sustainability." The Superintendent's mission was to take care of the things that had been given to them, and acknowledge the school was a reflection of the community, and it also impacted the community because the students now can be the leaders of tomorrow.

The school was designed to meet LEED Silver certification. However, there are , remaining requirements required after the construction has completed. Once these are completed, it will become the first LEED Silver certified high school in the state. The design scored 39/110 credits based on the LEED BD+C: Schools v3 2009 rating system. The credits were gained in the following areas; Sustainable sites (11 of 24), Water efficiency (8 of 11), Energy and atmosphere (13 of 33), indoor environmental quality (4 of 19), Innovation (2 of 6), and Regional priority (1 of 4).

The school opened in January 2014, and is a state of the art facility, featuring modern technology, and a green environment. It has a student population of 1,000 students from grades 9 through 12, and an adult population of 78 faculty, and 27 staff. The new high school was built to accommodate the growing number of students. The Superintendent wanted to move forward in a positive way for the future of the school district, and provide students a quality education in well-equipped facilities.

Benefits from designing the facility with LEED School standards included reduced energy use, which equals to $6 million in overall savings and avoided costs over the next 15 years, and a decrease in the amount of school's greenhouse gas emissions that are equal to carbon withdrawn by 537 acres of pine forest annually. The design of the facility did score very well on the LEED rating system in areas of Energy and Atmosphere, Water Efficiency, and Minimum Acoustic Performance.

The Energy and Atmosphere address the energy performance of the building systems including HVAC systems and lighting efficiency. The heating and cooling systems are converted into a single networking solution to lower costs and decrease long-term operational and utility expenses. The district will save critical resources by eliminating the need to manage multiple, duplicate or discrete systems under various vendors, contracts and proprietary protocols in the evolving technology marketplace. The school district has an Energy Service Agreement with Johnson Controls, which funded the integrated technology design. The upgrades to all systems will estimate a savings of $6 million in energy and operational costs over the nex 15 years. The high school is powered by a modular central energy plan which will help keep ongoing maintenance costs to a minimum (Johnsoncontrols.com).

The design also accommodates a technology rich learning environment and environmentally-friendly space for the community and school population. The new school facility also offers cutting-edge technologies for a safe and secure environment for students, teachers, and staff, offering life safety and security systems such as fire alarms, surveillance cameras, and access control to the campus. Overall, the decision to make it a priority to meet the LEED for Schools standards was significant because it creates a healthy environment conducive to learning while saving natural resources, energy, money, benefiting students, teachers, and taxpayers.

The layout of the campus includes a 2 story main building that has a central space for public use and 4 wings on each floor. The wings are located at each of the 4 corners, and they include labs and classrooms. The corners are organized by subjects. Wing M is Mathematics, wing H is History, wing S is science, and wing W is wisdom. There is a central space includes the library, student gathering, restrooms, and administration office areas. Within the entire building mechanical rooms, electrical rooms, and other support spaces are included in the design. There is a 1 story building that has the cafeteria and band hall, and there is a 2 story building that has the gymnasium.

Through specific site orientation, each building maximizes the amount of natural light and views. Figure 5.1A shows the view of the main entrance of this high school. The south facing façade, which receives the most direct sunlight, and potential heat gain of the building, integrated smaller windows in order to control the amount of direct sunlight. Figure 5.1B shows the back view of the main building and exterior courtyard. This façade of the building faces north, therefore there are larger aluminum storefront systems that provide abundant natural light, and views outdoors.

Figure 5.1A: Site A – View of Main Entrance

Figure 5.1B: Site A – Back View of Main Building (Court Yard)

The larger windows on the north side were used because there is not as much direct sunlight throughout the day compared to the south side. This window concept of smaller sizes on south side of buildings, and larger window systems on north, east, and west sides of buildings is typical throughout the new campus. Figure 5.1C shows the 2 story main building floor plan, and the type of spaces are identified through a color coding system. Figure 5.1D shows the 2 story gymnasium building, and the 1 story band hall and cafeteria building. These plans are also color coded in order to identify the organization of spaces in each building.

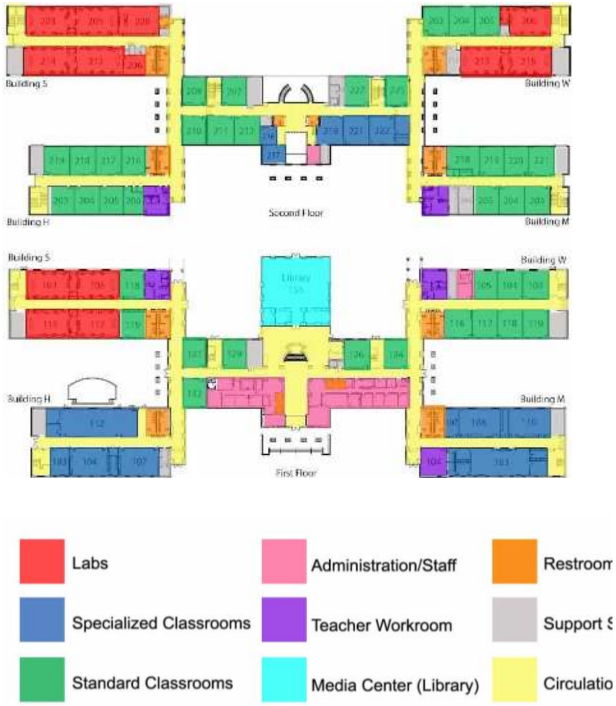


Figure 5.1C: Site A – Floor plan (Administration, Classrooms, and Library)

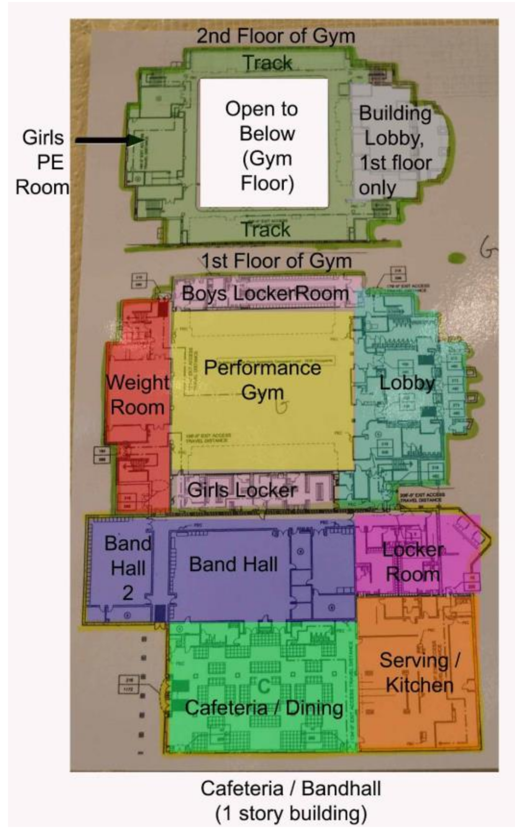


Figure 5.1D: Site A – Floor plan (Cafeteria and Gymnasium)

5.1.1: Overview of Core Learning Spaces

When conducting the site visit at Site A, the intent of the visit was to evaluate the core learning spaces. These were identified by the researcher as areas were learning would occur the most. The core learning spaces observed included the classrooms, labs, library, gymnasium, hallways, cafeteria, and any outdoor spaces. When entering the facility, there is a circular receptionist desk in the lobby which is the first thing visitor's view in the space. Past the entry a large gathering space, this is also the grand stair case. There is built-in seating with data outlets for students to use during breaks, time between classes, or after school programs.

This area is supportive of a new sustainable school environment because it’s surrounded by large windows with views to the outdoors, and tall 30’-0” tall ceilings to create an open atmosphere. The circular design feature aided in creating a sustainable indoor environment because it the shape supports natural lighting, and reduces the building’s development footprint. It also enriches the occupants using the space through beautiful design by creating a healthy indoor environment with abundant light.

Other sustainable design features included a good acoustical environment by providing sound absorbing finishes and materials. There are acoustical wall panels located on the walls, and suspended lay-in ceiling tiles with insulation above to help absorb sound and reduce noise. The wood located on the stair system, and edge of landing came from the trees that were cut down on the site.

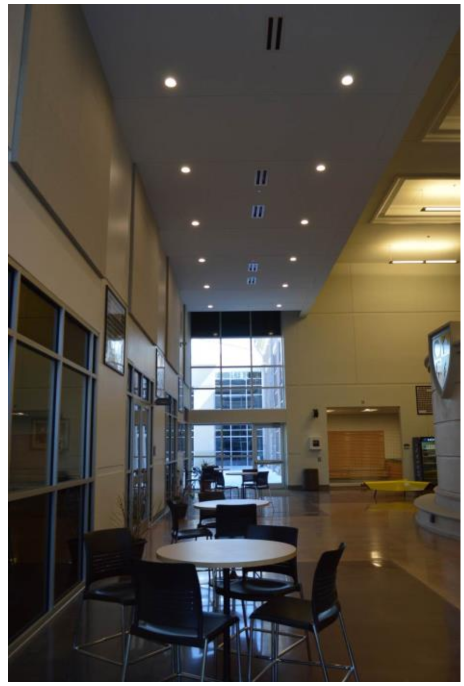


Figure 5.1.1 A: Site A – View of Student Gathering Space Before Entering Library

The flooring also contributes to a healthier indoor air quality environment because it is a polished concrete. This floor system is more sustainable than traditional vinyl composition floor tile (VCT) because it doesn’t require stripping and waxing twice a year, there are no VOC's or coatings, it prevents waste, and is long lasting. It's easy to maintain by using a dust mop with gritless sweeping compound to remove dirt, or a gentle neutral PH cleaner and then clean it off. Figures 5.1.1 B, 5.1.1 C, 5.1.1 E, and 5.1.1 E shows these views. The seal of the school has been digitally covered for confidentiality purposes). Figures 5.1.1 D and 5.1.1 E shows the difference between the polished concrete and VCT flooring durability.

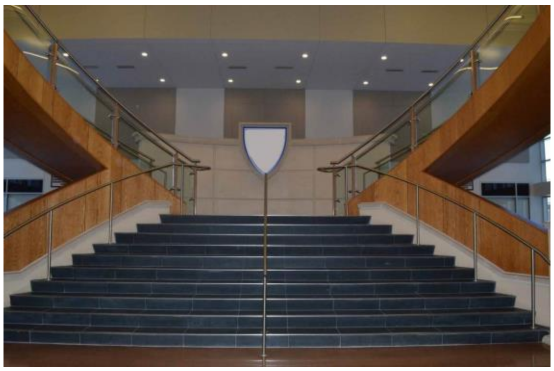


Figure 5.1.1 B: Site A – View of Monumental Stair in Student Gathering Space

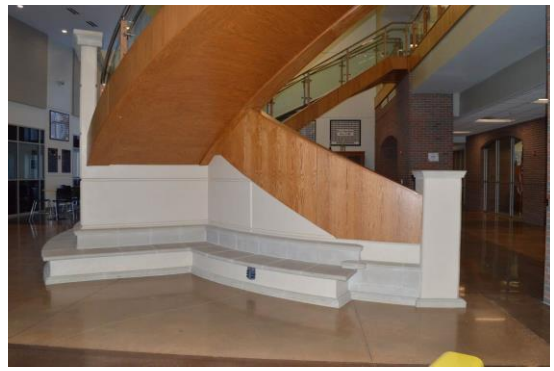


Figure 5.1.1 C: Site A – View of Monumental Stair in Student Gathering Space

Figure 5.1.1 D: Site D – View of VCT Floors in Stairwell

Figure 5.1.1E: Site A – View of Polished Concrete Floor

The stairwells (except the monumental stairwell in center of building) have VCT, and all hallways, and classrooms have the polished concrete in main building.

The design of this high school facility incorporated flexibility by allowing the spaces to be multi-functional. This design strategy supports a sustainable school because the spaces can adapt and accommodate various functions. Since there isn't a way to predict how future educational technologies or teaching modalities will evolve, learning spaces must adapt to the changes of the future. Designers must design spaces with movable walls, furniture that can be easily reconfigured for different activities. This is a sustainable principle because it eliminates excess construction, and reduces the campus footprint.

Figure 5.1.1 F: Site A – View of the South (no windows) and West (with windows) walls of Library

Figure 5.1.1 G: Site A – View of the East wall of Library

These flexible spaces in this high school include the library, cafeteria, and gymnasium. The library is centrally located, and easily accessible to teachers, students, and staff. Its primary function is an academic library, but also is used for tutoring capabilities, and student extracurricular meetings. It has Wi-Fi, and multiple furniture types to accommodate the multi-purpose functions. The library has sustainable design features which include large two-story aluminum storefronts (on 3 of the 4 walls) to allow natural light into the space, and views to the outdoors. It is a massive space, with 22'-0" ceiling height, sound absorbing wood ceiling and acoustical wall panels, LED suspended light fixtures, recycled wood floor base, and carpet tiles with recycled content and is low-emitting to contribute to high indoor air quality. Figures 5.1.1. F and 5.1.1.G shows the view of the library.

The cafeteria is a separate building from the main building. This building has the cafeteria, kitchen, band hall, and band hall lockers. The sustainable principles integrated in the cafeteria are durable finishes, abundant natural light, connection to the outdoors, LED lighting, and movable furniture to accommodate flexibility. The flooring is commercial linoleum which is naturally sustainable because its USDA-certified bio-based product, has superior performance, non-toxic, anti-microbial, and easy to maintain. The floor design has a color palette that is light-reflecting, which is a daylighting strategy to improve energy efficiency. There are also recessed grille walk off mats to allow dirt and debris to fall through the mat instead of remaining on the surface. The mats offer ease of maintenance because it prevents dirt, mud, and moisture from reaching the primary floor surface. Figures 5.1.1.H, 5.1.1.I and 5.1.1.J are views of the cafeteria.

There is a tall ceiling height of 14'-0" to bottom of lay in acoustical ceiling tile, and LED direct / indirect 2'-0" x 4'-0" light fixtures. This type of lighting creates a good balance between ambient illumination of the room and accent lighting because they direct the light both upward and downward combining both direct and indirect lighting in one luminaire housing. This increases the perception of comfort within the space complying to visual comfort. There are windows located on the south and west wall to allow daylight to filter into the space which is a sustainable design feature.

The cafeteria is multi-functional and used for both student dining and teacher meetings. It has movable furniture that is easy to reconfigure to accommodate either function. It is also equipped with the latest audio visual technology was designed for presentations. See Figure 5.1.1.H.

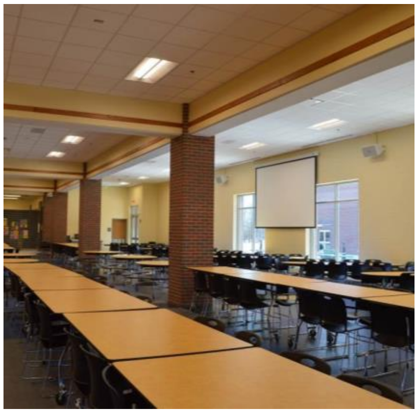


Figure 5.1.1 H: Site A – View of Cafeteria Entering the Space

Figure 5.1.1 I: Site A – View of Walk Off Mats at Entry Doors

Figure 5.1.1 J: Site A – View of Outdoor Courtyard

The gymnasium is located in a 2 story building adjacent to the cafeteria and band hall building. The sustainable principles integrated in the gym are flexibility, used by the community (economic and social sustainability), acoustic quality, lighting, less building materials (exposed structure), and durable finishes. This building is multi-functional with a basketball court for games and practice, walking track accessible to school and community, retractable bleachers for athletic training, weight rooms, locker rooms, lobby, and women’s fitness room. The facility is not only used for athletics, but it has also hosted the first high school Mississippi Citizenship Ceremony benefiting the community and State of Mississippi.

The lighting strategy was simple with LED fixtures and occupancy sensors which are both include benefits of energy savings, and is the cleanest most eco-friendly way of illumination. The natural light is used less because there are fewer windows, which are located along the north wall, in the lobby on the east wall, and in the women's fitness room on the west wall. The acoustic quality is achieved through acoustic wall panels. Overall the space is comfortable and conducive to extended periods of activity because the thermal and indoor air quality. This environment also supports the human body performance, because athletes are able to perform their best in spaces that have healthier indoor conditions. It creates a competitive athletic advantage, and it's through a better indoor environment.

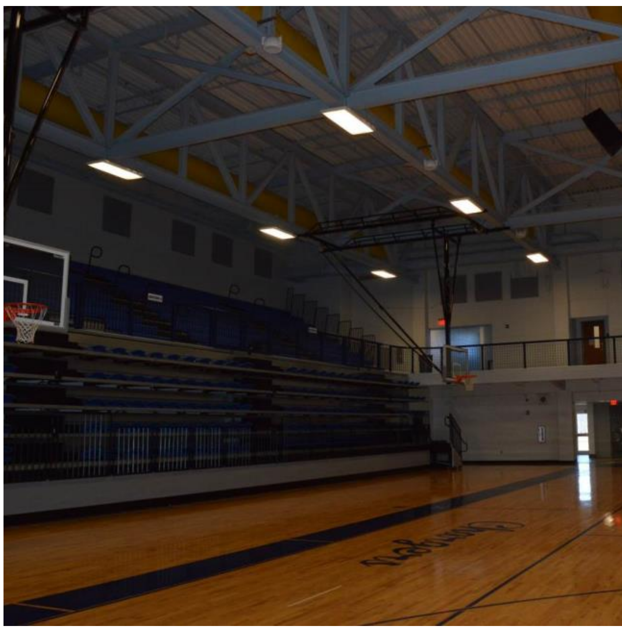


Figure 5.1.1 K: Site A – View of the Gymnasium from the 1st Floor

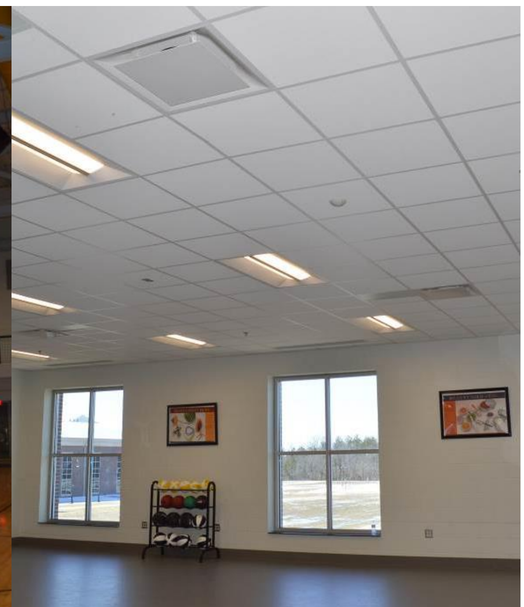


Figure 5.1.1 L: Site A – View of Women's Fitness Room

There is not a finish ceiling, and structural members are exposed (columns, bar joists, and trusses). This is a sustainable principle because it eliminates extra building materials. The floor finishes include VCT in the corridors and lobby, ceramic tile in the restrooms, wood flooring in the gymnasium, and rubber flooring around the track women's fitness room, weight room, and locker rooms. Figure 5.1.1.K is a view into the gymnasium on the first floor, and Figure 5.1.1.L is a view from the entry door looking into the women's fitness room.

The classroom spaces in the same building as the library (the main building). They are primarily located in the four wings of the main building. To access the classrooms throughout the day, students circulate in large hallways. These hallways are 10'-0" wide, have 10'-0" tall ceiling heights, and 70 inch LED screens which display school events throughout the day. The sustainable principles integrated in the cafeteria are durable finishes, acoustic quality, flexibility, and lighting quality.

Figure 5.1.1 M: Site A – View of Hallway on Second Floor in Building M (Mathmatics Wing).

The finishes and fixtures in both the classrooms and hallways include polished concrete floors, 2'x2' acoustical lay-in ceiling tile, LED 2'x4' indirect/direct lights, durable wall finishes of brick and CMU block walls, and aluminum storefronts to allow natural light to filter into the space. The larger hallways support a collaborative learning environment. Figure 5.1.1.M: Site A is a view of a hallway on the second floor in building M (Mathematics Wing). This is the typical design and configuration of all hallways in the main building.

The design of the classrooms consists of three different types including standard classrooms (history, math, English), science labs (chemistry, biology, science), and specialized classrooms (SPED, broadcasting, drama, ROTC). The sizes vary depending on the type, but the majority of the classrooms measure 45'-0" length x 30'-0" width with 10'-0" ceiling heights. Every classroom has windows with blinds which reduces the need for electrical lighting, providing daylighting control, and promoting learning and productivity. The electrical lights are on occupancy and daylight sensors. The sensors help contribute to the energy savings, and create a longer lifetime for the bulbs. The ceiling material is acoustical lay-in ceiling tile with insulation above to reduce noise.

Strategies to protect the school's indoor environmental quality include all paints, and adhesives were selected for their low chemical emissions. Other strategies include indoor chemical and pollutant source control, and thermal comfort design through controllability of systems and design. The furniture was a multi-functional and can be reconfigured easily for group work and collaboration. There is also an outdoor amphitheater, inviting courtyards for students and staff to enjoy lunch and breaks outside between classes. The concept of the design features was created for learning in order to improve the indoor environment for teachers and students. Figures 5.1.1. N, 5.1.1.O, and 5.1.1.P are views of the classrooms, and labs.

Figure 5.1.1 N: Site A – View of Standard Classroom

Figure 5.1.1 O: Site A – View of Collaboration Configuration

Figure 5.1.1 P: Site A – View of Lab Classroom

All the buildings at site A's campus are primarily constructed with concrete masonry including brick, CMU block walls, stucco, and metal panels. These materials are durable and low maintenance products. There are also multiple reclaimed products used in the buildings. The concrete under the slab is recycled concrete material from old highways and house slabs. Wood from trees that were cut down on the site is being reused in the school as accent elements such as windowsills. The reinforcement steel in the building as well as the metal roofing on the front five buildings is also reclaimed. The use of regional materials: materials extracted and manufactured within 500 miles of the jobsite, eliminating high transportation costs and stimulating the regional economy were integrated into the building.

5.2: Site B – Documentation and Assessment of the Built Environment

The original high school buildings at Site B were constructed in 1998, and there was an English classroom and restroom addition constructed in 2009. The entire high school campus is estimated to have a total of 99,500 square feet. It has a student population of 728 which makes up grades 9 through 12, and an adult population of 59 faculty, and 11 staff. Other than the English addition in 2009, there has not been any new construction, renovations and/or upgrades to interior finishes, lighting, HVAC, or thermal barrier components at any of these facilities. The overall design of each building lacks sustainable design principles.

The layout of the Site B's high school campus includes a total of 4 one story buildings. These are organized by 1 main building which houses the majority of core learning spaces, 1 band hall building, 1 ROTC building, and 1 drama/chorus building. This campus is different from Site A because the high school (9-12) is located on the same site as the 4 other schools in this district which include grades K-8 (lower elementary, upper elementary and middle school). Figure 5.2A shows the floor plans of each building structure that makes up the high school facility, and the spaces are identified through a color coding system.

The space planning and organization of spaces were efficient, but incorporated a traditional double loaded corridor design. The classrooms, gymnasium, hallways, band hall, and science labs appear to have appropriate footage and support the functions for the spaces well. The tall ceilings add volume and create an open environment for engagement in the commons area.

Despite the safe condition of the structure, the principal still expressed problems with the building. These issues included, uncomfortable indoor environment, lack of windows in administration spaces and hallways, and poor thermal and functional properties of the windows. Another issue is with the HVAC and lighting systems being out of date, not conserving energy, and not providing effective controls for the occupants. Based on this initial information from the principal, it is evident that the outdated building design is creating negative impacts on occupants, the school district's bottom line, and the environment.

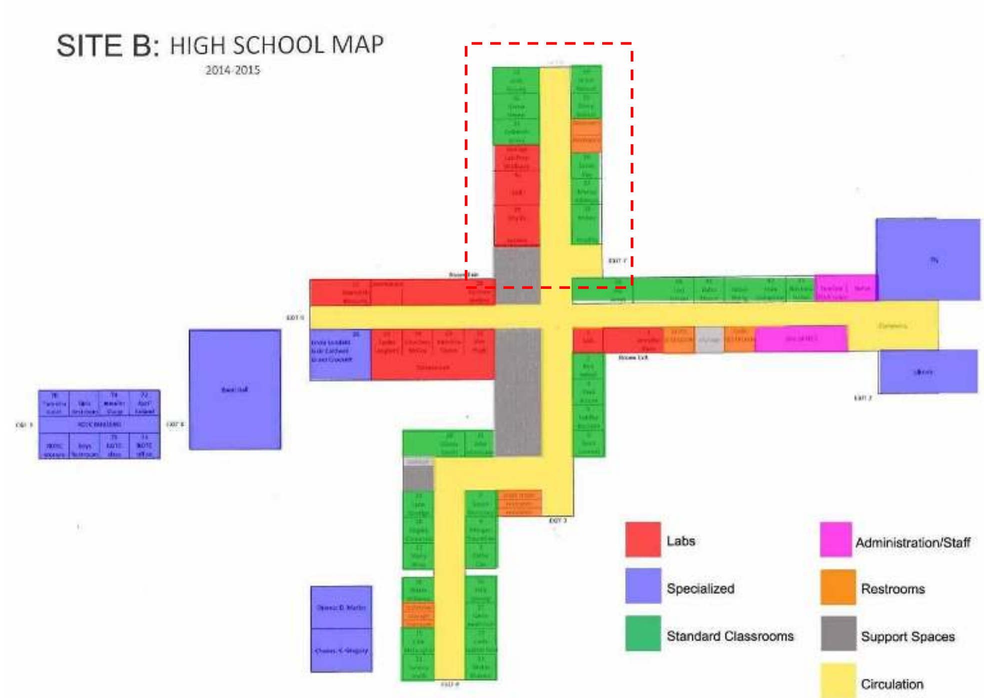


Figure 5.2A: Site B – High School Facility Floor Plans. The red dashed rectangle is the English wing addition.

5.2.1: Overview of Core Learning Spaces

When conducting the tour at Site B, the intent of the visit was to evaluate similar core learning spaces as Site A in order to compare findings from both sites, and to determine how the building design impacts the occupants teaching, learning, and overall wellbeing. The same method was used as Site A that the spaces were identified by the researcher as areas where learning would occur the most. The core learning spaces observed included the classrooms, labs, library, gymnasium, hallways, and cafeteria. The entrance is a large aluminum storefront that signifies entry, and allows natural light to filter through to the commons area, which is a multi-purpose and highly used space. It is used for the cafeteria, main entry, student gathering, and class transition space. It is centrally located, and adjacent to the gymnasium, library, and administration office suite. Figures 5.2.1A and 5.2.1B are views of the exterior front façade of the building (the high school name have been digitally covered for confidentiality purposes), and Figure 5.2.1C is the main entrance and commons area. This space included a sustainable design principle of natural light, but did not accommodate proper acoustics due to the hard floor and wall surfaces, and the volume of the space.

Figure 5.2.1A: Site B – Front Exterior Façade

Figure 5.2.1B: Site B – Exterior View of Main Entry (only window in commons area)

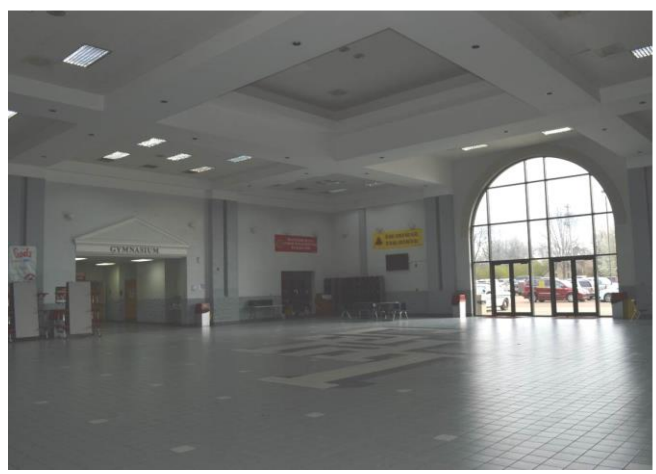


Figure 5.2.1C: Site B – View of Main Entry and Commons Area

The floor material in the commons area is a 6”x6” ceramic tile, which is problematic due to the amount of high traffic in this space. The floor finish does not have the durability to withstand the daily use, and is cracking. The walls are painted concrete block. There are very tall ceilings that are 21’-0” above finish floor, and the ceiling materials are both gypsum board and acoustical lay in ceiling tiles. Due to the amount of hard surfaces on the floor, walls, ceiling, and volume of the space, this room is very noisy making it difficult to have a conversation.

Figure 5.2.1D: Site B – View of Deteriorating Grout and Broken Ceramic Tile Base in Commons Area

Figure 5.2.1E: Site B – View of Broken Ceramic Tile in Commons Area

Although, a sustainable design feature was met by providing natural light, the artificial light levels are low making it appear dark. Due to the lack of lighting controls, this limited the flexibility to adjust lighting levels based on intended use. Another problematic design feature was the furniture. The furniture selection did not accommodate flexibility within the space because it was difficult to reconfigure for different uses. This daily movement of furniture was creating a negative impact on the interior’s physical condition by damaging the finishes. Figures 5.2.1D and 5.2.1E show the extent of the damage in the commons area.

The gymnasium was also located off the central commons area. The space was overall in good physical condition. The finishes and size of the space seemed adequate for functional needs. The sustainable design principles present in this space included natural light and proper acoustics, but were not executed well. The windows on each side wall of the gym brought a nice quality of daylight around the perimeter, but did not filter through to the court area. The acoustical lay-in ceiling above bleachers helped to a degree with the reverberation of the space, but if it was in the entire gym ceiling it would have had a better acoustic performance.

Another non sustainable design feature was the artificial lighting. The light levels were too low, the fixtures were not energy efficient, and they did not include controls to adjust light levels. The principal expressed this design hindered the school's capability to host events that met their satisfaction, and he felt it did not reflect the quality of their school's image. He preferred an improved lighting system, acoustical design, and PA system.

Figure 5.2.1F: Site B – View Gymnasium From Entrance

Figure 5.2.1G: Site B – View Gymnasium Lighting

Figure 5.2.1H shows the view of the library looking in from the entrance directly adjacent to the commons area, and on the opposite side of the gymnasium. The only sustainable design principle integrated in this space was natural light. There was a lack of proper acoustics, artificial lighting, and adequate space to conduct activities. Through observation, the researcher identified problems with the space plan design.

First, the relationship between the library (a quiet space used for concentration), and the commons area (high traffic, gathering, and noisy) was problematic for the occupants that required a quiet learning environment. The acoustics did not solve this problem, and noise was transmitted from the commons area to the library. Based on previous literature review, studies have shown that noise have shown to cause psychological distress, and have a negative effect on learning satisfaction of students. As a result, this can impact productivity, and performance (Akbari, J.; Dehghan, H.; Azmoon, H., & Forouharmajd, F., 2013, p1).

Secondly, the artificial lighting levels were intense fluorescent fixtures, and did not filter through the library well. This observation also supports previous research that poor lighting quality can contribute to vision disturbance, neck and shoulder pains, headaches, fatigue, and negatively impact performance, human temper, and learning satisfaction. To solve this issue, sustainable lighting strategies would be a better solution because research indicates high quality diffused light with controls for adjustment creates a more comfortable environment conducive to learning (Akbari, J.; Dehghan, H.; Azmoon, H., & Forouharmajd, F., 2013, p1).

The interior finish selections were durable and in good condition. The ceilings were acoustical lay in ceiling tile at a lower ceiling height of 14'-0" and the flooring was carpet. The carpet was broadloom, and in poor condition and in need of replacement. The entry had a more durable floor surface of vinyl composition tile. While both finishes seemed appropriate for the type of space, they were not sustainable products.

Figure 5.2.1H: Site B – View Library From Entrance

Moving down the corridors towards the classrooms, located opposite of the commons area, the flooring switches from ceramic tile to a vinyl composition tile. This is a traditional floor material in older education facilities, and is commonly used because it has a high resilience, resistant to scuffs and stains making it ideal for high traffic areas. Its life expectancy is for at least 15 years, and there are a variety of color and texture options to enhance the design, and there is a low level of noise generated when walking on the surface in lieu of a ceramic tile which is a harder surface.

However, because the product is made from PVC (polyvinyl chloride) it gives off harmful dioxins when it's incinerated, and typically when it's replaced it goes to landfills. There are companies that recycle the product, but it is typically associated with sustainable design principles and methods, and it is unknown by the researcher which if the vinyl composition tile was made from recycled content. The date of the building suggests it most likely was not. Another issue with this product is the yearly maintenance required to strip and wax the floor. This is inconvenient for the school because they are required to shut down operations, and the individual sealing the floor is exposed to off gassing.

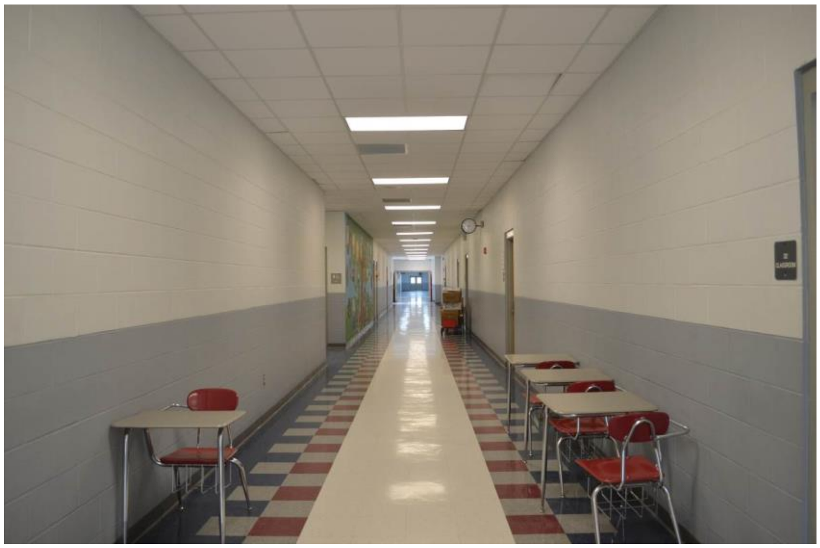


Figure 5.2.1I: Site B – View from English Wing Hallway into Main Building Hallway

Overall the appearance of the other interior finishes were dated, but in good physical condition. The facility was safe, clean, and functional. However, the noise levels were high between class changes. The lack of windows, and finish materials made the hallways have a long tunnel effect, and lack visual interest. The lack of connection to the outdoors can impact occupant's well-being (Olson, Kellum, 2003, 7; Devolder 2002, 322). Figure 5.2.1I shows the view looking from the English wing hallway into the main building hallway where the two spaces intersect.

The classrooms and labs were adjacent to the hallways, and located on the opposite end away from the common area. The classrooms and labs were generously sized and organized spatially. Both the spaces had the same VCT floor pattern which included a red accent color in a small quantity, which has the same characteristics as the corridor flooring. This pop of color added visual interest to the space, but did not over stimulate. The sustainable design principles present in this space included proper acoustics, and daylighitng. The acoustics of the space worked well with the VCT flooring and acoustical ceiling tile. There was a single window in the classroom and lab, and allowed some natural light to filter within the space, but not abundantly. Even though the artificial light provided adequate lighting levels, there were not any combination types of lighting or controllability available. All the lights were standard 2'x4' fluorescent light fixtures, which turned on by a single switch. This lighting system also lacked occupancy or lighting sensors, which contribute to energy efficiency. By not having these in place lights could remain on for extended periods of time or even it there was enough daylight for the space. Figures 5.2.1J shows a typical standard classroom, and 5.2.1K shows a typical lab.

Figure 5.2.1J: Site B – View of Typical Classroom

All the buildings at site B's campus are primarily constructed with concrete masonry including brick on the exterior with accents of precast and CMU (concrete masonry unit) painted block

Figure 5.2.1K: Site B – View of Typical Lab

walls on the interior. These materials are durable and low maintenance products. Overall the majority of the facility was clean, safe, and well maintained.

However, there were no reclaimed interior products used in any of the buildings. The researcher did not observe any eco-friendly design elements or purposeful integrated sustainable design features. Areas that were in need for improvement included poor acoustic properties of finishes, poor HVAC system due to uncontrollability of temperatures and humidity levels, lack of windows, and non-insulated windows contributing to poor thermal barrier.

Chapter VI: Results and Analysis

6.1: Site A and Site B – Overview of Teacher and Staff Survey

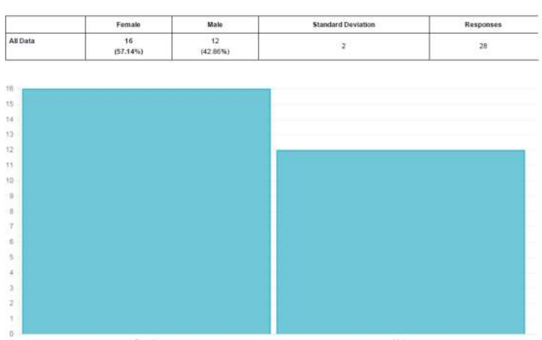
This chapter presents an analysis of the data collected from surveys answered by both teachers and staff from Sites A and B. The intent was to examine the effects of the indoor environmental quality (IEQ) variables that impacted both the teachers' and staffs' overall satisfaction of the school buildings they occupy, and use on a daily basis. The IEQ design principles were selected from the LEED 2009 For Schools New Construction and Major Renovations Rating System credits as a guideline used as a standard for measure. The IEQ principles selected for this study included: acoustics, lighting, thermal comfort, and indoor air quality (IAQ).

The objective was to gain a better understanding of the teachers' and staffs' level of satisfaction with their school's built environment. The intent was to determine if their level of satisfaction was a result due to a correlation with the Indoor Environmental Quality (IEQ) principles that were present in their buildings. The researcher also wanted to determine if the IEQ principles had a positive or negative impact on the participants' daily activities. This information is significant because it can help establish better sustainable design guidelines; in return, can provide interior designers and other design professionals the necessary solutions to create healthier school buildings for the future. By establishing better design guidelines with an emphasis on sustainable design, the outcomes can improve school facilities and enhance the learning experience for students, teachers, and staff of the 21st century.

The following subchapters summarize the survey responses from each site. The researcher documented both Site A and Site B's results separately, and then compared the data by using a descriptive statistics analysis and t-test. The descriptive analysis used frequencies to analyze each group's demographic characteristics. First, the mean scores were calculated to compare the participant's satisfaction levels, and then frequency distributions were analyzed and converted to percentages in order to measure and compare results. Lastly, an unpaired t-test was conducted to measure and compare the mean scores to determine the level of significance of each survey question.

6.2 Site A and Site B - Teacher Survey Results and Analysis

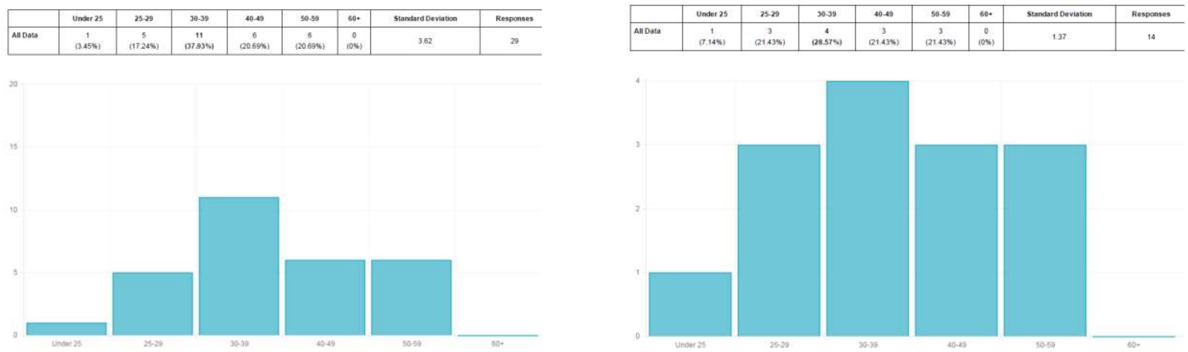
From Site A's overall number of 78 contacted teachers, 29 chose to participate in the study; the sample size n=29 yielded a response rate of 37.18%. The descriptive analysis of Site A's teacher demographics indicated that there was a similar population of both genders including male (42.9%) and female (57.1%). The teachers' age varied between 25 and 59 (See Figure 6.2.A), but the majority of the teachers were between 30 and 39 years old (37.9%). The teacher's responses on the number of years they have worked had a significant difference in responses from being their first year and working more than 20 years (Figure 6.2.B). Site B's overall number of 59 contacted teachers, 14 chose to participate in the study; the sample size n=59 yielded a response rate of 23.73%. The descriptive analysis of Site A's teacher demographics indicated that the majority were female (78.6%). The results indicated that the teachers that worked at the high school between 3 and 5 years were (42.9%). The teachers' ages varied between 25 and 59 (See Figure 6.2.C).



Site A

Site B

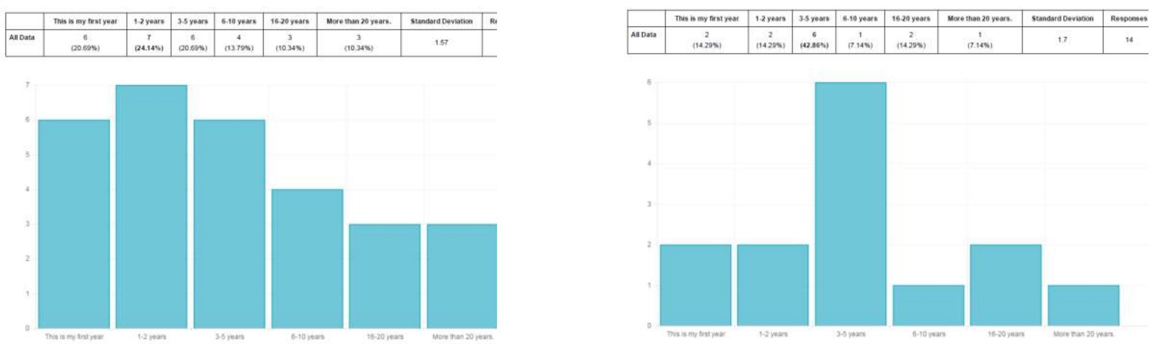
Figure 6.2.A. Teacher gender response review from Site A and Site B.



Site A

Site B

Figure 6.2.B. Teacher response review on their age from Site A and Site B.



Site A

Site B

Figure 6.2.C. Teacher response review of the number of years worked at the high school from Site A and Site B.

Figure 6.2.D shows the mean and standard deviation scores from the teacher responses to the survey questions from Site A. The majority of the teachers responses to the acoustic quality was satisfied (Q#4: M=2.89, SD=1.5). The responses having adequate natural and artificial lighting in the classrooms was reported being satisfied (Q#5: M= 7.5, SD=4.31 & Q#15: M= 8.1, SD=5.73). The level of agreement of the quality of thermal comfort in the classroom and overall high school building was viewed as extremely well (Q#8: M=6.5, SD=2.9). However, there were mixed responses on how they perceived the climate control (Q#17: M=5.5, SD=1.23). There was a high response

rate for wanting operable windows in the classrooms to control the ventilation (Q#16: M=3.8, SD=10.9). Their responses on the indoor air quality relative to the maintenance practices was thought to be designed well (Q#18: M=6.9, SD=3.5).

Site A: Teacher Survey Results					
Acoustic Quality	**Lighting Quality**	**Thermal Comfort**	**Indoor Air Quality**	**Environmental Responsibility**	**Overall Satisfaction and Performance Results**
Q #4: M=3.83 SD=2.48	Q#5: M=7.48 SD=4.31	Q#8: M=6.48 SD=2.86	Q#16: M=3.79 SD=10.89	Q#6: M=3.29 SD=5.87	Q#7: M=6.65 SD=2.74
	Q#15: M=8.10 SD=5.73	Q#17: M=5.52 SD=1.23	Q#18: M=6.93 SD=3.49	Q#9: M=6.90 SD=3.05	Q#13: M=6.10 SD=2.44
					Q#14: M=6.72 SD=2.3

Note: The survey questions sent to the teachers differs from the survey sent to the staff. The teacher survey questions focused on the design of the classroom interior and overall high school building. The staff survey questions focused on the design of their individual offices and the overall high school building. The highlighted boxes indicate the results are statically significant.

Figure 6.2.D. Total mean and standard deviation score results from Site A teacher survey responses.

Figure 6.2E shows the mean and standard deviation scores from the teacher responses to the survey questions from Site B. The overall response rate on how they perceived the acoustic quality was satisfied (Q#4: M=2.8, SD=1.5). They were also satisfied with the quality of artificial and natural lighting in their classrooms (Q#5: M= 7, SD=1.8 & Q#15: M= 7.14, SD=1.83). The thermal comfort responses varied between being well and not well designed (Q#8: M=6.35, SD=1.5 & Q#17: M=4.57, SD=1.5). The classroom existing windows were explained to be operable, and that they use them to control ventilation (Q#16: M=2.07, SD=3.77). They were also satisfied with and the maintenance practices throughout the high school building (Q#18: M=6.35, SD=1.5).

The environmental responsibility questions indicated a majority of the responses agreed their school didn’t provide an outdoor learning space, and perceived it was an important learning space (Q#6: M=2.76, SD=1.79). Their responses were mixed on how well the high school demonstrated environmental responsibility (Q#9: M=6.14, SD=0.83). The overall satisfaction and performance results category, the majority of the respondents were satisfied with the built environment supporting student achievement, but the overall responses varied from levels 3 through 9 (Q#7:M=6.64, SD=1.26). The overall satisfaction level of the high school supporting their work experience and was perceived as satisfied (Q#13:M=6.78,SD=2.22), but their response on the quality of the interior finishes varied from levels 3-9 (Q#14:M=6.57, SD=1.26).

Site B: Teacher Survey Results					
Acoustic Quality	**Lighting Quality**	**Thermal Comfort**	**Indoor Air Quality**	**Environmental Responsibility**	**Overall Satisfaction and Performance Results**
Q #4: M=2.78 SD=1.5	Q#5: M=7 SD=1.77	Q#8: M=6.35 SD=1.5	Q#16: M=2.07 SD=3.77	Q#6: M=2.76 SD=1.79	Q#7: M=6.64 SD=1.26
	Q#15: M=7.14 SD=1.83	Q#17: M=4.57 SD=1.5	Q#18: M=6.35 SD=1.5	Q#9: M=6.14 SD=0.83	Q#13: M=6.78 SD=2.22
					Q#14: M=6.57 SD=1.26

Note: The survey questions sent to the teachers differs from the survey sent to the staff. The teacher survey questions focused on the design of the classroom interior and overall high school building. The staff survey questions focused on the design of their individual offices and the overall high school building. The highlighted boxes indicate the results are statically significant.

Figure 6.2.E. Total mean and standard deviation score results from Site B teacher survey responses

After the total mean and standard deviation scores were calculated for each site's survey responses, an unpaired two sample t-test was conducted with a confidence interval for the difference between the scores. The unpaired t method tests the null hypothesis that the population means related to two independent variables from an approximately normal distribution (Creswell, 2012, 192). The un-paired t test results measures the difference between the results from the two study groups, Site A and Site B, to determine if they are significant.

TEACHER RESULTS - Unpaired *t* test results (#17):

P value and statistical significance:

The two-tailed P value equals 0.0384

By conventional criteria, this difference is considered **to be statistically significant.**

Confidence interval:

The mean of Group One minus Group Two equals -0.9200

95% confidence interval of this difference: From -1.7886 to -0.0514

Intermediate values used in calculations:

t = 2.1390

df = 41

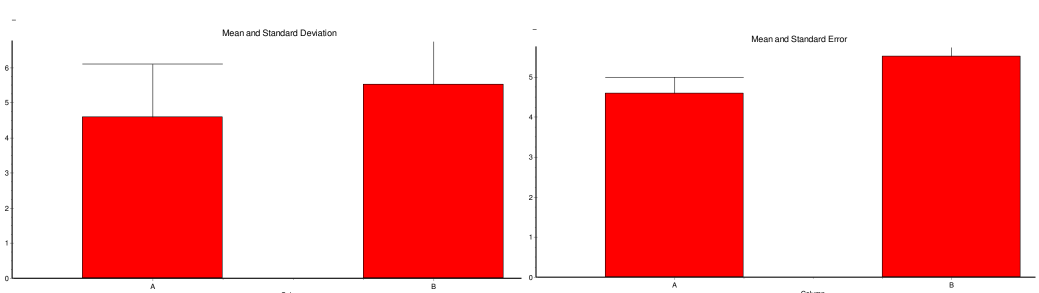
standard error of difference = 0.430

Review your data:

Group	Group One	Group Two
Mean	4.6000	5.5200
SD	1.5000	1.2300
SEM	0.4009	0.2284
N	14	29

Figure 6.2.F. The results from the unpaired t test based on question #17. Group one is Site B, and Group two is Site A.

The results confirmed that a majority of the responses had no level of significant differences between aspects. However, there were 1 questions was viewed as statistically significant. The question was #17 (Thermal Comfort Category). Question #17 asked the teachers their level of agreement of how well the climate control was perceived in the classroom. The two-tailed P value equals 0.0384 <= 0.05, and by conventional criteria this difference is considered to be statistically significant, and the null hypothesis is accepted. The confidence interval included the mean of group one (Site B) minus group two (Site A) equals -0.9200, and a 95% confidence interval of this difference from -1.7886 to -0.0514. The intermediate values used in calculation included a t=2.1390, df=41, and a standard error of difference = 0.430 (See Figure 6.2.F).



Site A

Site B

Figure 6.2.G. Bar graph of the results from question #17 unpaired t test. Group A is Site B, and Group B is Site A. Site A more satisfied, and Site B was less satisfied.

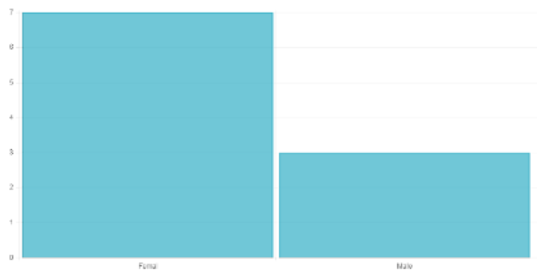
6.3: Site A and Site B - Staff Survey Results and Analysis

Site A's staff population of 27 with a total of 10 respondents (response rate of 37.04%). The majority of the respondents were female (70.0%). The staff's response for the amount of time they have worked at the high school varied between being their first year to more than 20 years (See Figure 6.3.B). A majority of the responses were between 1-2 years (30.0%) and 6-10 years (20.0%). A majority of the responses indicated that the age of the staff was between 30-39 (40.0%) and 40-49 (40.0%) (See Figure 6.3.C).

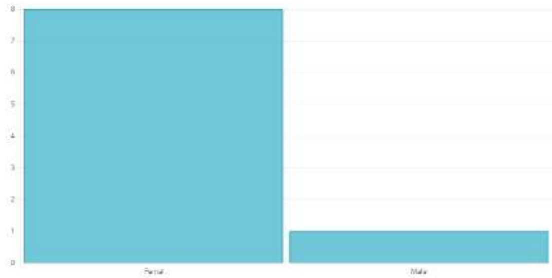
Site B's staff population of 11 and a total of 9 respondents (response rate of 81.82%). The majority of the respondents were female (89.9%). The amount of time they have worked at the high school varied between being their first year to more than 20 years (See Figure 6.3.B). A majority of the responses indicated that the age of a majority of the staff was 50-59 (44.4%) (See Figure 6.3.C).

Figure 6.3.D shows the mean and standard deviation scores for Site A from the staffs' responses to the survey questions. A majority of the responses on the acoustic quality perceived the high school of not being noisy with a 4 out of the 10 response total (Q#4: M=3.1, SD=1.2). The staff also agreed that the high school provided adequate Lighting quality and being satisfied (Q#5: M= 2, SD=1.97 & Q#6: M= 2.5, SD=1.66 & Q#15: M=8.1, SD=1.97). The overall response on the thermal comfort category agreed the facility did maximize the physical comfort well (Q#8: M=6.5, SD
2.9).

	Femal	Male	Standard Deviation	Responses
All Data	7 (70%)	3 (30%)	2	10



	Femal	Male	Standard Deviation	Responses
All Data	8 (88.89%)	1 (11.11%)	3.5	9

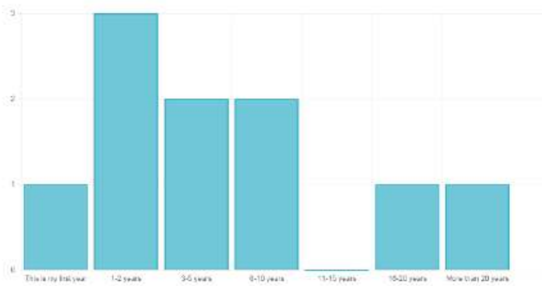


Site A

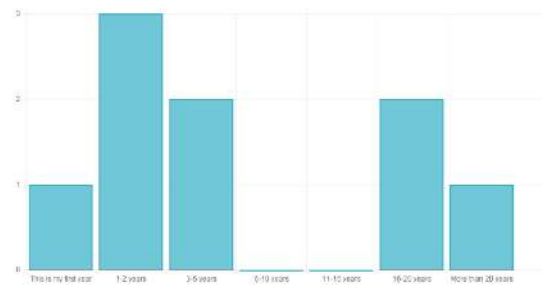
Site B

Figure 6.3.A. Staff gender response review from Site A and Site B.

	This is my first year	1-2 years	3-5 years	6-10 years	11-15 years	16-20 years	More than 20 years	Standard Deviation	Responses
All Data	1 (10%)	3 (30%)	2 (20%)	2 (20%)	0 (0%)	1 (10%)	1 (10%)	0.9	10



	This is my first year	1-2 years	3-5 years	6-10 years	11-15 years	16-20 years	More than 20 years	Standard Deviation	Responses
All Data	1 (11.11%)	3 (33.33%)	2 (22.22%)	0 (0%)	0 (0%)	2 (22.22%)	1 (11.11%)	1.03	9

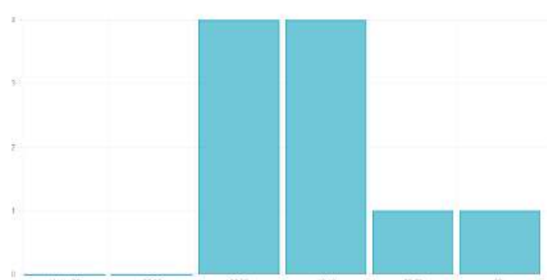


Site A

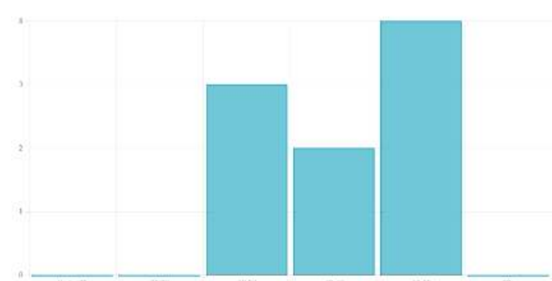
Site B

Figure 6.3.B. Staff response review on their age from Site A and Site B.

	Under 25	25-29	30-39	40-49	50-59	60+	Standard Deviation	Responses
All Data	0 (0%)	0 (0%)	4 (40%)	4 (40%)	1 (10%)	1 (10%)	1.7	10



	Under 25	25-29	30-39	40-49	50-59	60+	Standard Deviation	Responses
All Data	0 (0%)	0 (0%)	3 (33.33%)	2 (22.22%)	4 (44.44%)	0 (0%)	1.61	9



Site A

Site B

Figure 6.3.C. Staff response review of the number of years worked at the high school from Site A and Site B.

Site A: Staff Survey Results					
Acoustic Quality	**Lighting Quality**	**Thermal Comfort**	**Indoor Air Quality**	**Environmental Responsibility**	**Overall Satisfaction and Performance Results**
Q #4: M=3.1 SD=1.2	Q#5: M=2 SD=1.97	Q#8: M=6.2 SD=0.74	Q#16: M=2.77 SD=3.34	Q#9: M=7 SD=0.99	Q#7: M=5.3 SD=0.99
	Q#6: M=2.5 SD=1.66	Q#17: M=4 SD=0.74	Q#19: M=6.7 SD=0.99		Q#13: M=6.2 SD=0.99
	Q#15: M=8.1 SD=1.97				Q#14: M=6.6 SD=1.2
					Q#14: M=6.1 SD=1.52

Note: The survey questions sent to the teachers differs from the survey sent to the staff at each site. The teacher survey questions focuses on the classroom interior and overall high school building. The staff survey questions focuses on their offices and the overall high school building.

Figure 6.3.D. Total mean and standard deviation score results from Site A staff survey responses. Highlighted boxes indicate the t-test results were considered statistically significant.

A majority of the respondents perception on the level of climate control they had in their offices was answered not well (Q#17: M=4, SD=0.74). There was a high response rate on preferring operable windows in there, to control ventilation (Q#16: Q#16: M=2.77, SD=3.34). The maintenance practices were perceived as well (Q#19: M=6.7, SD=0.99). They also agreed that the high school was demonstrating environmental responsibility extremely well (Q#9: M=7, SD=0.99).

The overall level of satisfaction level the staff had for the built environment at their high school varied between questions. There were mixed responses on the satisfaction of the furniture and storage elements, and how well the built environment supported their work experience (Q#7: M=5.3,SD=0.99 & Q#13: M=6.2,SD=0.99). There was a high response rate (40% responded of being satisfied at a level 9) on being satisfied with the interior finishes (Q#14: M=6.6, SD=1.2). They also agreed that the facility's built environment allowed them to be highly motivated to accomplish their work responsibilities (Q#18: M=6.1 & SD=1.52).

Figure 6.3.E shows the mean and standard deviation scores for Site B from the staffs' responses to the survey questions. Site B's response to the acoustic quality varied on how they viewed the control of the noise level (Q#4:M=3.88, SD=1.25). The overall responses varied between being dissatisfied and satisfied with the of the responses agreed that lighting quality was adequate for both artificial and lighting control (Q#5:M= 3.33, SD=1.05 & Q#6: M= 1.88, SD=1.89). However, a majority of the responses varied Between being dissatisfied and satisfied with the natural lighting and outdoor views in their offices (Q#15: M=6.22, SD=1.25).

The questions regarding the thermal had varied responses. These included a mixed perception on the level of agreement of how well the facility maximizes physical comfort (Q#8: M=5.55, SD=0.47), and how well the climate control is in their offices Q#17: M=5.55, SD=0.67). The indoor air quality results indicated that the existing windows are operable, and they are used to control ventilation (Q#16: M=1.33, SD=2.77). The participants also responded that the building's built environment was maintained well (Q#19: M=6.44, SD=1.25). The response rate was extremely inconsistent on the level of agreement on how well the high school is demonstrating environmental responsibility (Q#9: M=5.11, SD=0.47).

The staffs' overall satisfaction of the high school had a mixed response rate. There were multiple responses on the level of satisfaction with the furniture and storage, but the majority were dissatisfied (Q#7: M=5.44,SD=0.87). Most of the participants Agreed that they were satisfied with how the building supported their work experience (Q#13: M=5.44, SD=0.87). Most of the staff reported being unsatisfied with the interior finishes throughout the high school facility (Q#14: M=5.44, SD=0.82).

The majority of the participants agreed that the high school's built environment allowed them to be highly motivated, productive, and accomplish their daily tasks (Q#18: M=6.11, SD=1.05).

After the total mean and standard deviation scores were calculated for each site's survey responses, an unpaired two sample t-test was conducted with a confidence interval for the difference between the scores. The unpaired t method tests the null hypothesis and gathers the results using the same method described for the teacher survey results. Again, similar to the teacher survey results, the t-test results confirmed that a majority of the responses had no level of significant differences between aspects.

However, there were 4 questions that were viewed as statistically significant which included the following: #15 (Lighting Quality Category), #17 (Thermal comfort), #9 (Environmental Responsibility), and #14 (Overall Satisfaction and Performance Results). In both the staff survey and teacher survey t test results a thermal comfort question was found to be statistically significant indicating differences between scores. The thermal comfort question response results for both the staff and teachers were considered to be statistically significant when analyzing the data.

Site B: Staff Survey Results					
Acoustic Quality	**Lighting Quality**	**Thermal Comfort**	**Indoor Air Quality**	**Environmental Responsibility**	**Overall Satisfaction and Performance Results**
Q #4: M=3.88 SD=1.25	Q#5: M=3.33 SD=1.05	Q#8: M=5.55 SD=0.47	Q#16: M=1.33 SD=2.77	Q#9: M=5.11 SD=0.47	Q#7: M=5.44 SD=0.87
	Q#6: M=1.88 SD=1.89	Q#17: M=5.55 SD=0.67	Q#19: M=6.44 SD=1.25		Q#13: M=7 SD=1.15
	Q#15: M=6.22 SD=1.25				Q#14: M=5.44 SD=0.82
					Q#18: M=6.11 SD=1.05

Note: The survey questions sent to the teachers differs from the survey sent to the staff at each site. The teacher survey questions focuses on the classroom interior and overall high school building. The staff survey questions focuses on their offices and the overall high school building.

Figure 6.3.E. Total mean and standard deviation score results from Site B staff survey responses. Highlighted boxes indicate the t-test results were considered statistically significant.

Question #15 asked the staff their level of agreement of how satisfied they were with the amount of day-lighting, and view the windows provided in their offices. The two-tailed P value equals 0.0254 <= 0.05, and by conventional criteria this difference is considered to be statistically significant, and the null hypothesis is accepted. The confidence interval included the mean of group one (Site B) minus group two (Site A) equals -1.8800, and a 95% confidence interval of this difference from -3.4992 to -0.2608. The intermediate values used in calculation included a t=2.4497, df=17, and a standard error of difference=0.767 (Figure 6.3.F.).

STAFF RESULTS - Unpaired *t* test results (#15):

P value and statistical significance:
The two-tailed P value equals 0.0254
By conventional criteria, this difference is **considered to be statistically significant.**

Confidence interval:
The mean of Group One minus Group Two equals -1.8800
95% confidence interval of this difference: From -3.4992 to -0.2608

Intermediate values used in calculations:
t = 2.4497
df = 17
standard error of difference = 0.767

Review your data:

Group	Group One	Group Two
Mean	6.2200	8.1000
SD	1.2500	1.9700
SEM	0.4167	0.6230
N	9	10

Figure 6.3.F. The results from the unpaired t test based on question #15. Group one is Site B, and Group two is Site A.

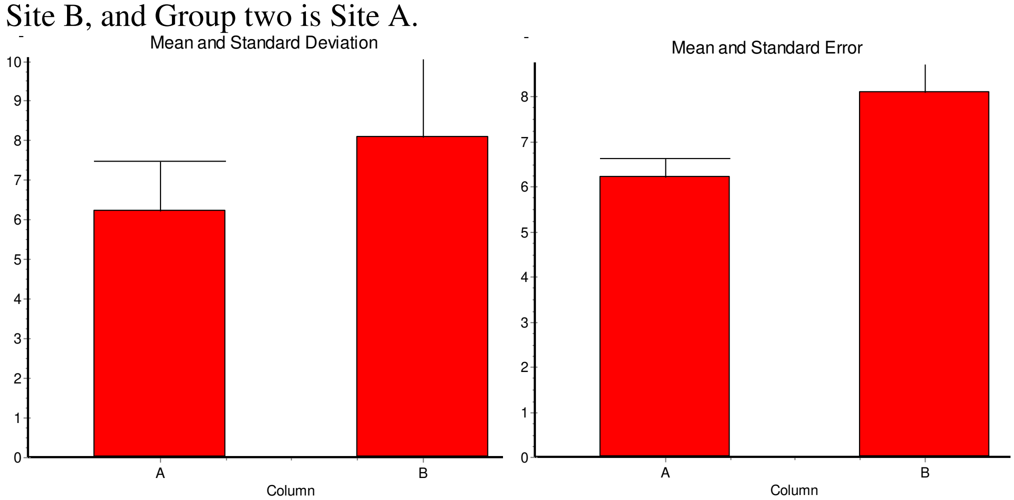


Figure 6.3.G. Graphed results from question #15 unpaired t test. Group A is Site B, and Group B is Site A. Site A was more satisfied, and Site B was less satisfied.

Question #17 asked the staff their level of agreement of how well the climate control is in their offices. The two-tailed P value equals 0.0001 <= 0.05, and by conventional criteria this difference is considered to be extremely statistically significant, and the null hypothesis is accepted. The confidence interval included the mean of group one (Site B) minus group two (Site A) equals 1.6000, and a 95% confidence interval of this difference from 0.9137 to 2.2863. The intermediate values used in calculation included a t=4.9190, df=17, and a standard error of difference=0.325 (Figure 6.3.H.).

STAFF RESULTS - Unpaired *t* test results (#17):

P value and statistical significance:
The two-tailed P value equals 0.0001
By conventional criteria, this difference is considered to be **extremely statistically significant.**

Confidence interval:
The mean of Group One minus Group Two equals 1.6000
95% confidence interval of this difference: From 0.9137 to 2.2863

Intermediate values used in calculations:
t = 4.9190
df = 17
standard error of difference = 0.325

Review your data:

Group	Group One	Group Two
Mean	5.6000	4.0000
SD	0.6700	0.7400
SEM	0.2233	0.2340
N	9	10

Figure 6.3.H. The results from the unpaired t test based on question #17. Group one is Site B, and Group two is Site A.

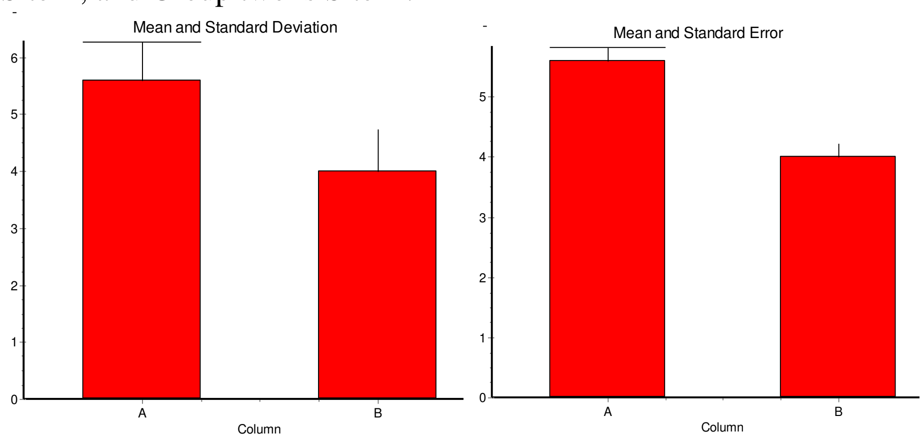


Figure 6.3.I. Graphed results from question #17 unpaired t test. Group A is Site B, and Group B is Site A. Site A was less satisfied and Site B was more satisfied.

Question #9 asked the staff their level of agreement of how well their high school facility demonstrates environmental responsibility. The two-tailed P value equals 0.0001

<= 0.05, and by conventional criteria this difference is considered to be extremely statistically significant, and the null hypothesis is accepted. The confidence interval included the mean of group one (Site B) minus group two (Site A) equals -2.3900, and a 95% confidence interval of this difference from -3.1550 to -1.6250. The values used in calculation included a t=6.5911, df=17, and a standard error of intermediate difference=0.363 (Figure 6.3.J.).

STAFF RESULTS - Unpaired *t* test results (#9):

P value and statistical significance:
The two-tailed P value is less than 0.0001
By conventional criteria, this difference is considered to be **extremely statistically significant.**

Confidence interval:
The mean of Group One minus Group Two equals -2.3900
95% confidence interval of this difference: From -3.1550 to -1.6250

Intermediate values used in calculations:
t = 6.5911
df = 17
standard error of difference = 0.363

Review your data:

Group	Group One	Group Two
Mean	5.1100	7.5000
SD	0.4700	0.9900
SEM	0.1567	0.3131
N	9	10

Figure 6.3.J. The results from the unpaired t test based on question #9. Group one is Site B, and Group two is Site A.

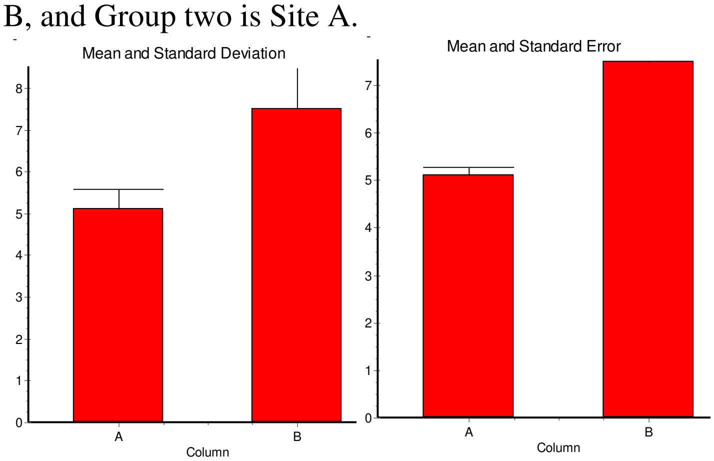


Figure 6.3.K. Graphed results from question #9 unpaired t test. Group A is Site B, and Group B is Site A. Site A response was extremely well, and Site B response was not well.

Question #14 asked the staff their level of agreement on how satisfied they were with the interior finishes such as flooring, wall finish, and ceiling material in their high schools. The two-tailed P value equals 0.0264 <= 0.05, and by conventional criteria this difference is considered to be statistically significant, and the null hypothesis is accepted. The confidence interval included the mean of group one (Site B) minus group two (Site A) equals -1.1600, and a 95% confidence interval of this difference from -2.1669 to -0.1531. The intermediate values used in calculation included a t=2.4307, df=17, and a standard error of difference=0.477 (Figure 6.3.L.).

STAFF RESULTS - Unpaired *t* test results (#14):

P value and statistical significance:
The two-tailed P value equals 0.0264
By conventional criteria, this difference is **considered to be statistically significant.**

Confidence interval:
The mean of Group One minus Group Two equals -1.1600
95% confidence interval of this difference: From -2.1669 to -0.1531

Intermediate values used in calculations:
t = 2.4307
df = 17
standard error of difference = 0.477

Review your data:

Group	Group One	Group Two
Mean	5.4400	6.6000
SD	0.8200	1.2000
SEM	0.2733	0.3795
N	9	10

Figure 6.3.L. The results from the unpaired t test based on question #14. Group one is Site B, and Group two is Site A.

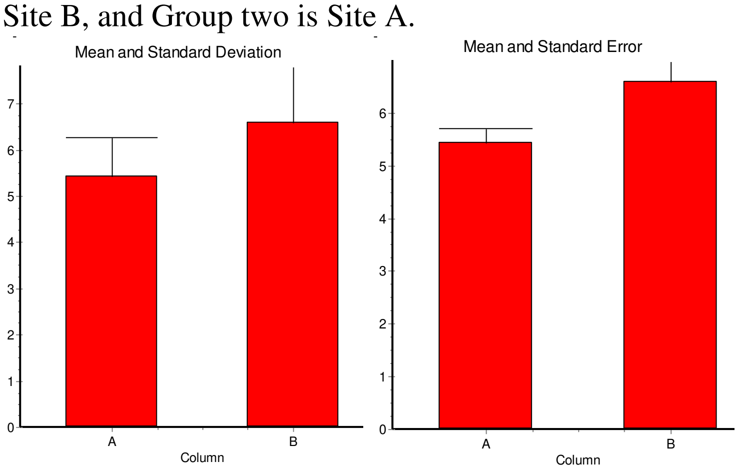


Figure 6.3.M. Graphed results from question #14 unpaired t test. Group A is Site B, and Group B is Site A. Site A was more satisfied, and Site B was less satisfied.

6.4: Site A and Site B - Principal Interview Results and Analysis

The interview portion of the research study was conducted through an e-mail delivery method. Interview questions were sent electronically to both Site A and B's principals. The purpose of the e-mail interview qualitative method was to gain personal insights from each principal to understand their level of satisfaction with their school's built environment. The questions focused on their perception levels of how well the building adequately supported both teaching and learning activities. Additional questions were asked to gain a better insight on their knowledge about sustainable design. The intent was to determine their level of value for this method of design; would it be considered a high priority for their school's future construction needs?

Since the interviews were not face-to-face, the questions phrased clearly enough to avoid misinterpretations, and to motivate the participants to comment further on the topic. The interviews consisted of twenty-seven identical questions with an open-ended structure. The questions were intended to prompt the participants to honestly share their experiences, opinions, and views on their existing high school buildings, and their building's ability to support learning activities. Additionally, they were asked about their level of support for sustainable design (Cresswell, 2012). After the data was collected, the researcher identified that not all questions were answered. The principals both acknowledged this was a result because they were unfamiliar with the types of questions being asked about the design process and sustainable design principles. This was a result of the participants not being involved in the design of the space, and their lack of a general understanding about design. Therefore with these limitations, they were unable to respond to all interview questions. The questions being analyzed in this chapter will only be questions 1-21 because they were the most consistently answered, and based on the quality of responses.

The trustworthiness of this portion of the study was addressed by the researcher not influencing the research participants to answer the interview questions in a way that would be false. The intent was to pose questions that led the participants to answer questions honestly. Therefore, the researcher did not discuss their own experiences and opinions about the questions with the participants in order to avoid persuading them to answer in a certain way.

After the responses were reviewed, the researcher identified two themes found in the results (See Figure 6.4.A). The first theme was the Built Environment, and the second theme was Sustainable Design. The built environment theme questions focused on the building structure and the interior spaces. The researcher specifically wanted to understand how the principals' perceived their schools' built environment supporting their occupants' daily activities of working, teaching and learning. Overall, this theme represented the buildings material components, specifically interior finishes and the spatial qualities that were present within each school. The questions that were answered allowed the researcher to determine how these environmental characteristics influenced each principals' satisfaction levels with each school being observed in the study.

The second theme identified was Sustainable Design. The mission of sustainable design is to reduce consumption of non-renewable resources, minimize waste, and create healthy and productive environments (GSA, 2015). The purpose of this theme was used to address how the existing resources were being used at each site. In addition, the principals' responses relative to this theme helped determine if sustainable design was perceived as valuable to their current or future school environment; in order for the researcher to understand how each principal perceived their schools' built environment was reducing the negative impacts on the environment, health and comfort of building occupants.

Questions Selected to Analyze:	Principal Response – Site A	Principal Response – Site B
Current environment	Satisfied with space, and modern.	Overall satisfied, except for gymnasium lighting.
Age	1.5 years	15 years
Renovation or Additions	None	English wing
Rating of interior space (1-9). 9 is extremely well.	N/A (not answered)	7
Flooring	Stained Concrete	Vinyl Composition Tile (Tile Squares)
Ceiling Material	Ceiling Tiles	Ceiling Tiles
Artificial Lighting	LED with occupancy sensors	Fluorescent
Natural Lighting	Daylighting to illuminate classrooms and reduces energy costs. The building is orientated to maximize southern exposure.	Does not use daylighting to illuminate classrooms or to reduce energy costs. Does not maximize southern exposure.
Mechanical	New (1.5 years)	15 years
Maintenance	Mopped floors	Swept and mopped. Striped and Waxed in summer.
Image of School	First in Class	Clean
Collaboration	Teacher workrooms at each wing	Building is divided into academic wings.
What establishes an effective classroom?	A pleasant learning environment	Arrangement of room
What makes a sustainable school?	Construction	Lighting, heating, and cooling system.
Is sustainability important for your school system?	Yes	To some degree
Do you believe that a sustainable improvement to the existing facility would work better than current facility?	None	Yes

Figure 6.4.A. List of Questions and Responses from Principals Interview Questions at Site A and Site B Selected To Be Analyzed.

To further examine the themes identified, the researcher developed subcategories that had a connection to the main themes. A total of three subcategories emerged from the built environment theme. Each subcategory had a high level of satisfaction from both groups' principals (Site A and Site B) despite the differences in their responses. The subcategories included the following:

1. Lighting
    a. LED (Site A) & Fluorescent (Site B)
        i. Both sites perceived as positive
    b. Occupancy Sensors (Site A) & No Occupancy Sensors (Site B)
        i. Both sites did not express a level of satisfaction
    c. Daylight Strategy (Site A) & Only Windows (Site B)

i. Both sites perceived as positive

2. Mechanical Systems

   a. 1.5 year old system (Site A) & 17 year old system (Site B)

      i. Researcher identified a significant age difference between the two buildings.

3. Interior Finishes

   a. Floor: Stained Concrete (Site A) & Vinyl Composition Tile (Site B)

      i. Durability and Maintenance was identified by the researcher to have been more successfully implemented at Site A when compared to Site B.

Each principal perceived the sub-categories as being non-problematic (except for the gymnasium lighting at Site B). The qualitative findings from both principals' were compared to determine the differences. Past research was referenced to enhance the accuracy of the study, and support the categories established by the researcher.

Each site's lighting was reviewed. Site A had LED indirect/direct 2'x4' fixtures on occupancy sensors and Site B has fluorescent 2'x4' fixtures. Site A's LED lighting has a 90%-99% energy converted into visible light, lifespan of 60, 000+ hours, easy recycling plastic and aluminum, durable in extreme conditions, instant on flicker free, and has low maintenance and energy costs. Site B's fluorescent fixtures emits UV, 15%-20% energy is converted into visible light, lifespan of approximately 10,000 hours, potential mercury vapor leaks, fragile, sensitive to fluctuation and frequent on/off, takes a couple of minutes to reach peak output, flickers, may cause eye strain and headache, and increase maintenance and energy costs (The U.S. Department of Energy, 2014).

The occupancy sensor (located at Site A only) is a lighting control device that detects the amount of people in the room, and turns lights on and off. They are motion detectors that reduce energy consumption in building spaces by automatically shutting off the lights during periods of non-use. They can eliminate 20%-30% of lighting energy costs, and they are convenient (DiLouie, C., 2011).

There was a difference between the two principals' responses on how daylighting was used to illuminate classrooms and reduce energy costs. The high school building at Site A met LEED guideline requirements for daylighting, by providing windows designed to affect daylight performance, location of the building's orientation and massing, size and placement of windows, and the glazing and shading systems. Site B had windows present in each classroom, and in a majority of the occupied spaces, but the windows were not designed with a daylighting strategy to reduce energy costs, or maximize proper natural light. The difference between the two designs was Site B did not create luminous comfort for the occupants because the daylight levels could not be controlled. Based on previous literature review, this can have a negative impact on the thermal and acoustical comfort, energy consumption, and views (Heschong Mahone Group, 2003).

The mechanical system for Site A was designed to meet LEED guidelines which supports energy efficiency and lowers energy consumption and costs. A newer HVAC system delivers cleaner air and better indoor air quality by controlling dust, particulates, odors, VOCs, viruses and bacteria typically found in education facilities. Site B has a mechanical system that is 17 years old. The average life span of an air conditioning (HVAC) system has a life span of 20 to 30 years. There is significant difference in

HVAC systems as little as ten years ago because today's systems are 60% more efficient than those systems. The inefficiency of an old system can cause higher utility bills and expensive repairs (Greim, C., 2005).

The second theme identified in Figure 6.4.A. was sustainable design. This theme was sorted into four subcategories which had two overlapping subcategories identified in category #1. Due to the overlap in subcategories, lighting and energy savings will not be compared and contrasted in theme #2 because it was identified in theme #1 subcategories. The four subcategories for sustainable design theme were the following:

1. Lighting
    a. Artificial Lighting
        i. LED Light Fixtures
    b. Natural Lighting
        i. Daylighting
        ii. Energy Savings
2. Level of Understanding the Topic of Sustainable Design
3. Level of Support for Sustainable Design in Education Facilities

Chapter VII: Conclusion

7.1: Overview

The purpose of this study was to use evidence from conducting research to support the need for improving educational facilities across the nation through new construction and the renovation of existing buildings with an emphasis on sustainable interior design. The findings supported the initial research problem, that there is a problem with our nation are school facilities having deteriorating building conditions, and there is a need for repairs. This gives design professionals an opportunity to solve this problem with new and renovated construction with an emphasis on sustainable design. With these results, sustainable design guidelines can be established and used in the future as a better school design approach. The significance of the results were to indicate that sustainable design principles used in school buildings are beneficial to 21st century learning environments because they increase productivity, enhance learning, and provide an overall improvement in the wellbeing and health of occupants. The findings from this research study are valuable to school districts because they can provide evidence to fund, support, and justify new construction and building renovations for their communities in order to create healthier environments for students, faculty and staff.

The focus was on specific aspects relative to the Indoor Environmental Quality (IEQ), which include acoustic quality, indoor air quality, natural and artificial light quality, and thermal comfort, which were used as a standard of measure during the observations, survey, and interview analysis. These areas were selected as the focus because the ideology of creating healthy learning environments correlated with sustainable design principles. The benefits of integrating sustainable design principles have been identified as improvement in the performance, health, environment, and energy consumption (Samani, S.A; Samani, S.A., 2012, 129; Ford, 2007, 6; Olson, Kellum, 2003, 3-5; US EPA, 2000). Using this previous research as the foundation for this study, specific environmental factors of both Sustainable and Non-Sustainable schools were identified to determine if implementing these design principles into a building's design proved to create a better quality learning environment for stakeholders.

7.2: Findings

Through the course of this study, the results indicated that sustainable design principles within the school's built environment were perceived as positive according to Site A's participants responses and research from the initial literature review. However, there were additional findings that indicated other variables outside of sustainability influenced the participants' overall satisfaction with their school buildings. The faculty, staff, and principal participants at Site B perceive their school facility as a positive environment despite lacking sustainable design within their space. This indicates that there are subjective variables that are not measurable, including but not limited to, the school's culture, atmosphere, and political aspects; these variables can also influence the learning experience within school buildings.

Through the use of a qualitative and quantitative mixed method approach, this study acquired data from the participating schools to determine accurate comparisons between each type of school design; the participants in this study included both a sustainable school and a non-sustainable school. The purpose of this methodology was to identify which interior environmental factors, sustainable or non-sustainable, were perceived as positive by participants. The researcher established during the site observational phase that Site A's building design met LEED rating requirements in the categories of proper acoustics, lighting, thermal, and interior finishes. After comparing the findings of both Site A and B, the researcher confirmed that Site B did not meet any of LEED rating requirements identified at Site A. This information was evident because of the deteriorating conditions present; these included significant cracks in the ceramic tile floors, poor artificial lighting quality in gymnasium, and a significant difference between the qualities of interior finish materials used to contribute to the aesthetics of the space. When comparing the inventory, previous literature, and hypothesis, the actual findings were not inclusive.

In addition to the observational results, the survey and interview questions answered by both Site A and Site B's staff, teachers, and principals did not support the previous literature review; Site B's respondents were overall satisfied with their school building despite lacking updated facilities and sustainable design. This evidence supports that there is a need for future research because outside variables impact perceptions of quality learning environments. Due to the many factors that contribute to creating a school facility, the research identifies that each site, despite the difference between designs, was both perceived to have satisfactory environmental factors.

There is also a need to determine if occupants of school buildings understand that a building can negatively impact their daily activities. If students, teachers, and staff are unaware that their current building condition could be better designed, how can they truly understand the negative impacts of the space? This evidence from the research indicated the participants did not fully understand the relationship between the physical environment of their school building and how the design could positively or negatively impact them. This information created a limitation of the survey and interview questions in this study. This finding is significant because it suggests that occupants are not aware of the potential negative impacts that they encounter during their daily activities in a learning environment.

A majority of the responses were inconsistent with the actual building's characteristics observed and documented by the researcher. This information shows that culture and peers have just as big of impact as sustainable design principles, and should be a factor during the design process. There was also inconsistency indicating that outdated lighting, HVAC, and interior finishes had a negative impact on occupants (Uline 2000, 444-448). Despite the inconsistency, this finding was consistent with other research indicating there is a problem with general public's awareness of sustainable design, and as a result not recognizing the benefits (Mokhtar, Deng 2014, 166).

Another finding from the research that was consistent with the literature review was the neglect to update outdated building systems. Site B was a significantly older building when compared to Site A. Site B had not had any infrastructure updates except for an English department addition. Site A also supported this evidence that school districts neglect maintaining their buildings. Before moving into their new facility, Site A's original school facility was 50 years old school, and this is what caused them to build a new school facility. This data retrieved from both sites supported the initial research problem that a majority of schools do not receive repairs and upgrades when needed, and this lack of responsibility can contributes to deterioration of school buildings (GAO, 1996).

While not all the findings supported the hypothesis, there were many extraneous variables outside the researcher's control that may have influenced findings. The researcher recommends continued research to substantiate or disprove the inconsistent results of the hypothesis of the study.

7.3: Recommendations for Future Study

The positive impact of sustainable design in school environments has been confirmed by a number of studies (Brundtland Report, 1987a). A high quality school environment setting is essential for a learning environment; a complete assessment of these spaces, building components, design features, and interior finishes can uncover critical information for design professionals, school administrators, students, teachers, and staff.

This thesis demonstrated that the crucial stakeholders of school building design – teachers, staff, and principals – had some strong pro-sustainable design values that positively influenced their perceptions of their schools' built environment. However, a majority of the results from the surveys and interviews collected from Site A and Site B were similar. This indicates that both groups observed were equally satisfied with their schools' built environments despite the presence or non-presence of sustainable design principles specifically focusing on the indoor environmental factors identified in the study: acoustic quality, indoor air quality, lighting (natural and artificial), and thermal comfort.

Due to the inconclusive results, the researcher compiled recommendations to be incorporated into future research. This was recognized after the design of the study, which leads to an inability to fully validate linking positive benefits and sustainable design principles found within the school buildings. Although the research compiled throughout this study did suggest the participants did support environmental responsibility, the results also indicated they did not express that the non-presence of sustainable design principles had negative impacts. Therefore further research into this topic will be necessary to expand upon the results of this research study to confirm or disprove this relationship of sustainable design within school built environments, and positive outcomes among occupants.

The first recommendation for future research is for the questions being asked to provide more descriptive and/or specific responses from the participants. The questions asked in this study were not interpreted correctly by the participants. By creating questions that allow the participants to answer based on their connection with the built environment, would help them better understand the designed centered questions. Their responses would provide the researcher a more consistent response data for analysis. Examples of questions include:

1. Thermal Comfort: How did the temperature feel in the summer?
2. Indoor Air Quality: Is the air in the winter smelly or odorless?
3. Lighting Environment: Is there a glare from the artificial lights being none or too much?

Second, this study was primarily administered electronically. A small response rate from each participant group was the result. It is unknown why some respondents chose to participate and others did not. This low response rate limited the comparisons between groups. Therefore, in the future a mixed method approach to gathering data would be recommended. Face to face focus groups with the participants would allow the participants to develop trust with the researcher, and better understand the intent of the study.

Third, the researcher wanted to identify sustainable design strategies, in order to promote the use of sustainable design for schools. The researcher would recommend interviewing design professionals that have been successful in designing a sustainable school. This information would provide evidence based design for stakeholders, so they would gain awareness of how and why they should integrate sustainable design for school building projects.

Fourth, this study concentrated solely on principals, teachers, and staff. However, students, superintendents, and the government could also contribute to the presence of sustainable design in school building environments. Currently, the students generally concentrate on the use of the space for learning purposes within a school building. Superintendents concentrate on educational and operational services of school buildings. The government carries important roles associated with cost and quality regulator. Government is associated with funding state school projects, and there is a need to gain their support to increase their financial support for improving school buildings' infrastructure, which, in addition, could improve the levels of school built environments' environmental qualities. Additional studies examining students', superintendents'', and government's sustainable design knowledge and preferences might reveal important data that could have a strong impact on sustainable design school design presence and future.

Fifth, the researcher would recommend further study on outside variables that are influential in creating a positive school environment for students, teachers, and staff. Because Site B perceived their built environment as positive despite not having sustainable design principles, this finding indicates that other factors within a school's built environment can be perceived as positive. These can include but are not limited to a school's culture, political sides of an academic environment, and or a schools organizational structure. Therefore, the research question should be asked, "How or why do school occupants value the worth and atmosphere of their schools' built environment?"

This research study indicated that positive outcomes can be achieved in multiple ways; in both physical aspects of a school environment as identified in Site A's responses, and outside variables not related to the built environment as indicated in Site B's responses. Additional research should assess the role of these variables and evaluate occupants' preferences to meet their satisfaction needs. The only solution to creating a healthy school building may be more complex than just a sustainable design approach.

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Appendix A

IEQ Prerequisite 3: Minimum Acoustical Performance

Required

Intent

To provide classrooms that are quiet so that teachers can speak to the class without straining their voices and students can effectively communicate with each other and the teacher.

Requirements

Achieve a maximum background noise level[1] from heating, ventilating and air conditioning (HVAC) systems in classrooms and other core learning spaces of 45 dBA.

Design classrooms and other core learning spaces to include sufficient sound-absorptive finishes for compliance with reverberation time requirements as specified in ANSI Standard S12.60-2002, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools.

AND

CASE 1. Classrooms and Core Learning Spaces < 20,000 Cubic Feet

For classrooms and core learning spaces less than 20,000 cubic feet, options for compliance include, but are not limited to the following:

OPTION 1

Confirm that 100% of all ceiling areas (excluding lights, diffusers and grilles) in all classrooms and core learning spaces are finished with a material that has a Noise Reduction Coefficient (NRC) of 0.70 or higher.

OR

OPTION 2

Confirm that the total area of acoustical wall panels, ceiling finishes, and other sound-absorbent finishes equals or exceeds the total ceiling area of the room (excluding lights, diffusers and grilles). Materials must have an NRC of 0.70 or higher to be included in the calculation.

CASE 2. Classrooms and Core Learning Spaces ≥ 20,000 Cubic Feet

For classrooms and core learning spaces 20,000 cubic feet or greater:

Confirm through calculations described in ANSI Standard S12.60-2002 that all classrooms and core learning spaces greater than or equal to 20,000 cubic feet are designed to have a reverberation time of 1.5 seconds or less.

Potential Technologies & Strategies

Reverberation time requirements can generally be met through the use of sound absorbent materials on ceilings and other surfaces. Consider using acoustical lay-in ceilings and/or other acoustical ceiling materials in combination with sound absorbent finishes such as acoustical panels.

1 Recommended methodologies and best practices for mechanical system noise control are described in Annex B of ANSI Standard S12.60-2002 and the 2007 HVAC Applications ASHRAE Handbook, Chapter 47 on Sound and Vibration Control (with errata but without addenda).

Appendix B

IEQ Credit 9: Enhanced Acoustical Performance

1 Point

Intent

To provide classrooms that facilitates better teacher-to-student and student-to-student communications through effective acoustical design.

Requirements

Sound Transmission

Design the building shell, classroom partitions and other core learning space partitions to meet the Sound Transmission Class (STC) requirements of ANSI Standard S12.60-2002, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools, except windows, which must meet an STC rating of at least 35

AND

Background Noise

Reduce background noise level[1] to 40 dBA or less from heating, ventilating and air conditioning (HVAC) systems in classrooms and other core learning spaces.

Potential Technologies & Strategies

Design considerations include reducing noise from exterior to interior spaces, between spaces within the building, and within the classroom space. External to internal noise transmission can be reduced by orienting classrooms away from external noise sources and using thick and/or massive materials in walls and roofs. Also, windows should be well-sealed and have adequate air gaps between sheets of glass. See IEQ Prerequisite 3: Minimum Acoustical Performance for more potential technologies and strategies.

1 Recommended methodologies and best practices for mechanical system noise control are described in Annex B of ANSI Standard S12.60-2002, and the 2007 HVAC Applications ASHRAE Handbook, Chapter 47 on Sound and Vibration Control (with errata but without addenda).

Appendix C

IEQ Credit 2: Increased Ventilation

1 Point

Intent

To provide additional outdoor air ventilation to improve indoor air quality (IAQ) and promote occupant comfort, well-being and productivity.

Requirements

CASE 1. Mechanically Ventilated Spaces

Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1-2007 (with errata but without addenda[1]) as determined by IEQ Prerequisite 1: Minimum IAQ Performance.

CASE 2. Naturally Ventilated Spaces

Design natural ventilation systems for occupied spaces to meet the recommendations set forth in the Chartered Institution of Building Services Engineers (CIBSE) Applications Manual 10: 2005, Natural Ventilation in Non-domestic Buildings. Determine that natural ventilation is an effective strategy for the project by following the flow diagram process shown in Figure 2.8 of the CIBSE Applications Manual 10.

AND

OPTION 1

Use diagrams and calculations to show that the design of the natural ventilation systems meets the recommendations set forth in the CIBSE Applications Manual 10: 2005, Natural Ventilation in Non-domestic Buildings, CIBSE AM 13 (Mixed Mode Ventilation), or natural ventilation/mixed mode ventilation related sections of the CIBSE Guide B2 (Ventilation and Air Conditioning).

OR

OPTION 2

Use a macroscopic, multizone, analytic model to predict that room-by-room airflows will effectively naturally ventilate, defined as providing the minimum ventilation rates required by ASHRAE Standard 62.1-2007 Chapter 6 (with errata but without addenda[1]), for at least 90% of occupied spaces.

Potential Technologies & Strategies

For mechanically ventilated spaces: Use heat recovery, where appropriate, to minimize the additional energy consumption associated with higher ventilation rates.

For naturally ventilated spaces, follow the 8 design steps described in the Carbon Trust Good Practice Guide 237:

- Develop design requirements.

1 Project teams wishing to use ASHRAE approved addenda for the purposes of this prerequisite may do so at their discretion. Addenda must be applied consistently across all LEED credits.

Appendix C (Continued)

- Plan airflow paths.
- Identify building uses and features that might require special attention.
- Determine ventilation requirements.
- Estimate external driving pressures.
- Select types of ventilation devices.
- Size ventilation devices.
- Analyze the design.

Use public domain software such as NIST's CONTAM Multizone Modeling Software, along with LoopDA Natural Ventilation Sizing Tool, to analytically predict room-by-room airflows.

Appendix D

IEQ Credit 4: Low-Emitting Materials

1–4 Points

Intent

To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Requirements

Projects may choose any of the following credits, with a maximum of 4 points.

CREDIT 4.1. Adhesives and Sealants (1 point)

All adhesives and sealants installed in the building interior (defined as inside the weatherproofing system and applied on-site) must meet the testing and product requirements of the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.

CREDIT 4.2. Paints and Coatings (1 point)

All paints and coatings installed in the building interior must meet the testing and product requirements of the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.

CREDIT 4.3. Flooring Systems (1 point)

All flooring elements installed in the building interior must meet the testing and product requirements of the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.

CREDIT 4.4. Composite Wood and Agrifiber Products (1 point)

All composite wood and agrifiber products installed in the building interior must meet the testing and product requirements of the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.

CREDIT 4.5. Furniture and Furnishings (1 point)

Classroom furniture including all student and teacher desks, tables and seats that was manufactured, refurbished or refinished within 1 year prior to occupancy must meet 1 of the requirements below. Salvaged and used furniture that is more than 1 year old at the time of occupancy is excluded from the credit requirements.

OPTION 1

Furniture and seating must be GREENGUARD Children and Schools certified.

Appendix D (Continued)

OR

OPTION 2

Calculated indoor air concentrations that are less than or equal to those listed in Table 1 for furniture systems and seating determined by a procedure based on the EPA Environmental Technology Verification (ETV) Large Chamber Test Protocol for Measuring Emissions of VOCs and Aldehydes (September 1999) testing protocol conducted in an independent air quality testing laboratory.

Table 1. Maximum Indoor Air Concentrations

Chemical Contaminant	Classroom Furniture	Seating
Total VOCs	0.5 mg/m³	0.25 mg/m³
Formaldehyde	50 parts per billion	25 parts per billion
Total aldehydes	100 parts per billion	50 parts per billion
4—Phenylcyclohexene (4-PCH)	0.0065 mg/m³	0.00325 mg/m³

OR

OPTION 3

Calculated indoor air concentrations that are less than or equal to those established in Table 1 for furniture systems and seating determined by a procedure based on ANSI/BIFMA M7.1-2007and ANSI/BIFMA X7.1-2007testing protocol conducted in an independent third-party air quality testing laboratory.

CREDIT 4.6: Ceiling and Wall Systems (1 point)

All gypsum board, insulation, acoustical ceiling systems and wall coverings installed in the building interior must meet the testing and product requirements of the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.

Potential Technologies & Strategies

Clearly specify requirements for product testing and/or certification in the construction documents. Some programs that offer verification of the cited standard for Options 1-4 and 6 are Indoor Advantage Gold, GREENGUARD Children & Schools, the Resilient Floor Covering Institute's FloorScore program, the Carpet and Rug Institute's Green Label Plus program, and the Collaborative for High Performance Schools product list. Indoor Advantage Gold offers verification of the BIFMA standard cited in Option C of the Furniture Option.

Appendix E

IEQ Credit 6.1: Controllability of Systems—Lighting

1 Point

Intent

To provide a high level of lighting system control by individual occupants or=groups in multi-occupant spaces (e.g., classrooms or conference areas) and promote their productivity, comfort and well-being.

Requirements

CASE 1. Administrative Offices and Other Regularly Occupied Spaces

Provide individual lighting controls for 90% (minimum) of the building occupants to enable adjustments to suit individual task needs and preferences

AND

Provide lighting system controls for all learning spaces including classrooms, chemistry laboratories, art rooms, shops, music rooms, gymnasiums and dance and exercise studios to enable adjustments that meet group needs and preferences.

CASE 2. Classrooms

In classrooms, provide a lighting system that operates in at least 2 modes: general illumination and A/V.

Potential Technologies & Strategies

Design the building with occupant controls for lighting. Strategies to consider include lighting controls and task lighting. Integrate lighting systems controllability into the overall lighting design, providing ambient and task lighting while managing the overall energy use of the building.

Appendix F

IEQ Credit 8.1: Daylight and Views—Daylight

1–3 Points

Intent

To provide building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

Requirements

Through 1 of the 4 options, achieve daylighting in at least the following spaces:

Classroom Spaces	Points
75%	1
90%	2

OR

- 75% of all other regularly occupied spaces (1 additional point). Project teams can achieve a point for these other spaces only if they have also achieved at least 1 point for classroom spaces.

OPTION 1. Simulation

Demonstrate through computer simulations that 75% or 90% or more of all regularly occupied spaces achieve daylight illuminance levels of a minimum of 25 footcandles (fc) and a maximum of 500 fc in a clear sky condition on September 21 at 9 a.m. and 3 p.m.; areas with illuminance levels below or above the range do not comply. However, designs that incorporate view-preserving automated shades for glare control may demonstrate compliance for only the minimum 25 fc illuminance level.

OR

OPTION 2. Prescriptive

Use a combination of side-lighting and/or top-lighting to achieve a total daylighting zone (the floor area meeting the following requirements) that is at least 75% (1 point) or 90% (2 points) of all the regularly occupied spaces.

For the Side-lighting daylight zone (see diagram below):

- Achieve a value, calculated as the product of the visible light transmittance (VLT) and window-to-floor area ratio (WFR) of daylight zone 0.150 and 0.180. The window area included in the calculation must be at least 30 inches above the floor.

$$0.150 < VLT \times WFR < 0.180$$

- The ceiling must not obstruct a line in section that joins the window-head to a line on the floor that is parallel to the plane of the window; Is twice the height of the window-head above the floor in, distance from the plane of the glass as measured perpendicular to the plane of the glass.
- Provide sunlight redirection and/or glare control devices to ensure daylight effectiveness.

Appendix G

IEQ Credit 7.1: Thermal Comfort—Design

1 Point

Intent

To provide a comfortable thermal environment that promotes occupant productivity and well-being.

Requirements

Design heating, ventilating and air conditioning (HVAC) systems and the building envelope to meet the requirements of ASHRAE Standard 55-2004, Thermal Environmental Conditions for Human Occupancy (with errata but without addenda[1]). Demonstrate design compliance in accordance with the Section 6.1.1 documentation.

For natatoriums, demonstrate compliance with the "Typical Natatorium Design Conditions" defined in Chapter 4 (Places of Assembly) of the ASHRAE HVAC Applications Handbook, 2003 edition (with errata but without addenda[1]).

Potential Technologies & Strategies

Establish comfort criteria according to ASHRAE Standard 55-2004 (with errata but without addenda[1]) that support the desired quality and occupant satisfaction with building performance. In gymnasiums, if mechanical ventilation is not used, follow ASHRAE Standard 55-2004 (with errata but without addenda[1]) requirements for naturally ventilated spaces. Design building envelope and systems with the capability to meet the comfort criteria under expected environmental and use conditions. Evaluate air temperature, radiant temperature, air speed and relative humidity in an integrated fashion and coordinate these criteria with IEQ Prerequisite 1: Minimum Indoor Air Quality Performance, IEQ Credit 1: Outdoor Air Delivery Monitoring, and IEQ Credit 2: Increased Ventilation.

1 Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

Appendix H

Nebraska UNIVERSITY OF Lincoln

COLLEGE OF ARCHITECTURE
Architecture & Interior Design Programs

IRB#14762

Title: Creating Healthy Schools: Identifying Barriers and Opportunities of Examining Sustainable Design in Education Facilities

Purpose: This research project will aim to examine the impact of sustainable designed education facilities have on student, faculty and staff performance, health, and overall well-being in high schools. You are invited to participate in this study because you are a high school that impacts students, staff, and faculty, and your information will aid in finding evidence that the physical environments can have many effects on occupants.

Procedures: You will be asked to send an electronic questionnaire link to faculty and staff. They will be anonymous, and have four weeks to complete the document. You will also participate in an interview along with the principal. This interview will last about an hour, and be conducted at the principal's office in spring of 2015. I will schedule an exact date and time that works with both yours and principals schedule.

Benefits: There are no direct benefits to you as a research participant.

Risks and/or Discomforts: There are no known risks or discomforts associated with this research.

Confidentiality: Any information obtained during this study which could identify you will be kept strictly confidential. The data will be stored in a locked cabinet in the investigator's office and will only be seen by the investigator during the study and for two years after the study is complete. The information obtained in this study may be published in scientific journals or presented at scientific meetings but the data will be reported as aggregated data.

Compensation: You will receive no compensation for participating in this project

Opportunity to Ask Questions: You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study. Or you may contact the investigator(s) at the phone numbers below. Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 to voice concerns about the research or if you have any questions about your rights as a research participant.

Freedom to Withdraw: Participation in this study is voluntary. You can refuse to participate or withdraw at any time without harming your relationship with the researchers or the University of Nebraska-Lincoln, or in any other way receive a penalty or loss of benefits to which you are otherwise entitled.

Consent, Right to Receive a Copy:
You are voluntarily making a decision whether or not to participate in this research study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

Signature of Participant:

Brian D Harvey

Signature of Research Participant

10/8/2014

Date

Name and Phone number of investigator(s)

Lindsey Ketchum, Principal Investigator Phone: (662) 295-2735
Dr. Betsy Gabb, Secondary Investigator Phone: (402) 472-9245

Appendix I

Nebraska UNIVERSITY OF
Lincoln

COLLEGE OF ARCHITECTURE
Architecture & Interior Design Programs

IRB#14762

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Signature of Participant:

Adam G. Pugh   10/6/14

Signature of Research Participant   Date

Name and Phone number of investigator(s)

Lindsey Ketchum, Principal Investigator Phone: (662) 295-2735
Dr. Betsy Gabb, Secondary Investigator Phone: (402) 472-9245

Appendix J

Note to teachers:

Our school is participating in a study on creating healthy schools: examining sustainable design in education facilities. The researcher is interested in how the interior environment affects teaching methods, health of occupants, and student learning. Please complete and return the questionnaire by **Thursday, February 26, 2015.** This survey is completely anonymous.

These questions are about you, and your experience teaching at the facility. In responding to the questions, please mark the appropriate box.

1. What is your gender?

   ☐ Female
   ☐ Male

2. How old are you?

   ☐ Under 25
   ☐ 25-29
   ☐ 30-39
   ☐ 40-49
   ☐ 50-59
   ☐ 60+

3. How long have you been working as a teacher at this school?

   ☐ This is my first year
   ☐ 1-2 years
   ☐ 3-5 years
   ☐ 6-10 years
   ☐ 11-15 years
   ☐ 16-20 years
   ☐ More than 20 years.

4. Please reflect on the following and circle the number that represents your level of agreement.

   a. There is too much noise in the classroom

1	2	3	4	5	6	7	8	9
Disagree								Agree

   b. There is inadequate lighting in the classroom

1	2	3	4	5	6	7	8	9
Disagree								Agree

Appendix J (Continued)

c. There is adequate lighting control in the classroom

1 2 3 4 5 6 7 8 9

Disagree Agree

d. There is a lot of student absenteeism in your classroom. Absenteeism primarily related to personal illness, illness or death in family, or exposure to contagious disease

1 2 3 4 5 6 7 8 9

Disagree Agree

e. There is a lot of teacher absenteeism in this school. Absenteeism primarily related to personal illness, illness or death in family, or exposure to contagious disease

f. Absenteeism primarily related to personal illness, illness or death in family, or exposure to contagious disease

1 2 3 4 5 6 7 8 9

Disagree Agree

5. Does your facility provide outdoor learning areas with adjustable sun filtering elements, rain protection, exterior storage, and electrical power? Do you think this is important?
   a. Yes, Yes
   b. No, No
   c. Yes, No
   d. No, Yes

6. How satisfied are you with the student achievement at this school?

1 2 3 4 5 6 7 8 9

Dissatisfied Satisfied

7. How well does the facility maximize physical comfort and well-being?

1 2 3 4 5 6 7 8 9

Not well Extremely well

8. How well is the facility demonstrating environmental responsibility?

1 2 3 4 5 6 7 8 9

Not well Extremely well

Appendix J (Continued)

9. How well can the facility adapt to changing needs of the classroom environment?

   1 2 3 4 5 6 7 8 9

   Not well Extremely well

10. Is this facility flexible, and support a collaborative environment?
    a. Yes it is flexible, and it does support a collaborative environment.
    b. No it is not flexible, and it does support a collaborative environment.
    c. No it is not flexible, and it does not support a collaborative environment.
    d. Yes it is flexible, and it does not support a collaborative environment.

11. Overall, are you satisfied with how the environment supports the teaching experience at this school, neither satisfied nor dissatisfied with it, or dissatisfied with it?

    1 2 3 4 5 6 7 8 9

    Dissatisfied Satisfied

12. How well do you think the school facility creates an environment that helps students learn?

    1 2 3 4 5 6 7 8 9

    Not well Extremely well

13. Are you satisfied with the furniture, storage elements, presentation equipment, maker boards, media carts, lecterns?

    1 2 3 4 5 6 7 8 9

    Dissatisfied Satisfied

14. Are you satisfied with the interior finishes such as flooring, wall finish, and ceiling, material?

    1 2 3 4 5 6 7 8 9

    Dissatisfied Satisfied

15. Are you satisfied with amount of day-lighting, and view windows in your classroom?

    1 2 3 4 5 6 7 8 9

    Dissatisfied Satisfied

16. Are your windows operable? Would you use these to control ventilation and fresh air if they were or do you use these if they are?
    a. Yes, and Yes.
    b. No, and No.
    c. Yes, and No.
    d. No, and Yes.

Appendix J (Continued)

17. How well is the climate control in your classroom?

1	2	3	4	5	6	7	8	9

Not well Extremely well

18. How well is the building maintained?

1	2	3	4	5	6	7	8	9

Not well Extremely well

19. What improvements need to be made in your school? You may select as many options below that apply.
    a. Organized, attractive classrooms, and school grounds
    b. Technology upgrades
    c. Climate control upgrades
    d. Lighting upgrades
    e. Other (please specify. Add your comments to the lines below.)

This is the end of the questionnaire.

Thank you very much for your cooperation!

Please return to main office by Thursday, February 26, 2015.

If there is any questions contact:
Lindsey Ketchum, Interior Design Graduate Student
Phone: (662)295-2735
Email: dlk27@live.com

This survey will be anonymous for participant's privacy.

Appendix K

Note to staff:

Our school is participating in a study on creating healthy schools: identifying barriers and opportunities of examining sustainable design in education facilities. The researcher is interested in how the interior environment affects working methods, health of occupants, and work productivity. The questionnaire should be completed by Thursday, February 26, 2015. This survey is anonymous.

These questions are about you, and your experience working at the facility. In responding to the questions, please mark the appropriate box.

1. What is your gender?

   ☐ Female
   ☐ Male

2. How old are you?

   ☐ Under 25
   ☐ 25-29
   ☐ 30-39
   ☐ 40-49
   ☐ 50-59
   ☐ 60+

3. How long have you been working as a teacher at this school?

   ☐ This is my first year
   ☐ 1-2 years
   ☐ 3-5 years
   ☐ 6-10 years
   ☐ 11-15 years
   ☐ 16-20 years
   ☐ More than 20 years.

1. Please reflect on the following and circle the number that represents your level of agreement.

   a. There is too much noise in the building

1	2	3	4	5	6	7	8	9
Disagree								Agree

Appendix K (Continued)

b. There is inadequate lighting in the building

1 2 3 4 5 6 7 8 9
Disagree Agree

c. There is adequate lighting control in the building

1 2 3 4 5 6 7 8 9
Disagree Agree

d. There is a lot of absenteeism of employees in this school. Absenteeism primarily related to personal illness, illness or death in family, or exposure to contagious disease

1 2 3 4 5 6 7 8 9
Disagree Agree

2. Are you satisfied with the furniture, and storage elements?

1 2 3 4 5 6 7 8 9
Dissatisfied Satisfied

3. How well does the facility maximize physical comfort and well-being?

1 2 3 4 5 6 7 8 9
Not well Extremely well

4. How well is the facility demonstrating environmental responsibility?

1 2 3 4 5 6 7 8 9
Not well Extremely well

5. How well can the facility adapt to changing needs of the physical environment of the school?

1 2 3 4 5 6 7 8 9
Not well Extremely well

6. Is this facility flexible, and support a collaborative environment?
   a. Yes it is flexible, and it does support a collaborative environment.
   b. No it is not flexible, and it does support a collaborative environment.
   c. No it is not flexible, and it does not support a collaborative environment.
   d. Yes it is flexible, and it does not support a collaborative environment.

Appendix K (Continued)

7. How well does the built environment aid in the staff at this school collaborating with each other?

   1 2 3 4 5 6 7 8 9

   Not well Extremely well

8. Overall, are you satisfied with how the environment supports the working experience at this school, neither satisfied nor dissatisfied with it, or dissatisfied with it?

   1 2 3 4 5 6 7 8 9

   Dissatisfied Satisfied

9. Are you satisfied with the interior finishes such as flooring, wall finish, and ceiling, material?

   1 2 3 4 5 6 7 8 9

   Dissatisfied Satisfied

10. Are you satisfied with amount of day-lighting, and view windows in your office?

    1 2 3 4 5 6 7 8 9

    Dissatisfied Satisfied

11. Are your windows operable? Would you use these to control ventilation and fresh air if they were or do you use these if they are?
    a. Yes, and Yes.
    b. No, and No.
    c. Yes, and No.
    d. No, and Yes.

12. How well is the climate control in your office?

    1 2 3 4 5 6 7 8 9

    Not well Extremely well

13. How well does your facility's physical environment allow you to be highly motivated, productive, and take pride in the accomplishment of your duties?

    1 2 3 4 5 6 7 8 9

    Not well Extremely well

14. How well is the building's built environment maintained?

    1 2 3 4 5 6 7 8 9

    Not well Extremely well

Appendix K (Continued)

15. What improvements need to be made in your school?
    a. Organized, attractive classrooms, and school grounds
    b. Technology upgrades
    c. Climate control upgrades
    d. Lighting upgrades
    e. Other (please specify. Add your comments to the lines below.)

____
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This is the end of the questionnaire.

Thank you very much for your cooperation!

Please return to main office by Thursday, February 26, 2015.

If there is any questions contact:
Lindsey Ketchum, Interior Design Graduate Student
Phone: (662)295-2735
Email: dlk27@live.com

This survey will be anonymous for participant's privacy.

Appendix L

Interview Questions Submitted by Lindsey Ketchum

Creating Healthy Schools: Identifying Barriers and Opportunities of Examining Sustainable Design in Education Facilities

(dlk27@live.com) – 662-295-2735

Thursday, February 26, 2015

1. Describe your current work environment. Are you satisfied with the conditions?
2. What is the age range of your facility?
3. Have you had any renovations or additions? If so, what were they, and did they meet your needs?
4. How would you describe the interior quality of your space?

1	2	3	4	5	6	7	8	9
Not well								Extremely well

5. Does the building have non-toxic or low-toxic materials (paints and sealants that are low voc)?
6. Is your building oriented to maximize southern exposure to maximize daylighting?
7. Does the building use daylighting to illuminate classrooms, and reduce related energy costs?
8. Do you think the building is noisy?
9. Are the classrooms noisy?
10. What type of ceiling materials are used in classroom?
11. What is the age of your mechanical system?
12. Do you feel that it is providing the fresh air requirements that meet today's building codes?
13. What types of light fixtures are used in the facility? Are they LED, and on occupancy sensors?
14. What type of flooring is used throughout the space? Is it Vinyl Composition Tile, Rubber Flooring, Luxury Vinyl Tile, Carpet, Ceramic Tile?
15. Are the floor finishes easy to maintain? Explain the typical cleaning practices.
16. When you visit a classroom, what are the first things you look for as signs that the classroom is an effective learning place?
17. As a building administrator, what message would you want your school to convey when visitors walk into the building?
18. What design features help accommodate a collaborative work environment at your school?
19. Is Sustainability important for your school system?
20. What do you think makes a school "sustainable"?

Appendix L (Continued)

Interview Questions (Continued)

21. Do you believe that a sustainable improvement to the existing facility would work better than what the current facility is doing? What improvements would you prioritize first, and why

22. Do you feel that the benefits of implementing sustainable design would outweigh the costs of doing so?

23. Do you think a sustainable design improves an occupant's physical as well as emotional wellbeing? Why or why not?

24. What types of spaces or activities need flexibility?

25. Can you accommodate flexibility easy? Why or why not?

26. Do you think sustainable design goals are directly connected with teaching and learning needs?

Appendix M

Observation - Areas to view:

- Core Learning spaces:
  - Classrooms
    1. Dimension
    2. Number of Windows
    3. Coverings on Windows Yes/No
    4. Size of Windows
    5. Floor material
    6. Wall material
    7. Ceiling Material
    8. Ceiling Height
    9. Type of lights
    10. Technology
    11. Furniture
    12. Flexibility
    13. Other features
  - Larger hallways
    1. Dimension
    2. Number of Windows
    3. Coverings on Windows Yes/No
    4. Size of Windows
    5. Floor material
    6. Wall material
    7. Ceiling Material
    8. Ceiling Height
    9. Type of lights
    10. Technology
    11. Furniture
    12. Flexibility
    13. Other features

Library

1. Dimension
2. Number of Windows
3. Coverings on Windows Yes/No
4. Size of Windows
5. Floor material
6. Wall material
7. Ceiling Material
8. Ceiling Height
9. Type of lights
10. Technology
11. Furniture
12. Flexibility
13. Other features

Gymnasium

1. Dimension
2. Number of Windows
3. Coverings on Windows Yes/No
4. Size of Windows
5. Floor material
6. Wall material
7. Ceiling Material
8. Ceiling Height
9. Type of lights
10. Technology
11. Furniture
12. Flexibility
13. Other Features

Appendix M (Continued)

Administration Offices / Areas

1. Dimension
2. Number of Windows
3. Coverings on Windows Yes/No
4. Size of Windows
5. Floor material
6. Wall material
7. Ceiling Material
8. Ceiling Height
9. Type of lights
10. Technology
11. Furniture
12. Flexibility
13. Other features

Cafeteria

14. Dimension
15. Number of Windows
16. Coverings on Windows Yes/No
17. Size of Windows
18. Floor material
19. Wall material
20. Ceiling Material
21. Ceiling Height
22. Type of lights
23. Technology
24. Furniture
25. Flexibility
26. Other features