ABSTRACT

The Relationship between School Design Variables and Student Achievement
in a Large Urban Texas School District

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The purpose of this study was to determine if a relationship existed between school facility design variables and student achievement as determined by the Texas Assessment of Knowledge and Skills. The Design Assessment Scale for Elementary Schools designed by Kenneth Tanner (1999a) was used to evaluate 21 schools in a large urban district. The design variables included movement patterns, large group meeting places, architectural design, daylighting and views, psychological impact of color schemes, building on student's scale, location of the school, instructional neighborhoods, outside learning areas, instructional laboratories, and environmental. The 2003-2004 Texas Assessment of Knowledge and Skill 5th grade scores on reading, math, and science were used to determine student achievement.

T-tests were used to determine the relationship between design variables and student achievement within TEA designated rating categories (Exemplary, Recognized, and Academically Acceptable). An ANOVA was used to determine if a relationship existed between Texas Education Agency school categories and building design variables.

The major finding of this study supports the literature. This study concluded all building design variables had a statistically significant relationship with student achievement within each school category. However, there was not a statistically significant relationship between building design variables and school ratings.

The Relationship between School Design Variables and Student Achievement
In a Large Urban Texas School District

by

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TABLE OF CONTENTS

LIST OF TABLES

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CHAPTER ONE

Introduction

The federal No Child Left Behind Act (NCLB) of 2001 mandated accountability for the academic achievement of all students in every district and every school. Still, school districts struggle to fulfill the requirements of this act including providing highly qualified teachers in every classroom, educated Title 1 assistants in all Title 1 schools, and curriculum that allows students to pass the high stakes testing requirements.

An important key but often-overlooked element of student achievement is the actual physical school facility. The statement “a good teacher can teach anywhere” is probably true; however, research indicates that student achievement depends upon the age, condition, and design of the school facility (Broome, 2003; Earthman, 2002; Earthman & Lemasters, 1998; Lyons 2001; Tanner, 1999a). According to Rebuild America Schools, a coalition of national organizations and school districts working to create federal support for the efforts of local communities to build, renovate, and modernize school facilities, an estimated 14 million students attend deteriorating public schools every day (Lyons, 2001). “The average school today at 42 years old faces demands that were never intended or even considered when the building was built”(Lyons, p. 1). “But their service continues, perpetuating overcrowded classrooms, outmoded designs, poor communication systems, limited technology, and inadequate security” (Lyons, p. 6). A concern of community members, parents, and educators is that the school facility is no longer meeting the needs of all students. The National Center for

Education Statistics (2000) conducted a survey on the condition of public schools in 1999. Some of the key findings of this report included:

- The average age of the main instructional building was 40 years old in 1999.
- Among schools that have been renovated, the construction occurred an average of 11 years ago.
- Three quarters of the schools surveyed need to appropriate more funds to improve the overall condition of facilities.
- Approximately one-fifth of schools reported that at least one of the life safety features (roofs, electrical power, plumbing) was in less than adequate condition.

School districts around the country continuously attempt to fix the inadequacies of their facilities. According to Mike Kennedy (2005) in *American School and University*, "renovating America's school house is big business" (p. 1). Schools and universities spent almost $20.6 billion on renovations in 2004, which is close to the same amount spent on new facility construction in the same year (Kennedy, 2005). Renovations of school facilities can occur for several reasons including: the facilities' age and condition; to correct inadequacies in design; when a school has changed its curriculum requirements, or to give an older facility a new purpose (Kennedy, 2005). Renovating is but one option when a school is no longer able to adequately house students. Sometimes a better decision is construction of a new school facility rather than renovating an older building. Often there is no educational input involved in facility construction. Stueck and Tanner (1996) state, "The major design decisions are being made by architects with a bias toward buildings and not educational experiences for students" (p. 2). The actual building design has also been shown to influence the academic outcomes of students (Tanner, 1999b). Steven Broome (2003) looked at the relationship between the design of the school facility and student behavior and academic achievement of eighth grade students in Mississippi and Tennessee. He found design variables did have an impact on student achievement at the middle school level. Design elements implemented into a new facility or a renovated facility is the decision of the school district. It would behoove districts to be aware of design elements that have a positive impact on student outcomes.

Statement of the Problem

There have been mixed results in recent studies on the effect of a school's facility on student achievement. In addition, there is a void of literature on the effects of design variables on achievement in elementary schools in Texas. The problem of this study was to analyze the relationships between school design variables on student achievement.

Statement of Purpose of the Study

The primary purpose of this study was to investigate the relationship between school design characteristics: movement patterns, large group meeting places, architectural design, daylighting and views, psychological impact of color schemes, building on student's scale, location of the school, instructional neighborhoods, outside learning areas, instructional laboratories and environmental components and an elementary school's rating (Exemplary, Recognized, and Academically Acceptable) as determined by the Texas Education Agency for the 2003-2004 academic school year.

Research Questions

To implement the primary purpose of this study, the following research questions were asked:

1. What is the relationship between building design characteristics and reading, math, and science Texas Assessment of Knowledge and Skills (TAKS) scores of children in elementary schools located in an urban Texas school district that were designated "Exemplary" by the Texas Education Agency for the 2003-2004 academic school year?
2. What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that were designated "Recognized" by the Texas Education Agency for the 2003-2004 academic school year?
3. What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that were designated "Academically Acceptable" by the Texas Education Agency for the 2003-2004 academic school year?
4. What is the relationship between the total score on the DASE and the state ratings (Exemplary, Recognized, Academically Acceptable) of elementary schools located in an urban Texas school district?

Significance of the Study

The influence of a facilities age and condition on student achievement is well documented as it relates to scores on norm-referenced tests such as the Iowa Test of Basic Skills (Andersen, 1999; Broome, 2003). However, there has been little study as to the influence of building design of elementary schools as it relates to standards based testing such as the Texas Assessment of Knowledge and Skills (TAKS).

In addition, the school age population in Texas is growing along the Interstate 35 corridor (Texas State Data Center and Office of the State Demographer, 2004). Currently, Texas educates about 4.3 million students annually (Texas Education Agency, 2005). However, Steve Murdock, a demographer at Texas State Data Center, states the number will grow by 75,000 students every year for the next 20 years (Texas State Data Center and Office of the State Demographer, 2004). In fact, "by 2030 the population of young Texans will increase from 5.9 million to 10.8 million" (p. 1). "The North Central Texas area is projected to increase by nearly 1.1 million by 2010" (p. 1). The results of these projections necessitate the addition of new facilities or renovation to existing facilities by school districts. It will be paramount for superintendents and school boards to understand and act upon the impact school facilities have on the results of standards based testing. The No Child Left Behind Act of 2001 dictates that all students will learn at high levels, and schools and school districts are responsible for providing a quality education to every child. In this era of high stakes testing and accountability it is imperative for school districts to provide their students with every possible advantage, which includes new or improved school facilities that promote success.

Overview of Methodology

This dissertation was a descriptive study. The study first determined Cronbach's Alpha to establish inter-rater reliability of the evaluators' use of the Design Assessment Scale for Elementary School (DASE), version 2003. Paired sample *t*-tests were used to see if a relationship existed between design sub-scores on the DASE and the 5th grade reading, math, and science TAKS scores. A one-way ANOVA was calculated to see if a relationship existed between the total score on the DASE and the school's state rating.

Assumptions

1. The evaluators evaluated the facilities honestly and to the best of their abilities.
2. The training led the evaluators to a common understanding of vocabulary in the DASE as well as consistent use of the DASE.
3. The evaluators used the DASE correctly when evaluating the schools.
4. All elementary schools evaluated were following the district curriculum. The district provides The Pathway to Excellence, a curriculum guide designed and distributed by the school district, for every subject area and every grade level.
5. The school district allocates money for facilities equitably among the elementary schools in the district.

Delimitations and Limitations

Delimitations

1. The study took place in one urban school district in North Central Texas.
2. Only elementary schools within the district that had attained state accountability ratings for the 2003-2004 school year were part of the study.
3. Only three out of four accountability ratings were used to because the district did not have any elementary schools with an "unacceptable" rating for the 2003-2004 academic school year.

Limitations

1. The study may not be generalized to other schools or school districts.
2. The study may not be generalized to middle schools or high schools.
3. The study is restricted to a single district to control for consistent funding of repairs and renovations of facilities.

Definition of Key Terms

1. *Texas Assessment of Knowledge and Skills (TAKS)* – standards based testing implemented in the state of Texas in the 2002-2003 academic school year. It tests students at the elementary, middle and secondary levels.
2. *TEA* – Texas Education Agency, the state governmental agency that regulates and supports public elementary and secondary schools.
3. *PEIMS* – Public Education Information Management System used to collect data for public schools in the state of Texas.
4. *AEIS* – Academic Excellence Indicator System for the State of Texas pulls together a wide range of information on the performance of schools and school districts in Texas every year.
5. *School design patterns* – According to Tanner (1999a) school design patterns are defined as the physical arrangements of the environmental components with which students interact (buildings and all their components, color, the physical context of the school, furniture, landscaping—natural or planned, and equipment).
6. *Economically disadvantaged* – students in Texas are considered economically disadvantaged if the student receives free or reduced lunches as determined by the state.

7. *Exemplary* – The highest state rating that can be attained by a public school. Ninety percent of all students and all subgroups must achieve the passing score for the tests taken at each grade level.

8. *Recognized* – The second highest state rating that can be attained by a public school. Eighty percent of all students and all subgroup must achieve the passing for the tests taken in each grade level.

9. *Academically Acceptable* – The third highest rating of a public school. Fifty percent of all students and all subgroups must achieve the passing rating for reading and writing, 35% of all students and all subgroups must achieve the passing standard for math, and 25% must achieve the passing standard for science. These percentages are accurate for the 2003-2004 academic school year.

10. *Pathways to Excellence* – the curriculum guide for all subjects and grade levels that is developed and distributed by the school district.

Organization of the Study

The remainder of this study is divided into the following chapters: Chapter 2 reviews the literature, Chapter 3 explains the methodology of the study, Chapter 4 presents the results, and Chapter 5 summarizes and discusses the results.

CHAPTER TWO

Synthesis of Related Literature

Introduction

The impact a school facility has on the academic outcomes of students can be either positive or negative. Often facility design is an afterthought in the construction and renovation process. Politicians, superintendents, and school boards do not see the facility design process as an integral part of student achievement. However, recent research studies have proven over and over again that school facilities do impact student achievement (Andersen, 1999; Earthman, 2002; Earthman & Lemasters, 1998). "The significance of the learning environment cannot be underestimated" (Chan & Petire, 1998, p. 3). The Tennessee Advisory Committee on Intergovernmental Relations (TACIR) (2003) asserted that children spend close to 24,000 hours in a school building during their school careers, which amounts to 15% of a child's life by the age of 18. With so much time of a child's life spent in the school facility, more attention must be given to creating not only safe and comfortable environments but also facilities that positively impact a student's achievement. Unfortunately, about 14 million students attend a deteriorating public school every day (Rebuild, 2000). Some of the building conditions that students face include leaking roofs, poor ventilation, inadequate lighting, and poor air conditioning and heating systems. Students are expected to achieve the same standards whether they attend a school in excellent condition or a facility in poor condition. In fact, the conditions in some schools are so poor that it is estimated it would take over $112 billion dollars to bring current facilities up to basic state and local codes.

Some districts today still believe that if the school building merely meets building codes for occupancy, class size, and acoustics then the school is appropriate for learning. Growing research on school design variables attempts to answer which elements are essential to student learning. Prakash Nair (2002) stated

> Much of the public discussion about the need for more construction money centers around the consensus that children need "a safe, clean, and comfortable environment" to learn. Beyond that, one would be hard pressed to find a public official saying what it is about new school buildings that improves learning. (p. 2)

Glen Earthman (2004) in Prioritization of 31 Criteria for School Building Adequacy concluded research indicates there are five areas at the elementary level that have an impact on student achievement. These areas include: human comfort, indoor air quality, lighting, acoustical control, and student capacity. According to the Australian Department of Education, Training and Public Affairs there are 15 factors that influence learning. Some of these variables include: building age, windows, locker conditions, lighting, noise, site acreage, and roof leaks (Clark, 2002). These areas, as well as physical age, building condition, and instructional areas will be reviewed in the rest of the chapter.

Physical Age

The age of a school building has an impact on student achievement. According to the Tennessee Advisory Commission on Intergovernmental Relations (2003), students in newer facilities have higher achievement scores than students in older facilities. In addition, there were fewer discipline referrals and higher attendance rates among students in new facilities compared to students in older facilities. Many studies have compared building age to student achievement. In every study, students in newer buildings outscored students in older facilities on achievement tests (Earthman, 2004). Mark Schneider (2002a) discussed a study completed by Burkett that attributes an approximate 3% variance in achievement scores on standardized tests if students are housed in a new or modernized facility. This difference in achievement could be due to the fact that older facilities are not built to hold current curriculum demands such as computer technology and complex science classrooms. The physical age of a school facility has continually been shown to influence academic achievement.

Facility Condition

Facility condition has been noted as a key component of student achievement. "A school's condition signals to the children how serious we adults are about education" (Chase, 1998, p. 1). Some districts have a difficult time keeping up with the deteriorating condition of schools in their communities. The costs to update or renovate key features of a building, such as air-conditioning and roofing, are extremely high, so many districts just mend old, outdated features instead of replacing them. What many school boards do not understand is the cost to student achievement when this occurs. In fact, Earthman (2002) stated, "school design features have a measurable influence upon student learning" (p. 1). The Tennessee Advisory Commission on Intergovernmental Relations (TACIR) (2003) supported this conclusion. TACIR completed an informational report in 2003, *Do K-12 School Facilities Affect Education Outcomes*? One conclusion of this study was: "Students attending school in newer, better facilities score 5 to 17 points higher on standardized tests than those attending substandard buildings" (p. vii). Also, the same study maintains as facility conditions improve, student achievement improves (p. 9). Another study completed by Edwards and cited in Clark's work (2002) stated that students attending schools in poor condition scored 6% lower on academic achievement tests compared to students attending schools in fair condition and 11% lower on academic achievement tests compared to students attending schools in excellent condition. These findings should not be surprising. Newer facilities are able to address current curriculum issues and support technology that cannot be accomplished in older facilities. Educational communities may not understand the impact the condition a school facility has on student achievement. Lyons (2001) cited a study on school facilities in Milwaukee by the Council of Educational Planners International. The conclusion of this report stated, “Facility condition may have a stronger effect on student achievement than the combined influences of family background, socio-economic status, school attendance, and behavior” (p. 6).

Lighting

The lighting in a school can have a great impact on what students are able to see in the classrooms. Students in dark classrooms may struggle to see what is written in textbooks or on the board. However, classrooms that are too bright may cause strain to the eyes as well. Another issue for consideration is the way the light hits the board, which may cause a reflection that makes it difficult for students to see. According to Earthman (2004), more studies have been completed on how lighting affects students than any other building component in the school.

Natural light is one type of light found in schools. One study found natural light has a tremendous influence on our bodies and minds (Lyons, 2001). In fact, research has found that patients in a hospital recover at a faster rate when natural light comes into the room through a window than patients who have identical rooms without a window

(Tennessee Advisory Commission on Intergovernmental Relations, 2003). Research indicates natural light has a positive effect on the sick and injured.

The Heschong Mahone Group (1999) reported that natural light also affects learning positively. The group completed a study regarding the effects of natural daylight on student achievement. The study took place in three separate elementary school districts and included over 21,000 students. Three districts participated; one each in California, Washington, and Colorado. The California students participated in a pretest and posttest as part of the study. Controlling for all other variables, the study found students in classrooms that had the most daylight progressed 20% faster in math and 26% faster in reading than students with the least daylight. The Colorado and Washington students' participation included only an end of the year assessment. In these two groups, students with the most daylight were found to have 7% to 18% higher scores than students with the least daylight. This study produced convincing evidence that daylighting does make a difference in student achievement. According to Fisher (n.d.), "Studies confirm that, for fifth and sixth grade students, appropriately designed and well-maintained lighting improves students' achievement scores" (p. 1).

Meer (1985) stated that "researchers have found that the brighter the room the better the performance" (p. 2). He also suggested lighting is critical to establishing mood, expectations and behavior.

Hathaway (1982) noted that previous studies indicate that some of the lights found in schools actually decay teeth and increase student absenteeism. Light effects a persons physical health, mental health, as well as academic achievement.

Safety and Security

Safety and security concerns have heightened since the tragedies of Columbine in Colorado and New York, City on September 11, 2001. In fact, the federal government addressed the safety of students and teachers in the No Child Left Behind Act (NCLB) of 2001. The challenge set forth by the government is for states and districts to provide all children with a safe environment in which to learn and achieve (Smith, 2002). Common safety issues that most elementary schools face are overcrowding in classrooms and hallways, cafeterias, and large, heavy backpacks that stick out when being carried. Before a student can learn any curriculum the student needs to feel safe. Safety is a fundamental need for all students. As districts add new buildings or renovate older facilities, security becomes a priority. Many schools are implementing the concepts of Crime Prevention Through Environmental Design (CPTED) to incorporate security steps into the planning process. This allows schools to improve natural surveillance and define the separation of public and private areas (Kennedy, 2002).

Safety and security are necessary design variables when renovating and constructing new facilities. Kennedy (2002) stated ". . . the best way to ensure that a school building provides a secure environment is to design it with that in mind" (p. 1). Feeling safe is a fundamental need for everyone. So when students and teachers feel safe in their school environments, teachers can teach and students can learn.

Visual Environment

The visual aspect refers to the paint colors on the exterior and interior of the school facility, the context in which the school is set, and the colors and textures around the school. The color of a school has shown to have an influence on students. Warren

Hathaway (1995) in *Effects of School Lighting on Physical Development and School Performance* found the visual environment is one of the most important in the mental attitude, attendance rates, and academic performance of students. Hathaway (1982) believes that when color is properly used it can improve the environment for learning. Changing the colors in the school is possibly one of the easiest and least expensive ways to change the classroom environment. Blue and pink are known to calm behavior while earth tones tend to raise heart rates and increase brain activity (Flannery, 2005; Grangaard, 1993).

According to Sheri Thompson (2003) in *School Planning and Management*, colors of schools should be chosen according to age groups. Younger children in elementary schools need mild, soothing colors such as warm, soft shades and cream with bright, colorful accents. Not only do colors affect learning but they also can increase school pride and lower behavior problems. It was also reported that distracting color combinations could lead to task confusion and slow reaction (Chan & Petrie, 1998). Teachers can create the type of learning environment conducive to learning by choosing the right color combinations for their classrooms. In addition, Fisher (1994) states that "colour is believed to influence student attitudes, behaviors, and learning, particularly student attention span and sense of time" (p. 1).

Color can have an effect on student achievement. Little changes in the color of schools and classrooms can have big impacts on student achievement.

Thermal Environment

Glen Earthman (2002) in Williams Watch Series stated, "Good thermal environment of a classroom is very important to efficient student performance" (p. 3).

According to the Architectural Partnership, David Harner in 1974 studied thermal temperatures and student academic achievement. Harner's study suggested, "Reading speed and reading comprehension appear to be most effected by increased temperature" (p. 9). Additionally, the same study by Harner concluded the ideal temperature for reading falls between 68 and 73.4 degrees Fahrenheit but mathematic performance seems to occur best between the temperature ranges of 68 to 74 degrees Fahrenheit. Harner also found under the best temperature conditions students learn best in the morning. Warm temperatures create sluggish, tired students while cold temperatures affect a student's dexterity (Lackney, 1999). "Student achievement is further reduced by poor ventilation, lack of air movement and poor humidity control" (p. 1).

Teachers should be allowed to control the thermal environment at all times in their classrooms. This allows teachers who receive morning or afternoon sunlight to adjust the temperature to accommodate the temperature change. In fact, "achievement was greater in facilities that allowed for individual preferences for heat" (Tennessee Advisory Commission on Intergovernmental Relations, 2003, p. 9). Schools that consistently struggle with heating and cooling issues are not only dealing with an issue that is frustrating but also one that affects student achievement. "Faulty classroom temperature and air circulation are two of the worst problems in schools today" (Lyons, 2001, p. 2).

Acoustics

The amount of noise in a classroom can be tremendous. There are three types of noise that occur within the classroom. The first is internal noise. This includes students and the teacher in the classroom interacting and communicating with each other. The second type of noise comes from students in other classrooms and in the hallway. Sound from carts being pushed down the hall, footsteps, and bells also create noise that can disturb students. A third type of noise is sounds that come from outside the school over which educators have no control such as traffic, airplanes, and trains. All these different types of noise can distract students from the teaching and learning that should be going on in the classroom. "Students require a higher level of acoustic quality than adults, and to attain the good speech recognition necessary for optimal comprehension and learning, classrooms must limit background noise, carefully manage reverberation of sounds, and keep noise to a minimum" (Lyons, 2001, p. 3).

Several studies have examined the effects of noise on student achievement. Earthman (2002) cited a study completed by the Department of Health Services in California in 1981. This study compared similar students in noisy neighborhoods to students in quieter neighborhoods. The conclusion of the study was that there was a negative relationship between reading achievement scores and noise levels. Another study concluded, "Higher student achievement was associated with schools with less external noise" (Tennessee Advisory Commission on Intergovernmental Relations, 2003, p. 11). In addition, another study concluded, "Exposure to traffic noise at elementary schools also has been associated with deficits in mental concentration, making more errors on difficult tasks, and greater likelihood of giving up on tasks before the time allotted has expired" (Lackney, 1999, p. 3). Additionally, "The ability to clearly hear and understand what is being spoken is a prerequisite for student learning" (Earthman, 2002, p. 5).

A study by Fisher (1994) suggested a way to combat the noise that exists in and around schools. “Background music can enhance reading comprehension and may also be of benefit to students who are below average in achievement and intelligence (p. 1). It is very important to limit the amount of noise that exists in the school to create a climate that is conducive to increased student achievement.

Activity Areas

School facilities today need to have specialized classrooms. The need for science laboratory space is even greater in the 2003-2004 school year since 5^{th} grade students are required to take the science TAKS test. Spaces for students to move around in are also important to achievement. Physical activity is essential in promoting the growth of mental functions (Chan & Petrie, 1998).

Eric Jensen (1998) in *Learning with the Brain in Mind* suggested that learning is enhanced by physical activity. Additionally, a study by Schneider (2002b) suggested, “Physical Education and recreational facilities are also essential to the well-being of students” (p. 1). School facilities need to provide a place for students to engage in physical activity.

Mark Schneider (2002b) conducted a study on *Public School Facilities and Teaching*, Washington, D.C. and Chicago teachers were unsatisfied with the inadequacy or lack of specialized classrooms such as music rooms, science laboratories, and art rooms. “Education is an increasingly complex task, and like professionals in other industries, teachers need space to work with their colleagues to discuss problems and techniques. Yet studies find that schools all too often don’t provide professional work space” (p. 9).

Sustainable and Green Designs

As a result of deteriorating facilities and the tremendous number of renovations and construction projects, there are a growing number of people who are in support of new design initiatives (Northwest Pollution Resource Center, 2001). Two of these design initiatives are sustainable school designs and green schools. These two initiatives are very similar. According to the State Energy Conservation Office (n.d.) “a sustainable building design consists of state agencies, architects, and contractors to design and construct sustainable buildings that consume less fossil fuel, limit environmental impacts, and improve worker health and productivity” (p. 1). According to the Alliance to Save Energy (n.d.), “A green school is energy and environmentally conscious, fiscally responsible, and well connected to the Real World” (p. 1).

Sustainable school designs are becoming popular across the nation (Classroom Design Forum, n.d.). “An essential component of a sustainable design is to integrate a school building’s design with the goals for learning while simultaneously recognizing the interdependency of the built environment and its occupants with the natural environment” (Pacific Northwest Pollution Resource Center, 2001, p. 1). Other components consist of daylighting to reduce energy costs, innovative designs of HVAC to increase natural ventilation, and light colored classroom settings (Classroom Design Forum, n.d.). In addition, one elementary school in McKinney, Texas, also harvests rainwater to irrigate the landscape. According to the State Energy Conservation Office (n.d.), additional components of sustainability include:

1. Optimize building orientation to take advantage of natural shading, and protect from extreme heat in the summer months and cold winds in the winter months.

2. Optimize natural lighting.
3. Establish an energy budget for each project.
4. Use local or national products when available.
5. Design the facility to minimize waste and use recycling during the construction stage.
6. Ventilate for acceptable indoor quality.
7. When selecting materials to use consider the impact on the natural environment.
8. Landscape with native vegetation.
9. Consider opportunities to provide shelter to the natural habitants, restore waterways, and vegetation.

Sustainable designs would allow a variety of curriculums and activities to take place over time. Sustainable schools also work with the natural environment around the facility. Federal, state, and local initiatives are promoting sustainable building design and construction as a means to preserve natural resources and enhance building performance (Bolin, 2003).

Green school programs combine "conservation and education in a way that strengthens schools, involves students in making a real difference, encourages teamwork and fosters community involvement" (Alliance to Save Energy, n.d., p. 1).

The elements of a sustainable building can be found from the Pacific Northwest Pollution Resource Center (2001). They state seven elements are present in a sustainable design: site preservation, building enclosure, resource conservation, interior quality, operations and maintenance, education, and community. Many of the components of green schools are also prevalent in sustainable schools.

Sustainable schools and green schools might be the answer to design variables that are hindering student achievement. “By designing to lead, we also are designing to learn, because evidence is growing that energy-efficient schools can provide learning environments that lead to improved student performance” (Reicher, 2000).

Future of Educational Facilities

Sustainable schools and green schools are just two of the recent development in school designs. Kenneth Stevenson (2002) in National Clearinghouse for Educational Facilities believes there are 10 trends that should be considered when building or renovating school facilities. The 10 trends are listed below:

Trend One: A blurring of attendance lines.

Trend Two: Schools will be smaller and more centered around the neighborhood.

Trend Three: There will be fewer students in each class.

Trend Four: Technology will dominate instructional delivery.

Trend Five: The typical space thought to constitute a school may change.

Trend Six: Students and teachers will be organized differently.

Trend Seven: Students will spend more time in school.

Trend Eight: Instructional Materials will evolve.

Trend Nine: Grade configurations may change.

Trend Ten: Schools may disappear before the end of the 21st century.

These trends suggest schools need to be flexible and constructed to implement a wide variety of curriculum as well as meet the communities' needs. DeArmond, Taggart, and Hill (2002) summed up the future of schools,

> In tomorrows schools, districts and teachers will not do the same thing for everyone. Instead, they will aim to give parents and students choices among many distinct schools. Schools across the country are already searching for new ways to teach, new ways to organize, and new ways to focus their energy and resources to maximize gains for students. The range of options where learning takes place will grow broader and more complex, not narrower and simpler. (p. 23)

Design Assessment Scale for Elementary Schools

The DASE designed by Kenneth Tanner at the University of Georgia was used in a previous study by Kathleen Ann Yarbrough. Yarbrough used the 2000 version of the instrument which included 11 design subscales and 86 questions. The purpose of her study was to determine if a relationship existed between design features and elementary school achievement. School design variables were able to explain 14.2% of the variance of third grade achievement scores and 9.7% of the fifth grade achievement scores. The study concluded that design variables do influence academic achievement.

Conclusion

The literature identifies a variety of facility characteristics that have an impact on student achievement. These characteristics include facility age and condition, thermal and acoustical control, lighting, visual environment, and safety and security issues. Sustainable schools and green schools are new design innovations that are increasing in popularity and address some of the issues seen in old and deteriorating buildings.

CHAPTER THREE

Methodology

This chapter will review the methods used to carry out the study. The research questions guided the participants, design, procedures, instrumentation, and data analysis used in this study.

Research Questions

1. What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that were designated "Exemplary" by the Texas Education Agency for the 2003-2004 academic school year?

2. What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that were designated "Recognized" by the Texas Education Agency for the 2003-2004 academic school year?

3. What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that were designated "Academically Acceptable" by the Texas Education Agency for the 2003-2004 academic school year?

4. What is the relationship between the total score on the DASE and the state ratings (Exemplary, Recognized, Academically Acceptable) of elementary schools located in an urban Texas school district?

Context of the Study

The study took place in a large urban district in North Central Texas. Twenty elementary school facilities and their reading, math, and science TAKS scores for 5th grade students in those schools were used. To limit discrepancies in facility funding, elementary schools in only one school district participated. For the purpose of confidentiality, the first 20 letters of the alphabet were used to identify the schools. The accountability ratings and TAKS scores for this study were from the 2003-2004 academic school year and were retrieved from the Texas Education Agency website. Two professional educators evaluated the 20 schools during the summer of 2005 using the Design Assessment Scale for Elementary Schools (DASE). The complete DASE is located in Appendix A. Additional information about the individual schools was obtained from the school district and the internet.

The participants in the study were 20 elementary schools in a large urban district in North Central Texas. Chapter 4 contains three tables that describe the schools. Table 2 describes the school facility, Table 3 describes the students, and Table 4 describes the professional staff.

Basic Assumptions

1. The evaluators evaluated the facilities honestly and accurately.
2. All elementary schools were following the district curriculum. The district provides The Pathway to Excellence, a curriculum guide, for every subject area and every grade level.
3. The school district repaired broken or damaged items in all elementary schools within a reasonable time.

Instrumentation

This study investigated the relationship of building design characteristics to each elementary school's rating for the 2003-2004 academic school year. Two instruments were used to collect data for this study. The first instrument used was the Texas Assessment of Knowledge and Skills (TAKS) that is given to most students in grades 3-11 in the state of Texas yearly. This study used the scores from the fifth grade math, reading, and science tests as well as the school's rating from the Texas Education Agency. The second instrument used in the study was the Design Assessment Scale for Elementary Schools (DASE), version 2003. Kenneth Tanner at the University of Georgia designed this instrument (personal communication, November 12, 2004).

Texas Assessment of Knowledge and Skills

The Texas Education Agency (TEA) assigns ratings to each school based on specific criteria including (1) percentage of students who met standards on the TAKS test, (2) percentage of students who met ARD expectations on the State Developed Alternative Assessment, (3) completion rate (high school only), and (4) annual drop out rate (grade 7 and 8 only) (Texas Education Agency, 2004). The rating labels for schools and school districts are: Exemplary, Recognized, Academically Acceptable, and Academically Unacceptable. New campuses are not rated Academically Unacceptable in their first year of operation. The accountability rating for the campuses is based on students who were enrolled on the PEIMS enrollment snapshot date in October. The date for the 2003-2004 school year was October 30, 2003. The Texas Assessment of Knowledge and Skills (TAKS) is the key accountability indicator. The TAKS standards for the 2003-2004 school year for each accountability rating are listed below in Table 1.

Table 1

TEA School Ratings and Accountability Standards

School Ratings	2004 Accountability Standards
Exemplary	>=90%
Recognized	>=70%
Academically Acceptable	
R/ELA, W, SS	>= 50%
Mathematics	>= 35%
Science	>= 25%
Student Passing Standard	1 SEM

Table 1 defines the standards that must be met to achieve a particular rating. For example, for a school to achieve the rating of Exemplary, 90% of the students taking the test must achieve the passing standard for each subject area. Schools that received Recognized must have 80% of their students passing each subject area test and schools receiving an Academically Acceptable rating must meet passing standards for the percentages represented in Table 1. A school that did not meet the above standards is designated Academically Unacceptable. The passing standards for each of the academic areas in 5th grade were at "1 Standard Error of Measurement for the 2003-2004 academic school year" (TEA Technical Digest, 2003, p. 98). Students who received a passing score in reading correctly answered 28 out of 42 questions with a scale scored of 2062 or 67%. Students who received a passing score in math correctly answered 27 out of 44 questions with a scaled score of 2037 or 63%. Students who received a passing score in science correctly answered 28 out of 40 questions correctly with a scaled score of 2016 or 70% (Texas Education Agency, 2004).

The accountability standards were also applied to subgroups designated by TEA. These subgroups include: African American, Hispanic, White, and Economically Disadvantaged, and All Students (Texas Education Agency, 2004). The subgroups were evaluated if the campus had test results for at least 30 testers in the group (sum across all grade levels) for the subject area; or if there were 30-49 testers in the subgroup and represented at least 10% of all test takers in that subject; or if there were test results for at least 50 testers even if they do not represent at least 10% of all test takers in that subject area (Texas Education Agency, 2004).

Validity and Reliability

Content and construct validity are interrelated in achievement tests. Committees of teachers, test development specialists, and Texas Education Agency staff members were assigned to each subject area to design the TAKS test. Students in the state field-tested test items developed by the committees. The committees met in the 2001-2002 academic year to review test questions and edit them for bias and content. The reliability of the TAKS test is based on internal consistency measures. The Kuder-Richardson Formula 20 was used for the multiple-choice test questions while the stratified coefficient alpha was used for essay prompts and short answer. “Most of the internal consistency reliabilities are in the high .80’s and low .90’s range” (Texas Education Agency, 2002, p. 105). The TAKS test met validity and reliability requirements.

Design Assessment Scale for Elementary Schools (DASE)

Kenneth Tanner at the University of Georgia’s School Design and Planning Laboratory developed the DASE in 1997. The design instrument used a 10-point Likert scale to evaluate the building design characteristics. "The first step in the development of the DASE was to review research and 'best practices' in school design" (Tanner, 1999a, p. 1). The validity phase of the research focused on identifying the design patterns that make up a school. "The instrument when constructed and administered properly will help us say that school design influences student learning" (p. 1). It also yields an index to say "how much" (p. 2). The work of Kenneth Tanner's design scale was tested for validity and reliability and presented at the 1999 Annual Conference of the Council of Educational Facility Planners, International in Baltimore, Maryland (Tanner, 1999b).

Tanner (1999a) conducted four tests of reliability. He conducted a test-retest on two different schools. The reliability coefficient on the first test-retest reliability was borderline at .68 while the internal consistency was good at .75. A second test-retest was completed on a different elementary school. This time the test-retest reliability coefficient was .82, an acceptable standard; while the internal consistency was also good with an overall reliability of .90.

The DASE used a wide range of vocabulary. Definitions of the terms that occur within the survey instrument are provided below (Tanner, 1999a).

1. Green areas – Outside spaces, close to the school building, where trees, grass or gardens may be seen (but no cars or roads).

2. Quiet areas – Solitary places where students may go to pause and refresh themselves in a quiet setting.

3. Play areas – Special locations where children are given the opportunity to be together, use their bodies, build muscles, and test new skills. Using imagination and releasing energy are two important activities seen in this area.

4. Entrance area – A friendly space connecting the outside world to the inside word. This age appropriate space should be inviting and highly visible for students and visitors. It should evoke a *welcome* feeling.

5. Private spaces for children – Social places where a small group of children may go to be alone (i.e., reading rooms, quiet places, reflection areas, listening areas, both inside and outside).

6. Circulation patterns within learning environment – indoor spaces for circulation should be broad and well-lit allowing for freedom of movement.

7. Hallways – Passageways, allowing students personal space when moving within the school (ample – not overcrowded).

8. Reference – Main building has an obvious point of reference among the school's buildings. It is a focal point where paths and buildings connect. This design feature heightens the sense of community. It stimulates students' imagination.

9. Administration centralized – Administrative offices are grouped together in a centralized area allowing for connection and convenience. If there are schools within a school or a campus plan, the person in charge should be readily accessible.

10. Acoustics – Control of internal and external noise~~s~~ levels.

11. Intimacy gradients – A sequence for larger to smaller–public to private spaces, giving the effect of drawing people into the area. These are usually found in main entrances, but may be used throughout the learning environment.

12. Pathways – clearly defined areas that allow freedom of movement among structures. These play a vital role in the way people interact with buildings. Pathways

may also connect buildings to one another so that a person can walk under the cover of arcades.

13. Auditorium – A public space that fosters a sense of community (unity and belonging) that offer inviting and comfortable settings, including ample lighting.

14. Media Center – A public space that fosters a sense of community (unity and belonging) that offer inviting and comfortable settings, including ample lighting.

15. Cafeteria – A public space that fosters a sense of community (unity and belonging) that offer inviting and comfortable settings, including ample lighting.

16. Context – The school and grounds are compatible with the surrounding and sufficient to facilitate the curriculum and programs.

17. Climate control – a system designed to maintain comfortable temperature in the classroom-learning environment.

18. Accessibility – students with disabilities have access to all areas of the facility.

19. Workrooms – teacher workrooms are near classrooms.

20. Roof system – A leaking roof can disrupt student learning.

21. Built to scale of children – A place designed and build to the scale of children including: door handles, light switches, seats, hand rails, shortened steps, water fountains, views.

22. Classrooms directly connected to outside – classrooms have a direct door from the classroom to the outside environment.

23. Teacher planning space – a space within the facility that allows for teacher planning.

24. Flex zones – a space within the facility that can be used for multiple reasons.

25. Small group area – a space within the facility that can be used for small group instruction.

26. Large group area – a space other than the classroom that can be used for large group instruction.

27. Areas for science instruction – a place that is used for science instruction, this space will include a wet area.

28. Area for art instruction – a place that is used for art instruction, this space will include a wet area.

29. Technology for students in the classroom – computers are placed within the learning environment in a manner that complements teaching and learning. Computers appear as an integral part of the curriculum.

30. Computer laboratories – this space should not be arranged in a rigid, institutionalized manner.

31. Computer view – the teacher should be able to view all the computer screens from one location.

32. Technology for teachers – computers (including laptops), multimedia and Internet connections are easily accessible. Teachers have access to technology (outside the media center) for use in research and planning lessons.

33. Comfort – Classrooms create a stress-free atmosphere.

34. Classroom walls – walls are conducive for displaying student work.

35. Stimulating classroom atmosphere – Classrooms create an atmosphere of excitement for learning.

36. Variety of outdoor spaces – outdoor spaces that allow students places to read, reflect, or work in small or large groups.

37. Safe location – the site and learning environments are free of excessive non-pedestrian traffic and noise. Natural or built barriers may protect these areas.

38. Separate age-level playgrounds – different playground are available for use by different age groups of students.

39. Developmentally appropriate playground equipment – the playground equipment available for use by students is developmentally appropriate.

40. Safe playground equipment – the playground equipment appears to be in good condition for students to use.

41. Separation of large and small children – lower and upper level students are separated throughout the instructional day.

42. Day security system – a security system including alarms, lights, and locks that is available during daytime hours.

43. Evening security system – a security system including alarms, lights, and locks is available during nighttime hours.

44. Supervisable circulation patterns – all circulation patterns are easy to supervise.

45. Phones within the classrooms – phones are available within the classroom so the teacher may receive and make phone calls.

46. Two-way intercom system – an intercom system is available in classrooms that allow teachers to contact and receive communication from the main office.

47. Phones in teacher workroom – phones are available in the teacher workrooms to make and receive phone calls.

48. Secured storage space for children – secured spaces for students to store their personal belongings, tools, and supplies.

49. Secured storage space for teachers – secured spaces for teachers to store their personal belongings, tools, and supplies.

50. Background detail – spaces for colorful displays on walls and doors (i.e., light switches, wall outlets, surface raceways that might be unnoticed by adults).

51. Visual stimulation – walls and finishes should effectively display color and vivid patterns.

52. Visual appearance of exterior of building – the overall general appearance of the exterior of the building including paint, windows, landscaping, and sidewalks.

53. Visual appearance of interior of the building – overall appearance of the interior building including paint, wall displays, and overall maintenance.

54. Variation of the ceiling height – a variation of ceiling heights allows individual comfort and intimacy within the school.

Research Procedures

This study explored the relationship between facility design variables and student achievement. It was a non-experimental research study that utilized descriptive statistics. This study did not control for any variables. The first phase of the study was to secure participation. School principals received an e-mail requesting their participation in the study. Thirty-three out of 70 school principals responded positively to the request, one principal declined participation, one email was returned for wrong address, one school was under construction and could not be entered for safety reasons, one school was used as a training school, and 34 principals did not respond. The schools that participated were divided into one of the three academic designations (Exemplary, Recognized, or Academically Acceptable). Two professional educators served as the evaluators for the study. The evaluators visited each of the 21 schools and used the DASE to evaluate them.

Procedures for Collection of Data

The following procedures were followed for the collection of data:

1. The superintendent of the district was contacted to request his permission to complete this study in the district (Appendix B).

2. Tanner's survey, The School Design Assessment Scale, is copyrighted so a request to use his survey was completed and granted (Appendix C) (personal communication, November 12, 2004).

3. A phone call from a director in elementary leadership confirmed the district's willingness to participate in the study.

4. The school district administrators insisted that the principal of each elementary school must volunteer his or her school for the study to be included.

5. A list of elementary schools and their 2003-2004 ratings was retrieved from the Texas Education Agency website.

6. Two schools were identified "Exemplary" while the rest of the schools were either designated "Recognized" or "Academically Acceptable." Ten schools from each of the last two categories were to be used for the study.

7. An email letter was sent to all the PK-5 elementary school principals in the district to ask for their participation in the study.

8. An email letter was sent to the directors and Assistant Superintendent to inform them that the visitation to schools would begin.

9. Schools that volunteered to participate were divided into the three groups: Exemplary, Recognized, and Academically Acceptable depending on their 2003-2004 rating.

10. More principals volunteered than were needed in the "Recognized" and "Academically Acceptable" categories. The schools chosen in each of these two categories were the ones who responded first to the email.

11. A team of two evaluators was trained to complete the DASE walk-through and score each school on the building design elements. The training consisted of a meeting that explained each of the variables as well as an explanation of each question. The two evaluators completed a walk-through of an elementary school in the district and rated each of the design variables. At the end of the walk-through, the two evaluators sat with the trainer and discussed their scores of each question to ensure both evaluators rated the variables similarly. If there was a discrepancy in the score the question was reviewed and the evaluators came to a common understanding of that question. The Texas standards for facilities were also included in the training. The guidelines can be found in The Texas Administrative Code (TAC) Chapter 61.1033. The code states requirements for school facility standards shall apply to projects from new construction or major space renovations approved by a school district's board of trustees after

September 1, 1998 and before January 1, 2004. The information covered in the training can be found in subsection (d) Space and minimum square foot requirements:

a. General Classrooms

    i. Classrooms for pre-kindergarten-Grade 1 shall have a minimum of 36 spare feet per pupil or 800 square foot per room.

    ii. Classrooms at the elementary school level shall have a minimum of 30 square feet per pupil or 700 square feet per room.

b. Specialized classroom

    i. Computer laboratories shall have a minimum of 41 square feet per pupil or 900 square feet per room at the elementary level.

c. Major support areas

    i. Primary gymnasiums or physical education space shall have a minimum of 3,000 square feet at the elementary level.

    ii. Libraries shall have a minimum of 3.0 square feet times the planned student capacity of the school. The minimum size of any elementary school library shall be 1,400 square feet.

    Space minimum requirements are the only facility standards in the state of Texas; however, all facilities also have to comply with local building codes.

The principals of the schools were notified through email of the time and date for the evaluation team to visit the school. The visits took place during the summer of 2005.

12. The evaluators scored the building individually as the facility was toured. The team was able to discuss and talk about the items as the school was being toured, but each

evaluator scored each topic individually. The evaluation team forwarded documentation to the researcher. Raw data for each school can be found in Appendix D.

13. A letter of the alphabet was assigned to each school facility to ensure confidentiality.

14. The TEA website was used to retrieve student descriptors and teacher descriptors.

15. The school district provided the documents for school facility descriptors.

Data Analysis

The scores for each design characteristic were recorded for each elementary school involved in this study. A total score was calculated for each of the 11 categories for each evaluator, and the total score was calculated for each school. Then a mean score was calculated for each question and for each of the 11 categories; also a mean was determined for each school. These scores are located in Appendix C. After the total and mean scores were determined for the categories on the DASE, Chronbach's alpha was calculated to determine the inter-rater reliability for the evaluators' use of the DASE. T-tests were used to determine if a relationship existed between TAKS reading, math, and science scores of each rating group and the subtopics on the DASE. In addition, a paired sample t test was used to discover if a relationship existed between TAKS reading, math, and science scores and the overall scores on the DASE. A one-way ANOVA was then used to compare the TEA designated schools and the total score on the DASE.

Inter-rater Reliability

Before data analysis could be run on the three research questions, it was first established that there was internal consistency of the evaluators' scores on the DASE and that any differences that did exist were not a result of personal bias. Cronbach's Alpha was used to determine internal consistency of evaluators' scores on the DASE. The first time, Cronbach's Alpha was determined using the two evaluators' sets of scores on the DASE; the reliability was very low at .3. After reviewing the raw data and discovering that the total scores on school J were very different, school J was eliminated and Cronbach's Alpha was run again. This time the inter-reliability was high at .96. The data were then configured for 20 schools rather than 21 schools.

CHAPTER FOUR

Results of the Study

Introduction

The purpose of this study was to examine the relationship between building design variables and student achievement. This chapter will review the results of the study by research question as follows.

1. What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that were designated "Exemplary" by TEA for the 2003-2004 academic school year?

2. What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that were designated "Recognized" by TEA for the 2003-2004 academic school year?

3. What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that are designated "Academically Acceptable" by TEA for the 2003-2004 academic school year?

4. What is the relationship between the total score on the DASE and the state ratings (Exemplary, Recognized, Academically Acceptable) of elementary schools located in an urban Texas school district?

School Descriptors

The 20 schools and their descriptions are listed below. Table 2 reviews the data for the actual school facilities including the original date the school was built, site acreage, square footage, number of floors the school has, student capacity, and student enrollment for the 2003-2004 academic school year. School D was the oldest building in the study. It was built 90 years ago while school G is the newest facility at 14 years old. The average elementary school in this study was built 50 years ago. The average square footage for the 20 facilities is 63,153 square feet. The largest school was school U at 94,577 square feet and the smallest was school M at 32,750 square feet. The average student capacity of the schools in the study was 600 students and the average student enrollment for the 2003-2004 school year was 548 students. The range of student enrollment was 723 while school S had a student enrollment of 905 and school M had an enrollment of 182.

Table 3 reviews the data for student populations of each of the elementary schools for the 2003-2004 school year. The percentage of economically disadvantaged students, Limited English Proficient (LEP) students, and ethnic groups is provided. All but two schools, school A and school E, serve students in Pre-Kindergarten through fifth grade. Schools A and E serve students beginning in Kindergarten. The mean percentage of economically disadvantaged students for the 20 schools in the study is 72.7% and 37.3% of the student population is considered Limited English Proficient. School G housed the largest percentage (69.9%) of LEP students and the largest percentage (95.3%) of economically disadvantaged students. The smallest percentage (4.3%) of economically disadvantaged students went to school A.

Table 2

School Facility Descriptors

School	TEA Designation	Original Build Date	Site Acres	Square Feet	No. of Floors	Student Capacity	Student Enrollment 2003-2004
A	Exemplary	1960	6.0	76,312	2	703	553
B	Recognized	1958	8.0	74,517	1	703	634
C	Acceptable	1949	7.0	72,574	2	737	572
D	Acceptable	1914	4.3	84,660	3	504	688
E	Recognized	1927	5.26	67,480	1	NA*	378
F	Acceptable	1989	8.0	65,400	1	931	840
G	Acceptable	1990	5.2	61,043	1	562	773
H	Acceptable	1957	6.0	83,118	2	627	544
I	Acceptable	1967	6.3	49,772	1	355	520
K	Recognized	1934	5.0	46,295	2	384	401
L	Recognized	Unknown	6.3	44,575	1	530	369
M	Acceptable	1927	4.5	32,750	2	293	182
N	Recognized	1988	17.1	50,174	1	502	445
O	Recognized	1948	7.2	64,505	1	646	608
P	Recognized	1955	6.1	45,811	1	NA*	283
Q	Recognized	1958	12.0	56,873	2	498	398
R	Recognized	1936	7.0	61,170	2	509	623
S	Acceptable	1955	7.2	77,329	2	904	905
T	Recognized	1947	3.7	54,125	1	669	576
U	Acceptable	1927	7.7	94,577	3	745	670
Avg.			6.993	63,153	1.6	600.111	548.1

Note: * These schools have a student application process so the student capacity is not noted.

Table 3

Student Descriptors

Schools	Grade levels	% ED	% LEP	% African-American	% Hispanic	% White
A	K-5	4.3	1.8	2.7	6.3	90.4
B	PK-5	29.3	29.3	15.0	20.5	62.8
C	PK-5	62.4	25.0	12.4	40.7	43.4
D	PK-5	92.0	58.4	2.6	93.6	2.8
E	K-5	17.5	2.6	20.4	27.0	50.5
F	PK-5	91.7	61.8	18.8	78.3	2.1
G	PK-5	95.3	69.9	13.1	85.0	1.8
H	PK-5	92.6	48.5	22.5	66.8	3.1
I	PK-5	75.8	6.9	78.8	10.0	7.3
K	PK-5	82.8	30.7	20.2	56.6	21.4
L	PK-5	85.4	37.9	3.5	64.0	28.2
M	PK-5	90.7	41.8	13.2	76.4	9.9
N	PK-5	89.9	14.2	79.1	10.8	1.8
O	PK-5	71.9	38.0	15.1	56.3	27.8
P	PK-5	65.0	33.9	11.3	66.1	17.7
Q	PK-5	58.3	11.8	9.8	39.2	50.5
R	PK-5	70.1	34.7	6.9	70.8	22.0
S	PK-5	91.5	63.6	1.2	96.5	1.7
T	PK-5	93.8	66.5	0.2	96.9	2.8
U	PK-5	93.4	69.0	1.2	91.2	6.4
Mean Average		77.09	40.19	17.96	61.63	22.98

Note: ED = Economically Disadvantaged

The 2003-2004 professional staff characteristics are included in Table 4. This table indicates that the mean number of professional employees in an elementary school. The mean number of professional staff is 37.4 with the largest number of professional staff at school S (53.5). The elementary school with the highest average for teacher years of service (15.6) was school M and the lowest mean was school N at only 5 years of teacher service. School M also had the lowest student teacher ratio at 10.9 students to every teacher. The mean teacher to student ratio for the school facilities in the study was 16.9 students per teacher with the highest student teacher ratio at school S at 19.7 to 1.

Table 4

Teacher Descriptors

Schools	# of Prof. staff	# of Teachers	# of Prof. Support	# of Campus Admin.	Teacher Average Years of Experience	# of students per teacher
A	33.7	29.2	2.5	2	12.3	18.9
B	40.1	34.1	4.0	2	10.5	18.6
C	40.0	34.0	4.0	2	13.2	16.8
D	42.5	36.0	4.5	2	13.1	19.1
E	25.7	21.2	2.5	2	14.2	17.8
F	60.9	53.9	5.0	2	6.2	15.6
G	47.7	40.5	5.2	2	7.7	19.1
H	38.2	32.2	4.0	2	13.9	15.1
I	36.4	31.4	3.0	2	8.1	16.6
K	30.1	25.1	3.0	2	9.9	16.0

(*table continues*)

Schools	# of Prof. staff	# of Teachers	# of Prof. Support	# of Campus Admin.	Teacher Average Years of Experience	# of students per teacher
L	27.2	23.2	2.0	2	11.4	15.9
M	20.8	16.8	2.0	2	15.6	10.9
N	28.4	23.4	3.0	2	5.0	19.0
O	42.4	36.9	3.5	2	9.0	16.5
P	20.6	16.1	2.5	2	9.7	17.6
Q	29.8	24.8	3.0	2	13.3	16.0
R	40.6	35.1	3.5	2	8.9	17.7
S	53.5	46.0	4.5	3	7.5	19.7
T	44.2	38.7	3.5	2	10.4	14.9
U	45.8	39.3	4.5	2	15.3	17.0
Mean Average	37.43	31.90	3.49	2.05	9.5	16.94

Research Question 1

What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that were designated "Exemplary" by the Texas Education Agency for the 2003-2004 academic school year?

A *t*-test could not be used for school A because it was the only Exemplary school in the study. A *t*-test compares two means and since there was only one school designated as Exemplary means could not be calculated. The school district required the principal's voluntary participation in this study. There were only two schools in the district that were Exemplary and only one of the principals chose to participate. However, a one-way ANOVA was used to see if a relationship was present between the total score on the DASE and each of the school's ratings. According to the ANOVA, the mean of the Exemplary school was 74 points higher than the mean of the Recognized schools and 89.67 points higher than the mean of Academically Acceptable schools. School A had the highest mean score for Architectural Design and Instructional Neighborhoods. It had the second highest mean for Daylighting and Views, Instructional Labs, and Building on a Student's Scale. Five of the 11 design variables were scored either first or second by the evaluators.

Research Question 2

What is the relationship between building design characteristics and reading, math, and science TAKS scores of children in elementary schools located in an urban Texas school district that were designated "Recognized" by the Texas Education Agency for the 2003-2004 academic school year?

Tables 5, 6, and 7 show the results of the *t*-tests that compared the means for the DASE categories and the mean for reading, math, and science scores.

The *t*-test compared the mean of the TAKS reading scores for Recognized schools (86.7%) and the mean of the design variables. The significance for 2-tailed *t*-test was .000 for all 11 design variables. According to McMillan and Schumacher (2001) in *Research in Education* two tailed tests are significant >.05. Table 5 shows the mean scores and the standard deviation for the design variables for recognized schools. In addition, it shows that 8 of the 11 design variables had positive correlation values to reading scores. Positive correlations show that the higher the DASE score in that design

Table 5

Results for Recognized Schools in Reading

DASE Categories	df	Mean	SD	t-Value	Correlation (r)	r^2
Color	9	30.3	3.23	-28.866	.710	50.41%
Location	9	20.15	3.41	-18.058	.542	29.38%
Outside Learning Areas	9	31.25	10.22	-9.432	.502	25.20%
Environment	9	21.85	2.20	-30.635	.464	21.53%
Day lighting	9	27.7	9.94	-8.555	.327	10.69%
Movement	9	117.25	5.18	-71.191	.167	2.79%
Large Group Meeting Places	9	30.8	5.40	-17.576	.155	2.40%
Instructional Neighborhoods	9	78.15	10.90	-22.416	.125	1.56%
Instructional Labs	9	31.3	4.35	-22.097	-.011	0.01%
Architecture	9	57.8	6.62	-27.177	-.036	0.13%
Building on a Students Scale	9	45.65	3.18	-44.829	-.421	17.72%

Note: df = degree of freedom; SD = standard deviation; r^2 = strength of relationship

variable the higher the score on the TAKS test. Negative correlations indicate that the higher the score on the DASE the lower the score on the TAKS test. Negative correlations indicate an inverse relationship. In addition, the greater the positive correlation the greater the importance the design variable is to student achievement. A correlation score of .7 and .8 would be considered a high correlation and would therefore be of greater importance. The *t*-value indicates that the scores are significant at the .001 level. Color had the highest positive value at .710 while Location (.542), Outside

Learning Areas (.502), and Environment (.464) had moderate positive values. Daylighting (.327), Movement (.167), Large Group Meeting Places (.155), and Instructional Neighborhoods (.125) had low positive values. There were low negative values with Instructional Labs (-.011), and Architecture (-.036). Building on a student's scale had a moderate negative value at -.421.

The *t*-value indicates that all of the scores for reading in recognized schools and the DASE are statistically significant. Therefore, all of the design variables have a statistically significant relationship with reading scores with the variable color having the greatest importance in Recognized schools for reading.

The results of the paired sample *t*-test for math and design variables are displayed in Table 6. The mean score on the 5th grade TAKS math test was 89.2% for recognized schools. The significance of the 2-tailed paired samples test was .000 for all design variables. The *t*-value also indicates that all of the scores are statistically significant for the correlation between student achievement in math and the DASE at the .001 level. The highest positive correlations for the DASE categories and math were for Instructional labs (.371) and Environment (.326); however, these correlations still fall within the low positive range. Other positive correlations included Movement (.288), Outside Learning Areas (.276), Color (.243), Location (.169) and Daylighting (.065), for a total of seven positive correlations. The other four design variables had negative correlations although they all fall within the low negative correlation range. Therefore, there was not a variable that had an important impact on student achievement in math for Recognized schools.

Table 6

Results for Recognized Schools in Math

DASE Categories	df	t-Value	Correlation (r)	r^2
Instructional Neighborhoods	9	-22.439	.371	13.76%
Environment	9	-30.414	.326	10.63%
Movement	9	-71.263	.288	8.29%
Outside Learning Areas	9	9.407	.276	7.62%
Color	9	-28.516	.243	5.90%
Location	9	-17.881	.169	2.86%
Daylighting	9	-8.530	.065	0.42%
Instructional Labs	9	-22.067	-.052	0.27%
Large Group Meeting Places	9	-17.505	-.092	0.85%
Architecture	9	-27.141	-.136	1.85%
Building on a Students Scale	9	-44.878	-.404	16.32%

Note: df= degree of freedom; r^2 = strength of relationship

The correlation results for recognized schools in science and the DASE are displayed in Table 7. The significance for 2-tailed t-test was .000 for all science and design variable pairs. The *t*-value indicates the scores are significant at the .001 level. The mean score on the 5th grade science TAKS test for the Recognized schools in the study was 81.2%. Only 2 of the 11 design variables showed a positive correlation (r). These two variables are Color (.132) and Outside Learning Areas (.065) and both variables fall in the low range. The other nine design variables had a negative correlation. Even though Color and Outside Learning Areas had positive correlations the strength of the relationship is minimal.

Some design variables did have a positive correlation with all of the 5th grade TAKS scores in Recognized Schools. In fact, Outside Learning Areas and Color had positive correlations with all three subjects. Large Group Meeting Places had a positive relationship with reading but a negative relationship with math and science. Daylighting, Instructional Neighborhoods, Movement, Location, and Environment all had positive relationships with reading and math but a negative correlation for science. Architecture, Building on a Students' Scale, and Instructional Labs had negative correlations in all three subjects.

Table 7

Results for Recognized Schools in Science

DASE Categories	df	t-Value	Correlation (r)	r^2
Color	9	-28.542	.132	1.74%
Outside Learning Areas	9	-9.419	.065	0.42%
Instructional Neighborhoods	9	-22.398	-.095	0.90%
Environment	9	-30.133	-.098	0.96%
Instructional Labs	9	-22.096	-.117	1.37%
Movement	9	-70.922	-.129	166%
Location	9	-17.843	-.137	1.88%
Architecture	9	-27.164	-.162	2.62%
Large Group Meeting Places	9	-17.476	-.388	15.05%
Building on a Students Scale	9	-44.867	-.424	17.98%
Daylighting	9	-8.519	-.509	25.91%

Note: df = degree of freedom; r^2 = strength of relationship

Research Question 3

What is the relationship between building design characteristics and reading, math, and science TAKS scores of elementary schools located in an urban Texas school district that were designated "Academically Acceptable" by the Texas Education Agency for the 2003-2004 academic school year?

Tables 8, 9, and 10 show the results of the t-test for Academically Acceptable schools in reading, math, and science.

The results of the paired sample t-test for the DASE and Reading are displayed in Table 8. The significance of the 2-tailed test was .000 for all design variables. The mean and standard deviation are noted for the scores on the individual design variables. The mean score on the TAKS reading test for Academically Acceptable schools in the study was 69%. Positive correlations show that as the score on the DASE increases the scores on the TAKS test also increase. However, a negative correlation indicates that as the scores on the DASE increase the scores on the TAKS test decrease. There were seven positive correlations in Reading with Instructional Labs having the highest correlation at .550. Large Group Meeting Places (.530) and Movement (.489) also had moderate positive correlations. Environment (.224), Instructional Neighborhoods (.102), Architecture (.012), and Color (.003) all had low positive correlations. The other design variables had negative correlations between reading in Academically Acceptable schools and the DASE. The correlation values indicated that the relationship between the scores and the design variable was moderately important.

The *t*-values indicated a statistically significant relationship between student achievement scores on the 5th grade TAKS test and the DASE at the .001 level.

Table 8

Results for Academically Acceptable Schools in Reading

DASE Categories	df	Mean	SD	t- Value	Correlation(r)	r^2
Instructional Labs	8	27.17	5.27	-15.260	.550	30.25%
Large Group Meeting Places	8	27.17	3.49	-23.356	.530	28.09%
Movement	8	113.4	7.25	-47.210	.489	23.91%
Environment	8	21.83	2.00	-31.811	.224	5.02%
Instructional Neighborhoods	8	78.89	14.54	-16.194	.102	1.04%
Architecture	8	56.94	6.36	-26.566	.012	0.01%
Color	8	30.78	3.77	-24.126	.003	0.0%
Location	8	18.11	3.83	-13.562	-.094	0.88%
Day lighting	8	26.50	5.55	-13.881	-.209	4.37%
Building on a Students Scale	8	41.61	5.28	-23.043	-.333	11.09%
Outside Learning Areas	8	31.00	7.30	-12.365	-.350	12.25%

Note: df= degree of freedom; SD = standard deviation; r^2 = strength of relationship

The results of the correlation between DASE scores and scores on the math TAKS test for Academically Acceptable schools are listed above in Table 9. The mean score for the math TAKS test for the sample group was 74.4%. The *t*-values indicate a statistically significant relationship at 0.01 level. There was a moderate positive correlation between DASE scores and TAKS math scores in Large Group Meeting Places (.674), Color (.502), and Instructional labs (.450). There were low positive correlations in the areas of Movement (.179), Instructional Neighborhoods (.162), and Building on a

Student's Scale (.110). A total of 6 of the 11 design variables had a positive correlation. The other five design variables had a negative correlation. The higher the correlation numbers the greater the strength of relationship; therefore, Large Group Meeting Place would have the greatest importance for math in Academically Acceptable schools.

Table 9

Results for Academically Acceptable Schools in Math

DASE Categories	df	t-Value	Correlation (r)	r^2
Instructional Labs	8	-15.180	.550	30.25%
Large Group Meeting Places	8	-23.033	.530	28.09%
Movement	8	-46.949	.489	23.91%
Environment	8	-31.939	.224	5.02%
Instructional Neighborhoods	8	-16.136	.102	1.04%
Architecture	8	-26.526	.012	0.01%
Color	8	-23.909	.003	0.00%
Location	8	-13.565	-.094	0.88%
Daylighting	8	-13.868	-.209	4.37%
Building on a Students Scale	8	-23.059	-.333	11.09%
Outside Learning Areas	8	-12.374	-.350	12.25%

Note: df = degree of freedom; r^2 = strength of relationship

The results of the correlation between DASE scores and the mean score on science TAKS test for Academically Acceptable schools are displayed in Table 10. The *t*-value indicates that the scores on all design variables on the DASE are statistically significant at the .001 level to student achievement scores on the 5^{th} grade science test.

The mean score for Academically Acceptable schools in science was 57.2%. The results indicate there was a moderate positive correlation (r) for Large Group Meeting Places (.674), Color (.502), and Instructional Labs (.450). Other positive correlations include Movement (.179) Instructional Neighborhoods (.162), and Building on a Student's Scale (.110). The other five design variables had a negative correlation for science TAKS scores in Academically Acceptable schools. Large Group Meeting Places appeared to have the greatest importance of the design variables for science in Academically Acceptable schools.

Table 10

Results for Academically Acceptable Schools in Science

DASE Categories	df	t-value	Correlation (r)	r^2
Large Group Meeting Places	8	-23.290	.674	45.43%
Color	8	-24.364	.502	25.20%
Instructional Labs	8	-15.254	.450	20.25%
Movement	8	-46.830	.179	3.20%
Instructional Neighborhoods	8	-16.178	.162	2.62%
Building on a Students Scale	8	-23.343	.110	1.21%
Architecture	8	-26.603	-.001	0.00%
Environment	8	-31.802	-.033	0.11%
Daylighting	8	-13.912	-.403	16.24%
Location	8	-13.493	-.698	48.72%
Outside Learning Areas	8	-12.372	-.777	60.37%

Note: df = = degree of freedom; r^2 = strength of relationship

Five of the design variables had a positive correlation with all three TAKS subject areas in Academically Acceptable schools. These design variables include: Instructional Labs, Instructional Neighborhoods, Large Group Meeting Places, Movement, and Color. Architecture and Environment had positive correlations with reading and math scores in Academically Acceptable schools but a negative correlation with science. The design variable, Building on a Student's Scale, had a positive correlation with science scores but negative correlations with reading and math scores. Three design variables, Daylighting, Location, and Outside Learning Areas, had negative correlations with all three subject areas for 5th grade TAKS scores.

Research Question 4

What is relationship between the total score on the DASE and the state ratings (Exemplary, Recognized, Academically Acceptable) of elementary schools located in an urban Texas school district?

Tables 11 and 12 show the results of the ANOVA.

Homogeneity of Variances

The Homogeneity of Variances test was satisfied with a score of .367. To be significant the score on the Homogeneity of Variance should be less than 0.5. This test ensures consistency within each individual group.

A one-way ANOVA was run to determine if a relationship existed between the total score on the DASE and the three groups (Academically Acceptable, Exemplary, and Recognized). Table 11 shows nine schools were in the sample from the Academically Acceptable group, one school was in the Exemplary group, and 10 schools were in the

Recognized group for a total of 20 schools. The lowest score for the total score on the DASE was in the Academically Acceptable group with a mean of 475.83. The Recognized schools scored the second highest with a mean score of 491.5. The one Exemplary school scored the highest on the DASE with a mean score of 565.5.

Table 11

DASE

Group	N	Mean	Standard Deviation
Academically Acceptable	9	475.83	30.12
Exemplary	1	565.50	
Recognized	10	491.50	35.70
Total	20	488.15	37.12

Table 12 indicates there was not a significant difference between the DASE scores and the three different ratings (Academically Acceptable, Exemplary, and Recognized) for elementary schools.

Table 12

Results of One-Way Analysis of Variance for DASE

Source	df	F	Sum of Squares	Mean Square	Sig.
Between Groups	2	3.387	7460.550	3730.275	.058*
Within Groups	17		18725.500	1101.500	
Total	19		26186.050		

Note: *ANOVA significant at >.05

CHAPTER FIVE

Summary, Conclusions, and Recommendations

This chapter will present a summary of the study, review the results of the findings, and provide a discussion on recommendations for practice and further research.

Summary

The purpose of this study was to determine if a relationship existed between facility design variables and student achievement as demonstrated on the Texas Assessment of Knowledge and Skills. The 11 design variables that were used were taken from the Design Assessment Scale for Elementary Schools created by Kenneth Tanner (1999a) at the University of Georgia. These design variables are: Architecture, Building on Student's Scale, Color, Daylighting, Environment, Instructional Labs, Instructional Neighborhoods, Large Group Meeting Places, Location, Movement, and Outside Learning Areas. Student achievement was measured by 5th grade reading, math, and science scores on the 2003-2004 TAKS tests. There were no control variables in the study. Descriptive statistics was used and independent t-tests and an ANOVA were used to determine if a relationship existed between the design variables and student achievement in 5th grade math, reading, and science.

The study took place in a large urban school district in north Texas. Using the DASE, two educators evaluated 21 elementary schools during the summer of 2005. To measure student achievement, TAKS scores were obtained from the Texas Education Agency for the 2003-2004 school year. Permission from the school district was obtained but principals of elementary schools were required to volunteer their school's participation in the study. A total of 35 principals responded to the request but only 21 schools were evaluated. Each school that was evaluated was assigned a letter of the alphabet to ensure confidentiality.

School J had to be eliminated from the study because the discrepancies of the total score on the DASE. These scores can be located in Appendix D. This brought the total number of elementary schools that participated in the study to 20: 1 Exemplary, 10 Recognized, and 9 Academically Acceptable.

According to McMillan and Schumacher (2001) correlation studies can only state there is a relationship between the two means and cannot determine causation; therefore, the study could only determine if a relationship existed between design variables and 5th grade reading, math, and science TAKS scores.

Discussion and Conclusions

This study does support previous research conducted on facility design and student achievement (Earthman, 2004; Schneider, 2002a; Tanner & Langford, n.d; Yarbrough, 2001). All design variables in this study did have a statistically significant correlation with student reading, math, and science scores.

In this study the average square footage of Academically Acceptable schools was 69,025 square feet while the average square footage for Recognized schools was 56,553 square feet. In addition, the mean student population for Academically Acceptable schools for the 2003-2004 school year was 633 students while the mean student population for Recognized schools during the same year was 472 students. The literature on smaller schools certainly supports the finding of this study. Stueck and Tanner (1996) state “Smaller facilities create a psychologically and emotionally better environment for growth"(p. 2). Additionally, Schneider (2002) cites a report by Cotton, "the consensus seems to be that small-school benefits are achieved in the 300- to 400- student range for elementary schools . . . " (p.10). In addition, using the data in Table 2 indicates that the Exemplary school had 137 square feet per student while the Recognized schools averaged 124.5 square feet per student. The Academically Acceptable schools averaged 117.3 square feet per student. It appears that the greater the average square footage per student the higher the school's state rating. As also shown in Table 2, there were five schools that were over the recommended student capacity for the 2003-2004 school year. Three of these schools were rated Academically Acceptable and two were rated Recognized. Upon further examination, the three Acceptable schools were overcrowded by 211 students, 184 students, and 165 students respectively. The two recognized schools were overcrowded by 114 students and 17 students respectively. This study suggests the possibility that the greater the overcrowding in an elementary school the lower the state's school rating.

Many positive correlations between building design variables and student achievement were reported in the study. However, only one of the 11 variables on the DASE, color, had a positive correlation in reading, math, and science in both Recognized and Academically Acceptable schools. Color is known to affect many aspects of people including heartbeat, blood pressure, and mood (Grangaard, 1995). Earthman and Lemasters (1998) also found color to be a key variable in schools by increasing student achievement, and decreasing blood pressure of students. Because color affects so many aspects of a person's well being it is not surprising that it is the one variable that had a positive correlation across all subject areas and all school ratings.

Research has indicated that daylighting has a positive impact on student achievement (Hathaway, 1995); but this study indicated that it had a negative correlation in all subject areas in Academically Acceptable schools and in science in Recognized schools. This result was surprising because the literature is so strong in reference to the positive effects lighting has on student achievement. Jago and Tanner (1999) referenced a study completed by Horton in 1972. The Horton study suggested that the ability for a student to concentrate on instruction is dependent upon factors such as lighting. Another study that supports Horton is one completed by Phillips in 1997. This study was also referenced by Jago and Tanner (1999), and concludes that there is a direct relationship between good lighting and student achievement.

The design variables Instructional Neighborhoods and Movement had positive correlations in all three subject areas in Academically Acceptable schools and in reading and math in Recognized schools. Instructional neighborhoods or wing(s) of the building that include teacher planning spaces, flex zones (places for multiple use), small and large group areas, wet areas for science and art, hearth areas, and restrooms are becoming increasingly important in school facilities (Tanner, 2003). Kennedy (2002) quoted Peter Kuttner, president of Cambridge Seven Associates, “Learning occurs in so many places” (p. 3). Learning is no longer confined to the four walls of a classroom. Educators are using all aspects of the school environment to educate students. Kuttner also stated, “Schools should actively promote lots of learning environments.” (Kennedy, 2002, p. 3) In fact, Massachusetts Institute of Technology believes only 20% of learning actually occurs within the traditional classroom walls (Kennedy, 2002). Prakash Nair (2002) also suggests the traditional classroom will give way to “learning studios” where students can be engaged in a variety of activities at the same time. Even though Instructional

Neighborhoods had positive correlations, the correlation values indicate that the importance of instructional neighborhoods is not very strong as it relates to student achievement.

Movement had positive correlations in all three subject areas in Academically Acceptable schools and in reading and math in Recognized schools. Tanner (2003) defines movement as the school's design regarding its ability to enable students and teachers to enter and move freely within and around a facility. Movement also relates to the safety of a school facility, and it is known when students feel safe they are free to learn. "Schools have begun paying closer attention to the spaces and amenities offered to students as they travel from class to class" (Kennedy, 2002, p. 3). Movement of students between instructional spaces needs to be considered when renovating or building a school facility however, the importance of these two variables was only in the moderate range.

The two design variables, Instructional Neighborhoods and Movement, appear to be very similar. Instructional Neighborhoods center around additional places in the school where students go to learn, for example: science classrooms, art rooms, and quiet areas and the design variable movement relates to how students and teachers move from one area of the school to another area of the school. Both of these variables exist outside the traditional classroom where students typically learn.

An interesting result of the *t*-tests was that the design variable, Instructional Labs, received positive correlations with reading, math, and science in Academically Acceptable schools, but had a negative correlation with reading, math, and science in Recognized schools. The reverse was true for Outside Learning Areas. The design variable Outside Learning Areas had positive correlations with reading, math, and science in Recognized schools but negative correlations with reading, math, and science in Academically Acceptable schools. This result could have occurred due to the location of the school. Often times Academically Acceptable schools are located in lower income neighborhoods and closer to busy streets and industrial areas. In the district the study took place, the average percentage of economically disadvantaged students (see Table 3) in Academically Acceptable Schools was 87.3% while the average percentage of economically disadvantaged students in Recognized schools was 66.4%. Possibly due to this fact, the design variable Location, received negative correlations in reading, math, and science in Academically Acceptable schools but positive correlations for reading and math in Recognized schools. These two design variables appear to be closely linked.

According to the results, design variables are more closely related to student achievement in reading and math. The Heshong group (1999) also found this to be true in their study of light. Students were found to progress faster in reading than math in two of the three districts that participated in the study. The positive correlation of design variables to 5th grade reading and math scores in Recognized and Academically Acceptable schools is high. Reviewing all the design variables across the two ratings, there were a total of 22 correlations. Of the 22 correlations, there were 15 positive correlations in reading and 14 positive correlations in math. The results for the correlations in science were much lower. In fact, there were only a total of eight positive correlations. Reading and math achievement appear to be influenced more by building design variables.

There has been a void in the literature of the effects of design variables on elementary students' achievement. One study by Yarbrough (2001) concludes that design variables do affect student achievement at the elementary level. This study also supports that conclusion. Additional research indicates that facility design variables do have an impact on student achievement at all levels (Broome, 2003; Earthman & Lemasters, 1998; Tanner, 2002; Yarbrough, 2001). The results of this study support those conclusions and indicate that design variables are statistically related to student achievement. The positive relationships in the study were stronger in reading and math than in science. This study, however, did not prove there was a significant relationship between the total score on the DASE and school ratings. The ANOVA performed on the total score on the DASE and the three TEA designated subgroups indicated that there was not a significant relationship between the total scores and school ratings (.058). However, the sample size for Exemplary schools was so small that it could be speculated that if the sample size was larger a significant relationship might exist between DASE scores and the school's state ratings.

Recommendations

Recommendations for Practice

1. Superintendents, school boards, and architects need to establish a mechanism for teachers and principals to be more actively involved in the planning and renovating process of school facilities.

2. Superintendents and school boards who are responsible for making decisions relating to the renovation, construction, and funding of facilities need to be updated on current research to enable good decision making and good use of funds.

3. Since Color was the only design variable to have positive correlations in all subject areas and both school ratings; all educators need to be informed about the importance of color and its relation to student achievement.

4. Educators need to have a greater voice, take a united stand, and demand facilities that promote greater student achievement.

5. When possible new schools should be built to relieve overcrowding since this study suggests that there might be a relationship between overcrowding in elementary schools and a decrease in student achievement.

6. The student population in an elementary school should be kept around the 400- range. This study supported the literature and concluded that schools in the 300 to 400 range are optimal for student achievement.

7. The design variables, Instructional Neighborhoods and Movement, had positive correlations with every subject in Academically Acceptable schools and reading and math in Recognized schools. Therefore, when renovating or building school facilities attention needs to be given to these two design variables which include factors such as: teacher planning spaces, flex zones, small and large group areas, restrooms, and wet areas for science, hallways.

Recommendations for Further Research

1. An investigation should be completed that replicates this study in an urban school district with a larger number of all school ratings (Exemplary, Recognized, Academically Acceptable, and Unacceptable).

2. An investigation should be conducted to determine which DASE design variables consistently produce the highest correlations so funds could be appropriately used for those design variables that consistently and significantly relate to student achievement.

3. A longitudinal study of renovated facilities should be completed. This study would allow students' achievement scores to be compared before and after facility renovation to determine if renovated facilities have a positive effect on student outcomes.

4. Using the DASE a study should rate the facility of schools that have been rated as Unacceptable or low performing three years or more.

5. Using the DASE a study should be completed that includes student achievement of elementary schools in other subject areas such as social studies and writing.

6. A study should be completed to compare the academic achievement of elementary students in classrooms with windows and natural light to students in classrooms without windows.

7. A study should be completed to determine the elementary school principal's knowledge and perception of the importance of design variables on student achievement.

8. Since this study indicated a negative correlation between science achievement and the design variable daylighting, a study needs to be completed to determine how light effects science achievement.

9. Since this study indicated a negative correlation between daylighting and scores in Academically Acceptable schools in all subject areas, a study should be completed that determines why lighting had negative correlations with 5th grade TAKS scores in those schools.

10. In addition to design variables on the DASE, a study should also compare the types and quantities of equipment (science equipment, musical instruments, physical education equipment) that are available in schools and the effects on student achievement.

11. Since this study indicated DASE variables had a stronger relationship with reading and math achievement, a study should determine why facility design variables influence reading and math achievement more than science achievement.

APPENDICES

APPENDIX A

Design Appraisal Scale Elementary
Version, 2003

Name of Appraiser: ______________________________ / Date: _________

School Name ____

Setting (Context): Urban _ Suburban _ Small City _ Rural _

Site-Acreage: ____________ / Gross Sq. Footage: ____________

Grades Housed: ____________ /Student Capacity: ____________

Number of Teaching Stations: ____________ / Number of Students: ____________

AC: ____________ / Number of Floors: ____________

Number of Mobile Units: ____________

Date of Original Construction: ________________________/ Comments:

Remodeled/Renovated : ___________

Learning Signature: ____

Total Score: _____________

Instructions: Please score design patterns on the scale (1 to 10) as defined in each section. If the school does not have a specific feature, the score is "0" for that item. Place each score at the left of individual items. Design includes the way the schoolhouse is made, how it is arranged, and how the outside areas, near the school complement the curriculum.

The scale measures the degree to which each item is present in the learning environment. The following sample scale suggests that the "stronger" the element is the higher the assigned score.

Weaker <---> Stronger
0 1 2 3 4 5 6 7 8 9 10

Place each score at the left of individual items. Design includes the way the schoolhouse is made, how it is arranged, and how the outside areas near the school complement the curriculum.

Movement Patterns

The school's design may be judged regarding its ability to enable students and teachers to enter and move freely within and around a facility.

1-______- **Promenade** – Outside walkways linking main areas; ideally placing major activity centers at the extremes.

Ambiguous Distinct
< -- >

0 1 2 3 4 5 6 7 8 9 10

2-______- **Pathways** - Clear and comfortable pathways that allow freedom of movement and orientation among structures. These play a vital role in the way people interact with buildings. This pattern defines the overall philosophy of the layout.

Ambiguous Clear
< -- >
0 1 2 3 4 5 6 7 8 9 10

Circulation Patterns - Indoor spaces for circulation. The passages should be broad and well-lit allowing for freedom of movement.

3-______- Within learning environments .

Poor Excellent
< -- >
0 1 2 3 4 5 6 7 8 9 10

4-______- **Hallways** – Passageways, allowing students personal space when moving within the school. [Ample spaces – non-crowded]

Meager Space Ample Space
< -- >
0 1 2 3 4 5 6 7 8 9 10

5-______- Supervisable circulation patterns [Percentage of supervisable circulation patterns: 0=0%, 1=10%, 10=100%]

6-______- **Egress** - Many exits from the building. The best situations are where students may exit directly from their classrooms.

None Ample
< -- >
0 1 2 3 4 5 6 7 8 9 10

7-______- **Classrooms** - Exterior doors lead to a courtyard.

Lacking Extensive
< -- >
0 1 2 3 4 5 6 7 8 9 10

***Spaces for Physically Challenged Students (MC)**

Limited   Unlimited
< -- >
0   1   2   3   4   5   6   7   8   9   10

8-_____ a. Access to Classrooms

9-_____ b. Access to Hallways

10-_____ c. Access to Lunchroom

11-_____ d. Access to Gymnasium

12-_____ e. Access to School Buildings

13-_____ f. Access to Toilets

14-_____ g. Access to Drinking Fountains

15-_____ i. Access to Computer Stations

16-_____ j. Access to School Grounds

17-_____ k. Access to Living Center (Teaching center)

<u>Large Group Meeting Places</u>

Public Areas – Spaces that foster a sense of community (unity and belonging). Inviting and comfortable settings including ample lighting.

Poor   Excellent
< -- >
0   1   2   3   4   5   6   7   8   9   10

18-_____ a. Auditorium

19-_____ b. Amphitheater

20-_____ c. Media center

21-_____ d. Commons (Spaces for casual student meeting)

22-_____ e. Dining room

***Historical Archives (MC)** - Spaces for students to browse historical works of all cultures. Quality refers to the amount of space made available and how it blends with the setting. Accessibility is also an aspect of quality.

Inadequate Adequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

23-_____ d. Media Centers (Library) - Artifacts

24-_____ e. Media Centers (Library) - Documents

25-_____ f. Media Centers (Library) – Literature

Architectural Design

26-_____- **Entrance Area** – A friendly space connecting the outside world to the inside world. This age appropriate space should be inviting and highly visible for students and visitors. It should evoke a 'welcome' feeling.

Not welcoming Welcoming
< -- >
0 1 2 3 4 5 6 7 8 9 10

27-_____ -**Administration Centralized** - The main administrative offices are grouped together in a centralized area allowing for connection and convenience (Assistant principals may be located elsewhere in the school). If there are schools within a school or a campus plan, the person in charge should be readily accessible, at least for the safety of the children. (Accessibility)

Poor Excellent
< -- >
0 1 2 3 4 5 6 7 8 9 10

28-_____- **Reference** - Main building has an obvious point of reference among the school's buildings in which paths and buildings connect. This design feature heightens the sense of community. An example might be a clock tower at front entrance.

Obscure Obvious
< -- >
0 1 2 3 4 5 6 7 8 9 10

29-_____- **Paths with Goals** - Places designed to provide focal points when walking to particular locations. (e.g. displays of students, work, meaningful posters, benches, or plants).

Non-existent Plentiful
< -- >
0 1 2 3 4 5 6 7 8 9 10

30-_____- **Intimacy Gradients** - A sequence from larger to smaller - public to private spaces. This gives the effect of drawing people into the area. Usually found in main entrances, but may be used through out the learning environment.

Non-existent Plentiful
< -- >

0 1 2 3 4 5 6 7 8 9 10

31-_____ - **Hallways** - Hallways are adequate/inadequate for displaying student work

Inadequate Adequate

< --- >

0 1 2 3 4 5 6 7 8 9 10

32-_____ - **Workrooms** - Workrooms locations with respect to classrooms.

Far From Classrooms Close to Classrooms

< --- >

0 1 2 3 4 5 6 7 8 9 10

Territoriality of Place. How comfortable the school is for the student regarding personal and social distance.

33-_____ a. General social distance per student - The complete facility.

Close (4' - 7') Far (7'-12')

< --- >

0 1 2 3 4 5 6 7 8 9 10

34-_____ - **Ceiling Heights** - A variation of ceiling heights allowing for individual comfort and intimacy within the school. [Percentage of variation (overall) 0=0%, 1=10%,..., 10=100%]

No Variance Varying

< --- >

0 1 2 3 4 5 6 7 8 9 10

Daylighting and Views

Windows – Spaces bringing natural light into the learning environment. Windows may have some form of glare control, but should be in use (when glare is not a problem), and be without painted obstructions and other devices that restrict views. Windows should invite the outdoors inside.

35-_____ a. Views overlooking life

None Numerous

< --- >

0 1 2 3 4 5 6 7 8 9 10

36-_____ b. Unrestricted views (when glare/curtains is/are not a problem)

Sparse Ample

< --- >

0 1 2 3 4 5 6 7 8 9 10

37-_____ c. Adequacy of natural light (includes skylights and borrowed light – natural, reflected light)

No Mixture of Lighting Ample Mixture

< --- >

0 1 2 3 4 5 6 7 8 9 10

38-________- **Living Views** - Views of indoor and outdoor spaces (gardens, animals, fountains, mountains, people, etc.) These allow minds and eyes to take a break.

Indequate Adequate

< -- >

0 1 2 3 4 5 6 7 8 9 10

39-________- **Natural Light/ Full Spectrum** - Artificial light plus natural light from the outside, preferably on two sides of every room.

No Mixture of Lighting Ample Mixture

< -- >

0 1 2 3 4 5 6 7 8 9 10

Psychological Impact of Color Schemes

[Tone = Quality: Hue = A scale of perceptions ranging (circular) form red - yellow - green - blue - red]

40-_____ a. Classroom

Warm Hue Neutral Light Hue With Stronger Color for Front Wall

< -- >

0 1 2 3 4 5 6 7 8 9 10

41-_____ b. Hallways

Dark Hue Neutral Light Hue With Bright Ends

< -- >

0 1 2 3 4 5 6 7 8 9 10

42-_____ c. Lunchroom

Dark Hue Neutral Light Hue With Bright Color Accents

< -- >

0 1 2 3 4 5 6 7 8 9 10

43-_____ d.Gymnasium

Dark Tones Neutral Light Tones With Bright Color Accents

< -- >

0 1 2 3 4 5 6 7 8 9 10

44-_____- **Background Detail** – Spaces of colorful displays on walls and doors (e.g. light switches, wall outlets, louvers, and surface raceways) that might be unnoticed by adults.

Inhibits Learning Promotes Learning

< -- >

0 1 2 3 4 5 6 7 8 9 10

45-_____ - **Visual Stimulation** - Walls and finishes that effectively display color and vivid patterns.

Inhibits Learning   Promotes Learning
< -- >
0 1 2 3 4 5 6 7 8 9 10

Building on Student's Scale

A place designed and built to the scale of children (e.g. Door handles or handrails low enough for children to reach to accommodate their heights.)

46-_____ a. Light switches

Too High/Low   Appropriate Height
< -- >
0 1 2 3 4 5 6 7 8 9 10

47-_____ b. Door handles

Too High/Low   Appropriate Height
< -- >
0 1 2 3 4 5 6 7 8 9 10

48-_____ c. Hand rails

Too High/Low   Appropriate Height
< -- >
0 1 2 3 4 5 6 7 8 9 10

49-_____ d. Shortened steps

Unsuitable   Suitable
< -- >
0 1 2 3 4 5 6 7 8 9 10

50-_____ e. Water fountains

Too High/Low   Appropriate Height
< -- >
0 1 2 3 4 5 6 7 8 9 10

51-_____ f. Views (doors/windows that allow the student to easily see the outside)

Too high/low   Appropriate Height
< -- >
0 1 2 3 4 5 6 7 8 9 10

52-_____ g. [Percentage of developmentally appropriate playground equipment: 0=0%, 1=10%, 10=100%]

Location of the School

53-_____- **Safe Location** – The site and learning environments are free of excessive non-pedestrian traffic and noise. Natural or built barriers may protect these areas.

Not Safe Very Safe
< --- >
0 1 2 3 4 5 6 7 8 9 10

54-_____- **Context** - The school and grounds are compatible with the surroundings and sufficient to facilitate the curriculum and programs.

Not Compatible Compatible
< --- >
0 1 2 3 4 5 6 7 8 9 10

55-_____- **Harmony** - The school is "in harmony with nature." It blends with the surroundings and brings nature into the learning environments.

Does Not Blend Blends
< --- >
0 1 2 3 4 5 6 7 8 9 10

Instructional Neighborhoods

Places [wing(s) of the building] that include teacher planning spaces, flex zones (places for multiple use), small and large group areas, wet areas for science and art, hearth areas, and restrooms. The hearth area is a place used for reading and quiet time.

56-_____ a. Teacher planning areas

Inadequate Adequate
< --- >
0 1 2 3 4 5 6 7 8 9 10

57-_____ b. Flex zones

Poor Excellent
< --- >
0 1 2 3 4 5 6 7 8 9 10

58-_____ c. Small group areas

Inadequate Adequate
< --- >
0 1 2 3 4 5 6 7 8 9 10

59-_____ d. Large group areas

Inadequate Adequate
< --- >
0 1 2 3 4 5 6 7 8 9 10

60-_____ e. Wet areas for science

Inadequate Adequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

61-_____ f. Wet areas for art

Inadequate Adequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

62-_____ g. Hearth areas

Poor Excellent
< -- >
0 1 2 3 4 5 6 7 8 9 10

63-_____- **Activity Pockets -** Spaces designed for small group work.

Non-existent Plentiful
< -- >
0 1 2 3 4 5 6 7 8 9 10

64-_____ a. Toilets in classrooms [Percentage of toilets in classrooms: 0=0%, 1=10%,..., 10=100%]

65-_____- **Storage** – Secured spaces for teachers and students to store their personal belongings, tools and supplies.

None Ample
< -- >
0 1 2 3 4 5 6 7 8 9 10

66-_____- **Classroom Walls -** Walls are adequate/inadequate for displaying students' work.

Inadequate Adequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

Quiet Areas –Solitary places where students may go to pause and refresh themselves in a quiet, supervisable setting.

67-_____- Inside Places

Inadequate Adequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

Private Spaces for Children – Social, supervisable places where a small group of children may go to be alone (i.e. reading areas, quiet places, reflection areas, listening areas, etc.).

68-_____ a. Inside

Inadequate   Adequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

69-_____- **Excitement** - Classrooms create an atmosphere of excitement for learning.

Inhibits Learning   Promotes Learning
< -- >
0 1 2 3 4 5 6 7 8 9 10

70-_____ a. Computers are placed within the learning environment in a manner that complements teaching and learning. Computers appear as an integral part of the curriculum.

Inhibits Learning   Promotes Learning
< -- >
0 1 2 3 4 5 6 7 8 9 10

71-_____ b. General personal distance per student - The classrooms and work areas.

Close (4' - 7')   Far (7'-12')
< -- >
0 1 2 3 4 5 6 7 8 9 10

Outside Learning Areas

72-_____ a. Outside Places

Inadequate   Adequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

73-_____ b. The campus contains soft areas for the students to work.

Inadequate   Adequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

74-_____- **Outdoor Rooms** - Defined spaces outdoors - enough like a classroom, but with the added beauties of nature.

Lacking   Extensive
< -- >
0 1 2 3 4 5 6 7 8 9 10

75-_____- **Outdoor Spaces** - Places which are defined; may be surrounded by wings of buildings, trees, hedges, fences, fields, arcades or walkways.

Non-existent   Plentiful
< -- >
0 1 2 3 4 5 6 7 8 9 10

76-_____- **Green Areas** - Outside spaces, close to the school building, where trees, grass or gardens may be seen [but no cars or roads].

Non-existent Plentiful
< -- >
0 1 2 3 4 5 6 7 8 9 10

77-_____- **Animal Life** - Places in a school or on the school grounds for animals to live (Includes butterfly houses, bird houses, trees, etc…). Caring for animals helps teach the students a sense of responsibility and respect (Values).

Lacking Plentiful
< -- >
0 1 2 3 4 5 6 7 8 9 10

Instructional Laboratories

Technology for Students - Spaces with computers, compact disks, programs, learning packages, Internet connections, television, and video.

78-_____ a. Computer laboratories are not arranged in a rigid, institutionalized manner.

Rigid Flexible
< -- >
0 1 2 3 4 5 6 7 8 9 10

***Music** (MC)- Quality of designated spaces for music

79-_____ a. Instruction

Inhibits Learning Promotes Learning
< -- >
0 1 2 3 4 5 6 7 8 9 10

80-_____ b. Performance

Adequate Inadequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

***Art (MC)**- Quality of designated spaces for art.

81-_____ a. Instruction

Inhibits Learning Promotes Learning
< -- >
0 1 2 3 4 5 6 7 8 9 10

82-_____ b. Display [International photo gallery]

Adequate Inadequate
< -- >
0 1 2 3 4 5 6 7 8 9 10

83-_____ c. Display [Students' display areas]

Adequate   Inadequate

< -- >

0 1 2 3 4 5 6 7 8 9 10

Environmental

84-_____- **Acoustics** - Control of internal and external noises levels.

Poor   Excellent

< -- >

0 1 2 3 4 5 6 7 8 9 10

85-_____- **Climate Control** - A system to maintain a comfortable temperature in the classroom learning environment.

Centrally Controlled   Individually Controlled

< -- >

0 1 2 3 4 5 6 7 8 9 10

86-_____- **Roof system** – A leaking roof can disrupt student learning.

Leaky   No Evidence of Leaks

< -- >

0 1 2 3 4 5 6 7 8 9 10

APPENDIX B

Request to Use C. Kenneth Tanner's The School Design Assessment Scale

Mr. Tanner

Hi-

My name is Stephanie Hughes and I am working on my dissertation at Baylor University. My dissertation will look at the differences that exist between school facility design variables and 5th grade reading, math, and science scores on the 2004 Texas Assessment of Knowledge and Skills. As I was reviewing research on this topic I came across C. Kenneth Tanner's The School Design Assessment Scale. I am requesting permission from the School Design and Planning Laboratory to use this assessment scale in the design of my survey on this topic. My dissertation will only be looking at physical features, visual appearance, safety and security, and instructional spaces. I believe this information will be valuable to educators and architects around the state of Texas. Steve Murdock of Texas A & M suggests that Texas school districts will grow by 75,000 students a year over the next several years. As a result, districts will be adding new facilities as well as renovating existing facilities. This dissertation will allow district administrators to make the best decisions possible to provide every student with facilities that help promote academic success. I would greatly appreciate your consideration of this matter.

Thank you-

Stephanie Hughes

Permission to Use C. Kenneth Tanner's The School Design Assessment Scale

YES. I would like to be a member of the committee and help guide you through this so I can learn more - you know you will need at least 2o schools to do any meaningful analysis. 40 is better. I have a version of the scale that has about 86 items - including a multicultural section. Let me know more about you and the committee.

I hope you say "Lick ert" for Likert, when I worked with Dr. Likert, he was sensitive to the pronunciation. It is not Like ert, it is Lick ert - with emphasis on LICK. This is just a cultural point - preciseness.

Thanks!
Ken Tanner

APPENDIX C

Letter to Superintendent for Permission to Use District

October 12, 2004

I am the Assistant Principal at an elementary school in the district and I am also a doctoral student at Baylor University. I have finished all of my course work and am starting to work on my dissertation. My dissertation will look at the relationship between school design variables and student achievement. I will use a design assessment scale to evaluate elementary schools variables and 5^{th} grade TAKS scores for student achievement.
I am requesting your permission to use the elementary schools in this district for my study. Thank you for your consideration of this request.

Stephanie Hughes

Verbal permission was received from a director in elementary leadership on October 26, 2004

APPENDIX D

Raw Data for Evaluator 1

Table D.1

Movement Patterns

Schools	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total Score
A	9	9	8	7	6	6	0	8	8	8	8	7	8	7	8	8	0	115
B	7	8	8	8	9	5	0	9	9	9	8	9	9	6	9	9	0	122
C	8	7	8	8	7	7	0	8	8	9	9	8	9	8	9	8	0	121
D	3	5	8	8	4	6	0	8	8	8	8	7	8	4	8	8	0	101
E	9	8	8	9	8	9	0	8	8	8	8	8	8	5	8	8	0	120
F	5	8	8	6	7	7	0	8	8	8	8	8	6	6	8	8	0	109
G	5	8	8	6	7	7	0	8	8	8	8	8	6	6	8	8	0	109
H	8	7	8	8	7	7	0	8	8	8	8	8	8	7	8	8	0	116
I	8	8	8	8	7	8	0	8	8	8	8	8	8	5	8	8	0	116
J	2	1	8	6	1	5	1	6	6	8	8	6	8	5	8	8	0	87
K	6	8	8	8	7	7	0	8	8	8	8	6	8	6	8	7	0	111
L	6	8	8	8	8	8	1	8	8	8	8	8	8	8	8	8	0	119
M	7	9	8	8	9	8	0	8	8	8	8	8	8	8	8	8	0	121
N	5	8	8	8	8	6	0	8	8	8	8	8	8	8	8	8	0	115
O	8	5	7	5	5	8	0	8	8	8	8	8	8	8	8	8	0	110
P	8	9	8	8	9	5	0	7	9	9	9	9	9	9	9	9	0	126
Q	7	9	9	9	8	4	0	7	9	9	9	9	9	4	9	9	0	120
R	8	4	8	8	6	9	0	9	9	9	9	9	9	9	5	9	0	120
S	7	7	8	7	5	6	0	8	8	8	8	6	8	8	8	6	0	108
T	7	5	6	6	4	8	0	8	8	8	8	6	8	8	8	8	0	106
U	8	7	8	8	6	7	0	9	8	9	7	7	9	7	9	9	0	118

Table D.2

Raw Data for Large Group Meeting Places

Schools	18	19	20	21	22	23	24	25	Total Score
A	7	0	8	0	8	0	0	9	32
B	6	0	9	0	6	0	0	9	30
C	8	0	8	0	8	0	0	8	32
D	5	0	7	0	5	0	0	7	24
E	8	0	9	8	9	0	0	8	42
F	6	0	8	0	7	0	1	6	28
G	6	0	8	0	7	0	1	6	28
H	7	0	8	0	8	0	0	8	31
I	6	0	7	0	8	0	0	7	28
J	13	0	8	0	8	0	0	8	37
K	9	0	6	0	9	0	0	7	31
L	7	0	6	0	7	0	0	6	26
M	8	0	6	0	8	0	0	8	30
N	0	0	8	0	7	0	0	8	23
O	6	0	8	0	10	0	2	8	34
P	8	0	9	0	10	0	0	9	36
Q	6	0	7	0	8	0	0	9	30
R	10	0	8	0	9	0	0	9	36
S	6	0	7	0	9	0	0	7	29
T	7	0	6	0	7	0	0	7	27
U	6	0	8	0	8	0	0	8	30

Table D.3

Raw Data for Architectural Design

Schools	26	27	28	29	30	31	32	33	34	Total Score
A	9	8	8	7	9	8	6	9	7	71
B	8	9	8	7	7	9	5	4	2	59
C	6	8	8	9	6	7	4	5	4	57
D	3	7	3	3	5	8	3	8	6	46
E	6	8	9	8	4	9	5	8	3	60
F	7	8	7	7	9	9	7	2	8	64
G	9	8	7	10	9	9	7	2	8	69
H	6	8	8	5	6	8	7	8	6	62
I	7	8	7	6	0	8	8	6	0	50
J	7	8	8	2	9	8	7	8	9	66
K	4	8	8	6	8	8	7	8	8	65
L	8	8	8	8	6	8	8	8	5	67
M	7	9	8	6	6	5	6	9	6	62
N	9	9	8	7	2	8	8	5	1	57
O	8	8	7	7	4	8	3	4	3	52
P	8	9	8	8	2	8	8	9	0	60
Q	5	9	2	7	2	8	2	7	2	44
R	7	10	10	9	3	8	3	8	3	61
S	7	7	5	6	4	8	9	4	4	54
T	7	8	8	5	7	8	8	8	4	63
U	9	8	10	8	8	6	4	9	7	69

Table D.4

Raw Data for Daylighting and Views

Schools	35	36	37	38	39	Total Score
A	6	7	6	5	6	30
B	6	8	8	7	8	37
C	3	6	5	4	7	25
D	5	8	8	6	7	34
E	7	8	7	8	6	36
F	5	5	5	5	5	25
G	5	5	5	5	5	25
H	2	2	6	3	5	18
I	7	8	7	7	6	35
J	6	5	5	4	5	25
K	7	7	7	7	5	33
L	6	4	5	5	6	26
M	5	6	7	6	6	30
N	1	1	3	2	3	10
O	4	6	5	4	3	22
P	5	8	7	7	9	36
Q	9	9	8	7	8	41
R	2	2	4	3	2	13
S	3	3	5	5	6	22
T	3	6	4	4	5	22
U	5	5	5	5	5	25

Table D.5

Raw Data for Psychological Impact of Color Scheme

Schools	40	41	42	43	44	45	Total Score
A	5	5	5	3	4	4	26
B	5	8	8	3	5	8	37
C	8	7	5	3	7	8	38
D	5	5	5	3	5	5	28
E	5	5	7	5	5	5	32
F	5	5	5	5	5	5	30
G	5	5	5	5	8	8	36
H	5	5	5	3	3	3	24
I	5	5	5	3	8	8	34
J	3	5	5	3	6	6	28
K	5	5	5	5	6	6	32
L	5	5	5	3	6	6	30
M	5	5	5	2	6	6	29
N	5	4	5	4	6	6	30
O	5	5	9	3	5	5	32
P	5	5	5	3	6	6	30
Q	5	5	6	3	5	5	29
R	5	5	5	0	4	3	22
S	5	5	5	3	5	5	28
T	5	4	5	5	5	5	29
U	5	5	5	1	7	5	28

Table D.6

Raw Data for Building on a Student's Scale

Schools	46	47	48	49	50	51	52	Total Score
A	4	6	8	8	6	8	8	48
B	3	8	8	5	4	9	8	45
C	4	8	8	6	5	6	7	44
D	3	3	8	8	3	7	5	37
E	3	5	8	8	3	8	9	44
F	3	5	8	8	6	5	8	43
G	3	5	8	8	6	5	8	43
H	3	4	8	8	7	3	10	43
I	4	6	9	9	4	8	7	9
J	3	4	8	8	5	5	8	41
K	4	4	8	8	4	7	8	43
L	3	8	8	8	8	6	8	49
M	3	4	8	3	8	2	7	35
N	3	5	8	8	8	3	8	43
O	2	5	8	5	8	6	8	42
P	2	8	7	8	8	8	7	48
Q	4	8	8	7	2	7	6	42
R	5	8	8	7	8	1	9	46
S	3	4	8	7	5	7	8	42
T	3	4	8	8	8	8	8	47
U	2	4	8	8	6	5	4	37

Table D.7

Raw Data for Location of the School

Schools	53	54	55	Total Score
A	7	8	8	23
B	9	8	7	24
C	4	5	4	13
D	7	6	3	16
E	9	9	8	26
F	7	6	6	19
G	7	6	6	19
H	5	6	6	17
I	9	8	8	25
J	8	9	8	25
K	4	8	8	20
L	8	8	8	24
M	5	8	6	19
N	8	4	4	16
O	7	7	6	20
P	8	6	3	17
Q	8	9	5	22
R	2	6	5	13
S	5	6	5	16
T	8	6	6	20
U	8	8	8	24

Table D.8

Raw Data for Instructional Neighborhoods

Schools	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	Total Score
A	8	4	4	5	10	10	3	3	3	8	8	5	5	8	8	8	100
B	5	3	4	5	9	9	1	2	5	8	8	3	2	8	7	4	83
C	3	10	7	10	10	9	2	7	5	7	8	4	5	9	7	7	110
D	3	5	5	1	2	2	3	5	0	8	8	2	2	6	8	8	68
E	8	5	5	4	2	2	4	4	0	7	8	4	4	9	9	9	84
F	7	2	2	2	8	8	2	2	3	8	8	2	2	5	7	2	70
G	7	2	2	2	8	8	2	2	3	8	8	2	2	9	8	2	75
H	9	7	7	6	6	6	2	3	0	8	8	4	4	5	8	8	91
I	9	4	4	4	10	10	3	4	2	8	8	3	3	7	8	6	93
J	8	5	5	3	5	5	2	5	0	4	8	3	3	5	5	5	71
K	3	5	5	5	2	2	3	5	0	8	8	3	3	7	8	8	75
L	8	4	4	4	4	4	2	2	4	7	8	3	3	8	7	8	80
M	8	4	4	5	1	1	2	2	0	4	8	3	3	8	6	9	68
N	8	2	2	4	5	5	2	1	3	8	8	2	2	9	8	5	74
O	6	1	1	1	3	3	1	1	4	6	8	1	1	7	8	5	57
P	8	1	2	1	1	8	4	3	4	7	8	3	3	8	6	8	75
Q	8	8	4	8	10	10	3	7	4	3	8	5	4	5	8	9	104
R	5	8	7	9	5	5	3	4	7	3	6	2	3	8	4	2	81
S	9	4	4	2	2	2	2	4	3	8	8	2	2	7	7	5	71
T	9	7	7	7	3	3	2	7	3	8	8	3	3	7	6	7	90
U	7	8	8	7	9	0	5	8	4	0	8	4	4	8	5	8	93

Table D.9

Raw Data for Outside Learning Areas

Schools	72	73	74	75	76	77	Total Score
A	8	8	4	6	8	6	40
B	5	3	0	4	5	3	20
C	5	4	1	4	4	3	21
D	6	6	2	8	6	5	33
E	9	9	6	9	9	9	51
F	6	6	3	8	4	7	34
G	5	5	3	8	4	7	32
H	7	8	2	2	7	3	29
I	8	8	4	9	5	7	41
J	8	8	2	5	5	4	32
K	8	8	4	8	8	8	44
L	7	8	3	8	8	2	36
M	7	7	4	5	3	3	29
N	8	8	2	8	7	4	37
O	7	7	1	4	3	1	23
P	9	8	1	2	3	2	25
Q	5	8	0	8	9	5	35
R	4	2	0	5	2	1	14
S	3	8	3	4	4	5	27
T	4	4	4	6	4	4	26
U	7	8	9	9	8	7	48

Table D.10

Raw Data for Instructional Laboratories

Schools	78	79	80	81	82	83	Total Score
A	7	9	2	9	10	1	38
B	5	5	3	9	10	1	33
C	8	7	8	6	10	1	40
D	2	5	2	5	10	1	25
E	1	5	2	8	10	1	27
F	3	5	2	2	9	1	22
G	3	5	2	2	9	1	22
H	4	5	2	5	10	1	27
I	5	5	2	5	10	1	28
J	5	5	1	5	10	2	28
K	4	5	1	5	10	2	27
L	5	5	1	5	10	1	27
M	8	5	2	5	10	5	35
N	5	5	1	5	10	1	27
O	8	5	4	6	10	1	34
P	5	8	2	9	10	2	36
Q	9	5	9	9	0	8	40
R	0	7	8	5	0	8	28
S	6	5	2	5	10	2	30
T	5	5	1	5	10	1	27
U	0	5	4	7	2	2	20

Table D.11

Raw Data for Environmental

Schools	84	85	86	Total Score
A	5	8	9	22
B	5	8	9	22
C	5	7	9	21
D	3	8	8	19
E	9	8	9	26
F	7	9	9	25
G	7	9	9	25
H	8	8	9	25
I	8	8	7	23
J	8	8	7	23
K	8	8	7	23
L	8	8	8	24
M	8	8	8	24
N	6	8	8	22
O	2	8	9	19
P	8	7	9	24
Q	9	9	8	26
R	7	5	8	20
S	5	8	8	21
T	8	6	8	22
U	3	8	8	19

Table D.12

Raw Data Movement Patterns

Schools	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total Score
A	9	9	7	8	6	6	0	8	8	9	9	8	9	9	9	8	0	122
B	6	6	7	8	8	7	0	9	9	9	8	9	9	7	8	9	0	119
C	8	7	8	9	8	8	0	9	8	9	9	8	9	7	9	8	0	124
D	4	3	8	7	4	6	0	8	8	8	8	8	8	4	8	8	0	119
E	9	7	8	9	9	8	0	8	8	8	8	8	8	5	8	8	0	119
F	6	7	7	4	6	7	0	8	8	8	8	8	6	7	8	8	0	106
G	6	7	7	4	6	7	0	8	8	8	8	8	6	7	8	8	0	106
H	8	7	7	8	6	7	0	8	8	8	8	8	8	8	8	8	0	115
I	8	7	8	7	7	9	0	9	9	9	8	9	9	4	9	7	0	119
J	3	1	6	5	2	5	1	6	6	8	8	6	8	5	8	8	0	86
K	6	8	8	8	8	8	0	8	8	9	9	8	8	5	8	7	0	116
L	6	8	6	8	6	8	1	9	9	9	8	9	9	6	8	9	0	119
M	6	8	8	9	8	7	0	8	8	8	8	8	8	8	8	8	0	118
N	6	8	8	8	9	5	0	8	8	8	8	8	8	7	8	8	0	115
O	7	5	6	4	6	9	0	9	9	8	9	9	9	8	9	9	0	116
P	8	7	8	8	7	6	0	7	9	9	9	9	9	8	9	9	0	122
Q	7	9	9	9	8	6	0	7	9	9	8	9	10	3	9	9	0	121
R	8	6	8	8	6	8	0	9	10	9	8	10	9	8	6	9	0	122
S	8	6	7	8	7	7	0	8	8	8	8	8	8	8	8	7	0	114
T	7	8	4	5	3	9	0	8	8	8	8	8	8	7	8	8	0	107
U	9	7	8	9	6	8	0	9	9	9	8	8	8	7	8	8	0	121

Table D.13

Raw Data for Large Group Meeting Places

Schools	18	19	20	21	22	23	24	25	Total Score
A	8	0	9	0	7	0	0	9	33
B	6	0	8	0	6	0	0	8	28
C	9	0	9	0	8	0	0	9	35
D	4	0	6	0	5	0	0	7	22
E	9	0	9	8	9	0	0	9	44
F	5	0	7	0	6	0	1	4	23
G	6	0	7	0	6	0	1	4	24
H	7	0	8	0	7	0	0	9	31
I	5	0	7	0	7	0	0	6	25
J	10	0	8	0	7	0	0	8	33
K	9	0	7	0	8	0	0	8	32
L	8	0	7	0	7	0	0	8	30
M	9	0	4	0	9	0	0	6	28
N	0	0	8	0	6	0	0	9	23
O	6	0	7	0	9	0	1	7	30
P	7	0	9	0	8	0	0	8	32
Q	5	0	6	0	8	0	0	9	28
R	9	0	6	0	7	0	0	7	29
S	5	0	5	0	9	0	0	6	25
T	4	0	8	0	7	0	0	6	25
U	4	0	8	0	6	0	0	8	26

Table D.14

Raw Data for Architectural Design

Schools	26	27	28	29	30	31	32	33	34	Total Score
A	9	9	8	8	8	9	5	8	7	71
B	8	9	10	8	7	10	3	9	3	67
C	4	10	6	9	4	9	2	5	4	53
D	2	8	2	3	5	7	2	7	8	44
E	5	9	8	9	3	8	5	8	2	57
F	6	9	7	4	8	8	5	2	5	54
G	8	9	8	9	8	8	5	2	5	62
H	6	8	8	4	7	8	7	8	5	61
I	7	9	9	7	1	8	7	6	1	55
J	7	8	8	2	8	8	7	7	8	63
K	4	7	7	5	8	8	5	6	7	57
L	8	8	9	9	7	9	7	7	4	68
M	4	8	7	4	7	4	4	9	6	53
N	6	9	9	7	3	9	7	4	1	55
O	8	9	6	8	3	8	2	3	3	50
P	7	9	7	8	2	8	7	9	1	58
Q	3	8	2	6	2	8	2	8	4	43
R	7	8	10	9	4	9	2	X	3	52
S	5	8	7	5	2	8	9	6	2	52
T	6	8	8	6	5	9	5	4	2	53
U	8	9	10	5	7	4	2	8	5	58

Table D.15

Raw Data for Daylighting and Views

Schools	35	36	37	38	39	Total Score
A	8	8	6	7	6	35
B	6	8	9	6	6	35
C	2	5	7	2	5	21
D	4	7	8	6	6	31
E	8	8	8	9	7	40
F	5	6	6	7	7	31
G	2	5	5	4	5	21
H	4	4	7	2	5	22
I	8	8	7	8	8	39
J	5	4	6	5	5	25
K	6	7	7	5	7	32
L	7	2	7	6	7	29
M	5	4	6	6	6	27
N	1	1	3	1	3	9
O	3	5	6	3	4	21
P	4	6	7	6	7	30
Q	9	8	8	8	6	39
R	4	5	5	5	3	22
S	2	5	6	2	6	21
T	2	5	6	2	6	21
U	5	5	5	6	4	25

Table D.16

Raw Data for Psychological Impact

Schools	40	41	42	43	44	45	Total Score
A	6	5	5	3	5	5	29
B	6	7	6	1	5	6	31
C	8	8	5	1	5	7	34
D	5	5	5	2	5	5	27
E	5	5	8	7	5	5	35
F	5	5	5	7	5	5	32
G	5	5	6	6	7	7	36
H	5	5	5	2	5	5	27
I	5	5	5	2	8	8	33
J	3	5	5	3	6	5	27
K	5	5	5	5	8	8	36
L	5	5	5	3	6	7	31
M	5	5	6	3	6	8	33
N	5	4	5	5	6	6	31
O	5	5	8	1	5	5	29
P	5	5	5	1	5	6	27
Q	5	5	6	3	5	5	29
R	5	5	5	0	X	5	20
S	5	5	6	3	5	5	29
T	3	4	6	7	5	5	30
U	5	5	5	1	7	5	28

Table D.17

Raw Data for Building on a Student's Scale

Schools	46	47	48	49	50	51	52	Total Score
A	3	8	8	9	7	8	9	52
B	3	8	9	5	4	9	8	46
C	6	9	9	6	4	8	8	50
D	3	5	9	9	3	8	6	43
E	3	7	8	8	3	8	10	47
F	3	8	8	8	4	8	8	47
G	3	8	8	8	4	8	8	47
H	3	3	9	8	6	2	1	32
I	3	5	9	9	3	9	10	48
J	3	3	9	8	3	6	9	41
K	3	3	9	9	3	8	9	44
L	3	8	8	8	5	8	9	49
M	3	4	3	2	8	2	7	29
N	3	5	8	8	8	1	9	42
O	2	3	10	5	8	7	8	43
P	3	8	8	9	9	9	7	53
Q	3	7	8	6	2	7	8	41
R	4	9	9	8	9	3	9	51
S	3	5	8	9	5	8	7	45
T	3	3	8	8	9	9	8	48
U	2	4	8	8	4	6	5	37

Table D.18

Raw Data for Location of the School

Schools	53	54	55	Total Score
A	9	8	8	25
B	7	7	7	21
C	3	7	3	13
D	7	7	5	19
E	9	9	8	26
F	6	5	5	16
G	5	4	4	13
H	5	6	6	17
I	8	7	7	22
J	9	9	7	25
K	7	7	7	21
L	8	8	8	24
M	6	7	7	20
N	8	5	3	16
O	6	5	6	17
P	8	7	5	20
Q	9	7	4	20
R	4	7	6	17
S	3	5	5	13
T	7	6	6	19
U	9	8	8	25

Table D.19

Raw Data for Instructional Neighborhoods

Schools	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	Total Score
A	8	5	5	6	10	10	2	5	2	9	9	6	6	9	9	7	108
B	3	5	4	6	8	8	0	4	5	6	8	1	1	6	5	4	74
C	1	9	9	9	8	9	1	8	5	6	9	2	3	9	8	5	101
D	3	6	6	3	2	2	2	6	0	7	8	2	2	4	7	7	67
E	7	4	4	3	2	2	5	2	0	5	8	5	5	9	8	7	76
F	3	1	1	1	8	6	1	1	3	8	8	2	2	6	7	4	62
G	3	1	1	1	8	6	1	1	3	8	8	2	2	7	7	4	63
H	7	6	6	6	7	7	1	6	0	7	8	2	2	7	8	7	87
I	8	4	4	1	9	9	2	3	2	7	9	3	3	7	7	7	85
J	8	6	8	4	5	6	1	7	0	3	8	1	1	6	6	4	74
K	2	6	7	6	1	1	1	6	0	8	9	2	2	7	7	6	71
L	8	5	6	6	5	5	1	4	3	8	9	3	3	7	7	7	87
M	8	5	5	5	1	1	1	1	0	5	8	2	2	7	6	8	65
N	8	2	2	4	5	5	1	1	3	8	9	2	2	7	8	6	73
O	7	1	1	1	3	3	1	1	4	7	9	1	1	8	8	4	60
P	7	2	2	3	3	8	2	2	3	5	8	2	2	5	5	8	67
Q	7	9	5	8	10	10	2	6	3	3	6	4	4	5	7	8	97
R	3	7	7	8	5	5	2	2	5	5	8	2	2	8	3	X	72
S	8	4	4	1	2	2	1	3	1	7	9	2	2	7	7	5	65
T	6	7	7	6	2	2	1	6	3	7	9	3	3	8	7	4	81
U	6	6	10	6	9	1	3	9	4	2	8	3	3	6	3	7	86

Table D.20

Raw Data for Outside Learning Areas

Schools	72	73	74	75	76	77	Total Score
A	9	8	8	8	9	8	50
B	7	5	0	7	3	1	23
C	7	8	0	6	3	1	25
D	5	4	1	8	4	3	25
E	10	9	5	9	8	8	49
F	7	8	1	7	7	2	32
G	6	7	1	6	4	1	25
H	5	7	0	3	5	2	22
I	9	8	1	9	6	4	37
J	7	7	1	6	4	2	27
K	7	7	2	8	8	6	38
L	8	8	1	7	7	7	38
M	7	7	3	6	4	2	29
N	8	8	1	8	6	1	32
O	8	6	0	6	3	1	24
P	9	8	0	8	1	1	27
Q	6	9	0	9	9	6	39
R	5	4	0	7	4	1	21
S	3	7	3	6	4	2	25
T	6	6	1	7	2	1	23
U	8	8	7	9	6	6	44

Table D.21

Raw Data for Instructional Laboratories

Schools	78	79	80	81	82	83	Total Score
A	9	9	1	9	10	1	39
B	5	5	4	7	10	3	34
C	7	8	6	8	10	1	40
D	1	4	4	6	0	2	17
E	2	5	2	8	10	1	28
F	5	5	8	5	10	2	35
G	3	3	2	4	10	2	24
H	4	5	2	5	10	2	28
I	5	5	2	5	10	1	28
J	5	5	1	5	10	1	27
K	4	5	2	5	10	2	28
L	8	8	1	5	10	2	34
M	9	5	2	5	10	4	35
N	5	5	3	5	10	1	29
O	8	4	5	6	10	3	36
P	5	8	3	8	10	3	37
Q	8	6	7	9	0	8	38
R	0	7	8	5	0	8	28
S	6	5	2	5	10	2	30
T	5	5	2	5	10	1	28
U	0	4	4	6	2	2	18

Table D.22

Raw Data for Environmental

Schools	84	85	86	Total Score
A	7	8	9	24
B	7	8	7	22
C	1	9	8	18
D	3	8	8	19
E	7	7	8	22
F	6	8	8	22
G	6	8	8	22
H	7	8	8	23
I	7	8	6	21
J	7	8	6	21
K	8	8	5	21
L	8	8	8	24
M	8	8	8	24
N	4	8	8	20
O	1	8	9	18
P	7	8	6	21
Q	9	8	7	24
R	5	4	8	17
S	5	8	7	20
T	7	5	8	20
U	5	8	9	22

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