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An analysis of the effect of a 21st-century-designed middle school on student achievement

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AN ANALYSIS OF THE EFFECT OF A 21ST-CENTURY-DESIGNED

MIDDLE SCHOOL ON STUDENT ACHIEVEMENT

An Abstract of a Dissertation

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

Approved:

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ABSTRACT

Considering the billions of dollars invested in school buildings and the accountability for improving student achievement, there has been the lingering question about how the physical learning environment impacts student achievement. This study explored the impact of a new 21st-century-designed middle school facility on student academic achievement in mathematics and science.

This case study used a mixed methods approach to examine the student achievement of 158 middle school students and the perceptions from 13 teachers and two administrators about the impact of the new facility on teaching and student learning. The purpose of this study was to analyze the effect on middle school student achievement in mathematics and science when students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility.

Proficiency on the Iowa Assessments in mathematics and science were the two continuous dependent variables for student achievement, and the discrete independent variable was the change in the physical learning environment from the old building to the new building. Two cohort groups of students were identified that attended school at both facilities for grades 6-8. Only the standardized test data for students who attended school at both facilities was used to conduct the matched cohort data analysis. Through the Statistical Package for Social Science (SPSS) software for quantitative analysis, paired-samples *t*-test was used to compare the difference between means of test scores of the two cohort groups.

Qualitative research was used to gain insight about the complex relationship between the school building and its occupants. A focus group interview was conducted with teachers and administrators who experienced the transition from the old facility to the new 21st-century-designed school facility. The objective of the focus group interview was to gain high-quality data in a social context where respondents could consider their own views in the context of the views of others.

The results of this study will provide insight for school leaders, planners, and architects about the effects of a new school building on student achievement.

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DEDICATION

This dissertation is dedicated to my family for the love, support, and understanding over the past four years. My wife provided continuous support and encouragement to help me complete this great journey. I will always be grateful for the numerous sacrifices that my wife made that enabled me to pursue this dream.

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INTRODUCTION

The perception of many people is that educational facilities are just buildings or big boxes that provide spaces for teachers to teach children in which learning occurs. Education has primarily consisted of people – teachers and students – whereas school buildings were considered incidental to the learning process. Students spend a large share of time in a number of environments in the school setting. Tanner (2008) stated that unfortunately, many educational decision-makers, teachers, school board members, parents, and architects feel that the design of school buildings has little to add to the process of learning.

A growing body of research in recent years has indicated that there is a relationship between the conditions of school buildings and student achievement (Hunter, 2006). Higher standards and accountability of the 2001 No Child Left Behind (NCLB) legislation and the requirement of Adequate Yearly Progress (AYP) have caused school systems along with architects, planners, and facility professionals to explore ways to improve student achievement. Earthman (2002) noted that correlation studies have shown a strong relationship between building conditions and student achievement showing a difference of 5-7% between achievement of students in poor buildings and students in standard buildings when the socioeconomic status of students was controlled. Fritz (2007) explored the effect of new school buildings on student achievement and discovered a significant increase in the proficiency subtests of reading and science but not a significant increase in writing, citizenship, and mathematics. Vandiver (2011) conducted a study to determine the difference in student performance before and after a new facility and discovered that the largest increase in student performance was in mathematics. Vandiver (2011) also stated that student performance results were higher after being in the new facility in all four subjects of English language arts, mathematics, science, and social studies when combining the results of all tests.

The Iowa Association of School Boards (IASB, 2012) noted that a school building is an important tool to support learning and school facilities should be designed to provide the best possible education for all students. The architectural history of the American schoolhouse was influenced by the evolution of educational philosophy and goals, curricular objectives, instructional methods, and cultural background and value systems of the schools’ governing boards. Architecture of educational facilities has evolved through the colonial period, Industrial Revolution, and the information age in response to societal and political influences (Tanner & Lackney, 2006). Buildings reflect the education program by accommodating how educators deliver instruction for improving student learning.

Earthman (2002) revealed in his studies that many old school buildings simply do not have the features, such as control of the thermal environment, adequate lighting, good roofs, and adequate space that are necessary for a good learning environment. Many older school facilities do not comply with the Americans with Disabilities Act accessibility requirements without extensive and often expensive renovation. The inflexible design of older school buildings has not been conducive for interactive group learning experiences, which have overshadowed the decades-old lecture/listen style of learning (Lyons, 2001).

Educational facilities must meet the 21st-century learning needs of students entering the technologically driven working environment. “And the difference to a child between receiving an education in a really well-designed, modern new school and a typical 42-year-old school can be compared to the difference between writing in the sand and surfing the Internet” (Lyons, 2001, p. 1).

School Facilities in Iowa

Millions of dollars are used to renovate existing school buildings and construct new school facilities each year. To provide a better understanding about school facilities in Iowa, school facilities funding information from the Iowa Department of Education (n.d.c.) was reviewed. The Iowa Department of Education has reported that there are over 3,600 school buildings valued over $13.9 billion. Information from 21st Century School Fund (2011) and Building Educational Success Together (BEST) reported that school districts nationwide spent $58.5 billion for capital outlay on construction, land, and building acquisition for elementary and secondary public school facilities. It was also reported that taxpayers throughout the nation in 2008 were responsible for paying $369.4 billion of long-term capital debt. Considering the value of school buildings and the amount of funding used to maintain, renovate, and construct new educational facilities, there has been exploratory research about how the physical learning environment of school buildings influences student achievement.

Iowa school districts have access to millions of dollars of funding from federal, state, and local sources for renovating existing school facilities and constructing new buildings. Federal programs that benefited Iowa schools are the Iowa Demonstration

Construction Grant Program (IDCGP), Qualified School Construction Bonds (QSCB), and Qualified Zone Academy Bonds (QZAB). The IDCGP was originally proposed by Senator Tom Harkin of Iowa in 1998 and has generated $132,590,845 in grant funds to help school districts correct fire safety citations and leverage local resources to construct new schools or modernize existing buildings (Iowa Department of Education, n.d.c.). To stimulate the economy, the Iowa Department of Education (n.d.c.) distributed $130,674,000 in QSCB authority through the American Recovery and Reinvestment Act (ARRA) of 2009 that provided a tax credit program with no-interest financing to renovate and construct new school buildings. QZABs are low- or no-interest bonds that are subsidized by the federal government in the form of tax credits to the bondholder that can be used to renovate school buildings. During the past five years, QZABs had the potential to generate $35,395,000 in loans to eligible school districts for improving existing facilities.

From the state and local perspective, Iowa school districts can use school bond elections and the sales tax for school infrastructure to generate funding for school facilities. These two forms of funding are the most common for funding new construction of school buildings in Iowa. Until the penny sales tax for school infrastructure became statewide in 2008, a school bond issue was the primary funding to build schools in Iowa. From 2007 through 2011, Iowa school districts had successful bond elections that generated $481,705,000 in loans through general obligation bonds for new construction, building additions, and renovation of existing school buildings (Iowa Department of Education, n.d.c.). General obligation bonds are paid with local property tax but can also be paid through the statewide sales tax funds for school infrastructure to provide property tax relief. The statewide sales tax for school infrastructure is known as Secure an Advanced Vision for Education (SAVE). SAVE is used solely for school infrastructure purposes or school district property tax relief and will expire in 2029. The Iowa Department of Revenue (n.d.) reported that the SAVE fund had approximately $379,500,000 for school infrastructure and property tax relief during the 2011-2012 school year. School districts can bond against SAVE through revenue bonds without an election for new school construction.

Conceptual Framework

Duke, Griesdorn, Gillespie, and Tuttle (1998) stated that when investigating physical learning environments, student outcomes must be the central concern. When relating student outcomes to the physical learning environment, there are complexities of what constitutes a student outcome. There are a variety of possible outcomes. Desired learning outcomes are high scores on standardized achievement tests, good grades, graduation rates, college admissions, and employment after high school (Duke et al., 1998). Indirect outcomes associated with student learning include student attendance, student behavior, feelings about school, teacher-student relationships, and levels of parent involvement. For the purpose of this study, student outcomes are synonymous with student achievement. Student achievement in this study is the percentage of students proficient in mathematics and science on the Iowa Test of Basic Skills that is administered annually through the Iowa Testing Programs.

Hunter (2006) and Schneider (2002) stated that a growing body of recent research has tested the widely held belief that there is a relationship between the conditions of school buildings and student achievement. Through researchers like Earthman (2002), Lyons (2001), Schneider (2002), and Tanner (2009), their studies have substantiated that student outcomes are affected by the physical learning environment of the facility. Akinsanmi (2008) explained that the physical learning environments were designed to support particular learning theories. Educational researchers often based theories on physiological, psychological, and sociological changes in learning and often excluded the physical conditions impacting the learning process. Akinsanmi (2008) described three historical perspectives of learning theories as behaviorism, cognitivism, and constructivism that affect the physical learning environment.

Akinsanmi (2008) noted that late 19th and early 20th century behaviorist psychologists believed "…that learning is evidenced by a change in actions through an explorative process that exposes individuals to external stimuli until a desired response occurs" (Behaviorism section, para. 1). Behaviorism theory put the responsibility of knowledge transfer on the teacher, while the learner is a passive participant. Learning environments were lecture-based, teacher-focused, structured, and used a reward and punishment system to promote learning. Akinsanmi (2008) stated that the school buildings designed to support this learning theory were typically fenced-in single buildings with several stories that had classroom wings where new learners were located at one end and moved through their classes similar to an assembly line until they graduated. The classrooms were laid out in rows and columns that provided minimal flexibility, and the teacher's desk was the main point of focus.

The second learning theory of cognitivism came in the second half of the 20th century and focused on the study of mental processes used to explain learning (Akinsanmi, 2008). The learner became the active participant in the learning process and the learner's actions were a result of thought. Unlike schools built to support the behaviorism theory, schools built on the philosophy of cognitivism were typically laid out like campuses without being fenced in. School buildings were usually single- or two-story buildings connected by walkways. Classroom buildings were sequentially arranged to house students according to their grades and consisted of long corridors with classrooms on both sides of the corridor. The internal layout of the classroom did not change from the classroom layout in the behaviorism learning environment.

The third learning theory of constructivism was explained as a process of constructing knowledge through experiences at the learner's level of cognitive development rather than acquiring it (Akinsanmi, 2008). Another explanation of constructivism theory is the learner interprets new information through contextual experiences and builds on existing knowledge through assimilation and reflection on new knowledge. Akinsanmi (2008) stated that this theory puts the responsibility of learning with the learner and emphasizes the role of social interaction and reflection in the learning process. Learning environments are student-centered, collaborative, cooperative, and experiential with teachers serving as facilitators rather than instructors.

Researchers in other states have established that there is a relationship between the physical learning environment and student outcomes through the use of hard data and quantitative methods. Cheng, English, and Filardo (2011) had analyzed 20 research studies involving school facilities and student achievement where all but one study showed a positive correlation between the achievement of students and the condition of the school facility once student demographic factors were controlled. To broaden the database of studying the relationship between the physical learning environment and student academic achievement, it is necessary to conduct additional research in different school settings across the United States.

Statement of the Problem

Considering the billions of dollars invested in school buildings and the accountability for improving student achievement, there has been the lingering question about how the physical learning environment impacts student achievement. This study explored the impact of a new 21st-century-designed middle school facility on student academic achievement in mathematics and science.

Purpose of Study

The purpose of this study has been to analyze the effect on middle school student achievement in mathematics and science when students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. Academic achievement was limited to measures of grades 6 through 8 mathematics and science scores on the Iowa Assessments for students who attended the old school then transferred to the new 21st-century-designed STEM-focused middle school. Research studies have provided evidence that the physical learning environment has an influential role in determining educational outcomes. Research has indicated that good facilities appear to be important to student learning, provided that other conditions are present that support a strong academic program in the school (IASB, 2012).

The following studies are examples of research that examined the relationship between the physical learning environment and student achievement. A research study by Cash (1993) examined the relationship between building condition and student achievement in small, rural Virginia high schools. Student scores on achievement tests, adjusted for socioeconomic status, were found to be as much as 5% lower in buildings with lower quality ratings. Edwards (1991) completed a study of the District of Columbia school system where after controlling for socioeconomic status, students in school buildings in poor condition had achievement 6% below schools in fair condition and 11% below schools in excellent condition. A research study by Fritz (2007) examined sixth-grade proficiency test results for students prior to moving into a new building and after moving into the new building. The conclusion of the Fritz study indicated that there was a significant increase in student achievement in reading and science but not a significant increase in writing, citizenship, and math.

What makes a 21st-century-designed school different from the traditional box-based classroom design where the teacher stands in front of a class of students sitting in rows, listening, taking notes, and doing worksheets? During the first decade of the 21st century, the United States had pockets of innovation in schooling where schools had moved away from teacher-directed whole-group instruction to learner-centered workplaces for a collaborative culture of learning (Pearlman, 2010). Defining educational outcomes is the start for designing 21st-century schools with new learning environments. Pearlman (2010) stated that 21st-century-designed schools do not have the typical classrooms but have three distinct learning environments: focused work environments, collaborative work environments, and hands-on project work environments. These new learner work environments are conducive to the learner-centered workplaces for collaborative learning. The United States General Accounting Office (GAO, 1995b) reported that schools are unprepared for the 21st century because most schools do not fully use modern technology, 40% of schools do not meet the functional requirements of laboratory science or large-group instruction, over half the schools reported the lack of flexibility of instructional space, and about two-thirds of schools reported that they cannot meet the functional requirements of before- or after-school care or day care.

The disciplines of Science, Technology, Engineering, and Mathematics (STEM) are considered vital for thriving in the 21st century for managing decisions of daily life or pursuing STEM careers (Iowa Mathematics and Science Education Partnership, 2012). In 2011, the governor of Iowa signed Executive Order 74 that created the Governor's STEM Advisory Council to assist with improving STEM education, STEM innovation, and STEM careers in the public and private sectors (Iowa Governor's STEM Advisory Council, 2012). Through the co-chair leadership of the lieutenant governor and the president of the University of Northern Iowa, the council has been convening to bolster STEM education to improve the economy and better position young people for the future.

Research Questions

1. To what extent, if any, does student proficiency on the Iowa Assessments in mathematics and science improve after moving into the 21st-century-designed STEM middle school?
2. How have teaching strategies changed from the old facility to the new 21st-century-designed STEM middle school?
3. How has student achievement been impacted because teaching has changed in the new 21st-century-designed STEM middle school?

Assumptions

The following assumptions were made for the purposes of this study:

1. The researcher will be impartial in collecting and analyzing the data gathered.
2. The Iowa Assessments data is a valid means of measuring student achievement.
3. Teacher homogeneity is the same across the population.
4. Teachers and administrators responding to interview questions will be considered accurate.

Limitations

The following limitations are noted for this study:

1. Only administrators and teachers during the 2012-2013 school year at the new 21st-century-designed school facility will be involved in the study.
2. Interview questions will be limited to teachers and administrators who worked in both the antiquated and new school designed for 21st-century learning.

3. This study is a non-random/purposeful sampling, so generalizations to the broader universe of school facilities must be made cautiously.

Significance of the Study

Today, education is delivered in an entirely new manner with new tools, techniques, and teaching methods that do not fit the school designs of 42-year-old buildings (O'Sullivan, 2006). Twenty-first century education reforms have required schools to accommodate new teaching and learning styles, which included laboratory classrooms; flexible instruction areas that can facilitate small-group, large-group, and multiage instruction; and multimedia centers that offer a variety of technological resources (Dewees, 1999). With federal, state, and local pressure for increased student achievement, adequate school facilities are an essential part of providing an appropriate atmosphere to maximize learning (Fritz, 2007). Duke (1998) stated that there is a need to increase our awareness of the interactions between physical conditions and the characteristics of different learners, while, at the same time, addressing the learning needs of groups. Numerous studies have shown a relationship between the condition of the school facility and student achievement.

There is limited research literature for reviewing student achievement when students move from an old building to a newly constructed 21st -century-designed building. Research studies have shown a positive influence on student achievement by the physical learning environment. Information gathered from this research study will be useful for lawmakers and educators in planning and making decisions about future funding for school facilities. School administrators will be able to utilize the results of this research as a part of the decision-making process for determining the necessity for new school buildings and for pursuing new building projects. This research can also be used to bolster a school district’s developmental plans for funding present and future repair or renovation projects. Research results from this study will provide insight for school leaders, planners, and architects about the effects of a new school building on student achievement.

Definition of Terms

The terms defined in this section are terms related to and used throughout the research study.

- *Adequate Yearly Progress* (AYP) was required by No Child Left Behind (NCLB) legislation, or now the Elementary and Secondary Education Act. All public schools and districts are required to report annually to the Iowa Department of Education the academic progress of all students. AYP determinations are made annually using reading and mathematics achievement and participation data from students in grades 3 through 8 and 11.
- *EdInsight* website is the educational data warehouse through the Iowa Department of Education that provides consistent and accurate longitudinal information on education outcomes and analytical tools needed to improve decision making and student success.
- *Elementary and Secondary Education Act* (ESEA) through the federal government that promotes rigorous accountability in student achievement. ESEA is commonly called No Child Left Behind.

- *Iowa Association of School Boards* (IASB) is an organization that represents K-12 school districts, area education agencies, and community colleges across the state to achieve the goal of excellence and equity in public education.
- *Iowa Test of Basic Skills* (ITBS) standardized testing that is now referred to as the Iowa Assessments.
- *Iowa Testing Programs* (ITP) is a research, development, and outreach unit in the College of Education at the University of Northern Iowa. ITP provides student assessment data to EdInsight.
- *No Child Left Behind Act* (NCLB) requires public school districts to report annually each student's level of proficiency in reading, math, and science to the parent or guardian.
- *National Percentile Rank* (NPR) compares a student's achievement ranking to the ranking of students in the same grade and the same subject area across the nation.
- *Physical Learning Environment* refers to the educational learning areas in a school building or educational facility where students learn and teachers teach.
- *Pods* are spaces within the facility designed to replace teacher-centered, traditional classrooms with learning communities that emphasize student-centered project spaces. Pods are designed to be flexible to accommodate various group sizes. Students can collaborate in a student-centered environment to develop academically, socially, and emotionally. A common area is designed within each learning pod to accommodate co-teaching and student-led projects.

- *Science, Technology, Engineering, and Mathematics* (STEM) is the curricular emphasis at the new school that helps prepare students for college and careers in the 21st century.
- *Student Achievement* includes the analysis of data in mathematics and science on the Iowa Assessments.
- *Student Proficiency* means that a student with a National Percentile Rank (NPR) of 41-99% on the Iowa Assessments is defined as "proficient," and a student with an NPR of 1-40% is defined as "less than proficient."

Organization of the Study

This dissertation consists of five chapters that are organized in the following manner: Chapter 1 includes an introduction to the study, conceptual framework, statement of the problem, purpose of the study, questions guiding the research, assumptions, limitations, significance of the study, and definition of terms. Chapter 2 contains the literature review pertinent to the impact of school facilities on student performance. Chapter 3 describes the procedures, methodology of research, and research design of the study. Chapter 4 presents results and analyzes the data obtained by the study. Chapter 5 includes the summary of the study, research findings, conclusions, implications of the study, and recommendations for further research.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

This study has explored the impact a new 21st-century-designed middle school facility has on student academic achievement in mathematics and science. The new school has been classified as a STEM school where the educational curriculum is focused on science, technology, engineering, and mathematics. This chapter provides insight, as evidenced by a review of pertinent literature, into the effect of school facilities on the educational environment. The review of literature has provided information about the condition of public schools, environmental conditions that affect the learning environment, the difference in a 21st-century-designed school, how STEM education is important in today's education, and the relationship between the physical learning environment and student achievement. Finally, a summary has been provided about the literature analysis.

Condition of Public Schools

During the fall of 2012, approximately 50 million students attended nearly 100,000 public elementary and secondary schools throughout the United States (The Center for Green Schools, 2013). The U.S. General Accounting Office (GAO) reported in 1995a that the nation had invested hundreds of billions of dollars in school infrastructure to create an environment where children can be properly educated and prepared for the future. Yeoman (2012) stated in a recent special report that the problems facing America's school buildings are not always visible – poor ventilation, insufficient lighting, poor acoustics, and hot and cold classrooms are causes for health issues, boosts absenteeism, and undermines teaching. It has been a very expensive and an enormous task for school districts to maintain nearly 100,000 public schools and facilities in good repair to provide a safe, healthy, educationally appropriate, and environmentally sustainable learning environment. The American Society of Civil Engineers (ASCE) reported in 2013 that school facility experts have estimated the investment needed to modernize and maintain our nation's school facilities is at least $270 billion or more. Fielding (2012) expressed the concern about how school districts are facing the dilemma of whether to invest millions of dollars to maintain outdated, educationally ineffective buildings or invest in new construction to meet the evolving needs of today's learners. Understanding the enormous expense for maintaining school buildings, the Center for Green Schools (2013) had indicated that public schools must be affordable but should also be a source of civic pride.

When conducting research about the physical condition of America's public schools, the challenge was to find current data and statistics. Kollie (2012) stated that most of the information about the condition of school facilities is not current and is over 10 years old. The 21st Century School Fund (2011) and Building Educational Success Together reported the difficulty in determining the condition of public school facilities is because not all states collect facilities data information and there is no national database of information on public school facilities. The Center for Green Schools (2013) stated that the last comprehensive report about the physical condition of America's schools was conducted by GAO in 1995a with portions updated in 1996. Mead (2005) expressed concern that the issue of school facilities was last addressed nationally during the 2000 election and has since fallen off the political agenda in Washington.

Without a basic inventory of public school facilities, the Center for Green Schools (2013) stated that it is difficult to determine the condition of the nation's public school buildings and grounds. The ASCE (2013) also reported in their *2013 Report Card for America's Infrastructure* that the condition of our nation's schools remains mostly unknown due to the absence of national data on school facilities for more than a decade. It has been 18 years since the GAO issued its 1995a report on the condition of the nation's school facilities. Assessing the conditions of the nation's public school facilities has been a difficult process without a comprehensive, authoritative nationwide data collection (ASCE, 2009). Many research studies have used data from the comprehensive federal reports dating back to 1995 through 2000. To gain an understanding about the condition of school facilities, these earlier comprehensive reports from United States GAO and National Center for Education Statistics (NCES) have been summarized.

The first comprehensive federal assessment about the condition of school facilities since 1965 was the GAO report, *School Facilities: Condition of America's Schools* (1995a). This report began the national conversation about the importance of safe, healthy, and energy-efficient physical learning environments. The U.S. General Accounting Office surveyed a national sample of about 10,000 schools in over 5,000 school districts and augmented the survey with visits to selected school districts. School officials reported that two-thirds of the schools in the study were in adequate or better condition but one-third of the school buildings required extensive repair or replacement.

Most frequently reported building features in need of repairs were heating, ventilation, and air conditioning; plumbing; roofs; exterior walls, finishes, windows, and doors; electrical power; electrical lighting; and interior finishes and trims. Environmental conditions surveyed in the study were acoustics for noise control, ventilation, physical security, air quality, heating, and lighting. Fifty percent of the schools reported at least one unsatisfactory environmental condition while 33% reported multiple unsatisfactory conditions. Noise control, ventilation, and physical security were the most frequently reported unsatisfactory conditions. School officials reported that the primary cause of the declining physical condition of America’s schools is insufficient funds. Insufficient funds led to decisions to defer maintenance and repair from year to year that had a domino effect for eroding the nation’s multibillion-dollar investment in school facilities. Some districts reported that overcrowding of school facilities also caused funds to be diverted from maintenance and repair of existing facilities to purchase additional facilities. The 1995a report also noted that building age was not a major factor contributing to deteriorating conditions because older buildings often have a more sound infrastructure than newer buildings. Buildings built in the early part of the 20th century were built for a life span of 50 to 100 years while those built after 1970 were designed for a life span of only 20 to 30 years. The 1995a report concluded that to complete all repairs, renovations, or modernizations needed to bring school buildings into good overall condition and comply with federal mandates was projected to cost $112 billion. Continuing to delay maintenance and repairs was predicted to escalate the erosion of the nation’s multibillion-dollar investment in school infrastructure.

The following year, GAO (1996) released a supplementary report, *School Facilities: America's Schools Report Differing Conditions*. This report identified differences in the condition of schools, amount of funding needed to repair or upgrade facilities, and number of students attending schools in inadequate condition by location, community type, percentage of minority and poor students, and school level and size. About 60 % of schools nationwide had reported the need for extensive repair, overhaul, or replacement of at least one major building feature that included roofs; framing, floors, and foundations; exterior walls, finishes, windows, and doors; interior finishes and trims; plumbing and heating; ventilation and air conditioning; electrical power; electrical lighting; and life safety codes. About 58% of schools reported at least one unsatisfactory environmental condition that included lighting, ventilation, indoor air quality, acoustics for noise control, energy efficiency, and physical security of buildings. The report estimated that it would cost about $112 billion to repair or upgrade school buildings into good overall condition. Good overall condition was defined as the physical condition and the ability of the schools to meet the functional requirements of instructional programs. Although two-thirds of the schools that reported to be in satisfactory condition were found in every state, the one-third of schools not in satisfactory condition were also found in every state. The majority of schools in unsatisfactory physical and environmental condition were concentrated in central cities and serve large populations of poor or minority students. The report indicated that about a third of the students in America, or about 14 million students, attended school in inadequate conditions. As for spending on federal mandates for removal or management of hazardous materials and accessibility for the disabled, the schools that reported above-average spending were those in central cities, those in the Midwest and the Northeast, large schools, secondary schools, and those schools in which greater than 50.5% of the students are minority.

Several years later, the National Center for Education Statistics (NCES) released a report about the condition of America's public school facilities. This report was spurred by the attention of press reports indicating that school buildings were deteriorating and crumbling, and the mounting concerns that the baby-boom echo was causing overcrowding of schools (NCES, 2000). Data had indicated that the condition of schools varied widely, from schools deteriorating with age and lack of maintenance to new, state-of-the-art school buildings. The NCES report provided results based on questionnaire data for 903 public elementary and secondary schools in the United States. Data had been collected about the condition of school facilities; school plans for repairs, renovations, and replacements; functional age of public schools; and overcrowding in schools. About three-quarters of the schools surveyed were in adequate or better condition but one-quarter of the schools reported at least one type of onsite building in less than adequate condition. Environmental conditions such as heating, ventilation, and air conditioning tended to be associated with comfort within the facility. Four out of 10 schools had reported unsatisfactory environmental conditions. One-fifth of schools had reported plans to build new additions, 41% of schools had indicated plans to make major repairs or renovations, and one-quarter planned to replace at least one building feature in the next two years. The estimated cost of repairs or renovations was $322 billion. About 6 out of 10 schools had reported a functional age of less than 15 years. The data had also suggested that three-quarters of schools did not have a problem with overcrowding but the remaining 25% of schools were exceeding the capacity of what the buildings were designed to accommodate. Although the NCES report summarized that a majority of schools were in adequate condition, functionally young, and not overcrowded, there were still a substantial number of schools that were aging, overcrowded, and in poor condition.

Several research articles have indicated that the average age of public school buildings in the United States was more than 40 years old (The Center for Green Schools, 2013; Filardo, Berstein, & Eisenbrey, 2011; Yeoman, 2012). Filardo et al. (2011) had expressed concern that chronic deferred maintenance and repair of school buildings could lead to energy inefficiencies, unsafe drinking water, water damage, molding environments, poor air quality, inadequate fire alarms and fire safety, compromised building security, and structural dangers. The 2013 Infrastructure Report Card by the American Society of Civil Engineers reported that the estimated investment needed to modernize and maintain our nation’s school facilities was at least $270 billion (American Society of Civil Engineers, 2013). Since the start of the recession in 2008, state funding for education has declined, which has slowed school construction for new building and modernizations. As school funding tightens for education, school districts have deferred maintenance and repair of school buildings to provide adequate funding for instructional programs.

Once every four years, the American Society of Civil Engineers (ASCE) has released a comprehensive assessment of the nation’s major infrastructure categories called the Infrastructure Report Card. ASCE (2013) has used a simple A to F school report card format that assesses current infrastructure conditions and needs. Grading criteria for infrastructures has been based on capacity, condition, funding, future need, operation and maintenance, public safety, resilience, and innovation. The most recent infrastructure report cards of 2009 and 2013 have assigned our nation's schools with the letter grade of D (ASCE, 2009, 2013). There has not been a change in the infrastructure rating of schools for the past four years, which is a concern. The letter grade of D has meant that the infrastructure is in poor to fair condition and mostly below standard, with many elements approaching the end of their life. Considering that almost half of America's public school buildings were built to educate the baby boomers, a generation that is now retiring from the workforce, the average age of public school buildings is now over 50 years old.

Abramson (2013) stated that when the "baby boom" was in full swing 50 years ago, new schools were constructed at a rapid rate with the assumption that the average life span of a new school building was 50 years. That means that 2012 should have been a boom year for school construction as districts moved to replace those 50-year-old structures. According to the construction report by Abramson (2013), 2012 was a relatively slow year for construction of new schools because the total dollars spent on new school construction was the lowest since 1996. This has been attributed to three reasons: (a) many of the 1962 schools did not last 50 years and were replaced, (b) many of those school buildings that are still in operation were significantly upgraded, and (c) there has been far less growth of new communities in the last several years that has caused existing schools to be upgraded and expanded to house new students. Abramson

(2013) stated that “the bottom line on school construction in 2012 is that total spending edged up slightly from the previous year, (to $12.9 billion from $12.2 billion), but the spending for new schools declined from $6.9 billion to $6.177 billion” (p. CR2). New school additions and a major increase in spending for renovations and upgrading existing buildings has attributed to the increase in school construction during 2012. For the first time in 12 years, spending on existing buildings has exceeded spending on new buildings. The 18th Annual School Construction Report showed that region 8, which includes the states of Iowa, Kansas, Missouri, and Nebraska, had spent over $829 million on school facilities during 2012, which is a major increase from $539 million in 2011 (Abramson, 2013). The spending in region 8 during 2012 showed equal spending on new buildings, additions to existing buildings, and renovation projects.

Environmental Conditions Affect the Learning Environment

According to Lyons (2001), there are environmental conditions such as indoor air quality, acoustics, and lighting in many school facilities that adversely affect student learning. A clean, quiet, safe, comfortable, and healthy learning environment was noted by Schneider (2002) to be a component for successful teaching and learning. Filardo (2008) stated that building deficiencies impair the quality of teaching and learning and also contribute to health and safety problems of staff and students. The United States Department of Education (1999) summarized from various studies that student achievement appeared to be more directly related to cosmetic factors than to structural factors such as substandard science facilities, air conditioning, locker conditions, classroom furniture, graffiti, and noisy external environments. Various studies have indicated that poorer achievement was associated with specific building conditions such as indoor air quality, lighting, acoustics, overcrowding or building size, condition of the facility, and building age. The National Center for Educational Statistics (NCES) surveyed public school principals during the fall of 2005 about the quality of the educational space in terms of nine specific environmental factors: artificial lighting, indoor air quality, size or configuration of rooms, acoustics or noise control, physical condition, ventilation, heating, natural lighting, and air conditioning (Chaney & Lewis, 2007). Heating and air conditioning were the most frequently reported interferences with classroom instruction, but 80% or more of the various subgroups of schools were satisfied with the environmental factors. In 2005, Global Green USA noted that in 14 studies comparing building age with student achievement, researchers found that students in old buildings scored 5-7% lower than students in new buildings. For facility conditions impacting student learning, this environmental conditions section has focused on air quality, lighting, acoustics, overcrowding, building age, and building condition.

Air Quality

The Environmental Protection Agency (EPA) reported that poor school design and facility conditions can lead to sick building syndrome (Filardo, 2008). In the report from the U.S. General Accounting Office (1995a), it was found that 15,000 schools suffered from poor indoor air quality (IAQ), affecting more than 8 million children, or one in five children in America’s schools. Symptoms of poor IAQ are irritated eyes, nose and throat problems, upper respiratory infections, nausea, dizziness, headaches, and fatigue. These symptoms have caused students and staff to have increased absenteeism.

The Cincinnati Asthma Prevention Study found that indoor irritants, long suspected of influencing rising asthma rates in young children, could be the key to asthma problems for four out of ten children (Lyons, 2001).

During the energy crisis of the 1970s, many buildings, including schools, installed air handling systems and controls that delivered less fresh air, which is now considered inadequate for good IAQ (Schneider, 2002). The energy crisis caused buildings to be sealed more tightly to reduce air leakage and minimize costs required to heat or cool air drawn from outside (Lyons, 2001). The EPA conducted a study of human exposure to air pollutants that indicated indoor levels of pollutants may be two to five times higher than outdoor levels and sometimes even 100 times higher. Without proper ventilation, contaminants build up inside the building. Indoor air contaminants come from people breathing, skin, clothes, perfumes, shampoos, deodorants, building materials, cleaning agents, pathogens, and from many other agents that when concentrated are harmful. It was learned from the 1970s that the indoor air quality in school buildings was unhealthy because of indoor air pollutants due to lack of outdoor air exchange. Good ventilation in schools is very important because children breathe a greater volume of air in proportion to their body weight than adults (Schneider, 2002).

Schneider (2002) had noted that temperature, humidity, and ventilation are the primary issues affecting air quality. Temperature and humidity affect indoor air quality most significantly because their levels promote or inhibit the presence of mold and bacteria. A high level of humidity has been determined to promote visible mold growth in schools and cause allergy symptoms associated with sick building syndrome (Filardo, 2008; Schneider, 2002). A study done in Canada had found absenteeism was reduced in schools by 20% if the humidity was controlled at 35%.

Moderate temperatures in the range of 68 to 74 degrees Fahrenheit have been determined through numerous studies to provide an effective learning environment that is necessary for satisfactory student performance (Earthman, 2002; Filardo, 2008; Schneider, 2002). The Green School Initiative of 2005 had reviewed a number of studies to find a significant positive correlation between student achievement and temperatures falling within the human comfort zone (Global Green USA, 2005). Overall, good air quality has proven to reduce respiratory infections, allergies, drowsiness, and increase attention spans for children in schools (The Tennessee Advisory Commission on Intergovernmental Relations, 2003).

Lighting

Light has been determined to be the most important environmental input, after food and water, in controlling bodily functions such as blood pressure, pulse, respiration rates, brain activity, and biorhythms (Tanner, 2008). Natural light has a profound influence on our body and mind that can alter mood and provides a major source of Vitamin D that is required for strong bones and healthy teeth. Studies have been conducted about how natural light or daylighting in schools affects student performance, mental attitude, and class attendance (Lyons, 2001). The 2000 Heschong Mahone Group study on daylighting showed that students with the most classroom daylight progressed 20% faster in one year on math tests and 26% faster on reading tests than students who learned in environments that received the least amount of natural light (Global Green USA, 2005; Lyons, 2001; Schneider, 2002).

There has been some controversy about full-spectrum fluorescent lighting being as beneficial as natural lighting (Schneider, 2002). Full-spectrum fluorescent lamps were developed to closely duplicate natural daylight but are several times more expensive than conventional lamps and produce significantly less light. Some schools have been re-lamped at considerable expense to offer this perceived benefit. Lackney (1999) described that under improved lighting conditions using full-spectrum fluorescent lighting, there is dramatic improvement in some children's classroom behavior. The Tennessee Advisory Commission on Intergovernmental Relations (2003) stated that classrooms with full-spectrum lighting with ultra-violet content had a significant positive effect on attendance and scholastic performance. While it is questionable about the effects of full-spectrum lighting, there is sufficient evidence that natural daylight provides the best lighting conditions for the learning environment.

Acoustics

The research linking acoustics to learning has been proven to improve academic performance. Earthman (2002) emphasized the ability to clearly hear and understand what is being spoken is a prerequisite for effective learning. Lackney (1999) stated that noise in the learning environment can originate from within as well as outside the school building and both forms of noise can have major affects on student behavior and in some cases achievement. The location and siting of schools is of critical importance for reducing noise to provide an environment effective for teaching and learning (Lackney, 1999). Studies have indicated that locating schools close to noisy streets increases children's blood pressure and causes deficits in mental concentration that affects student achievement. Higher student achievement has been associated with schools that have less external noise, that outside noise causes increased student dissatisfaction with their classrooms, and excessive noise causes stress in students (Schneider, 2002; The Tennessee Advisory Commission on Intergovernmental Relations, 2003). Schneider (2002) summarized that noise levels influence verbal interaction, reading comprehension, blood pressure, and thinking processes that cause feelings of helplessness, inability to concentrate, and lack of extended application to learning tasks.

Overcrowding

Tanner (2008) studied movement patterns in school buildings and concluded that a crowded school, ignoring personal and social distance, has a negative influence on student outcomes. Studies of overcrowded school buildings and classrooms have indicated that students do not score as high on achievement tests as students in non-overcrowded schools and classrooms (Earthman, 2002). Overcrowding has resulted in stress and a high rate of absenteeism among teachers and students. The U.S. Department of Education (1999) stated that there is evidence that overcrowding can have an adverse impact on learning through limited classroom activities and instructional techniques. Crowded classrooms have caused difficulty for students to concentrate on lessons, limited time for innovative teaching methods, and increased the likelihood of teacher burnout. Studies reviewed by Schneider (2002) indicated that the clearest evidence of positive effects of smaller class size is in the primary grades of kindergarten through third grade and the reduced class size had a positive effect on the disadvantaged and minority students. The Student/Teacher Achievement Ratio or STAR program authorized by the Tennessee legislature in 1985 had found that students in small classes did better in math and reading, behaved better, and African-American and low socio-economic students performed better at school (Schneider, 2002). Lyons (2001) noted that there is a growing body of research that shows more positive advantages for the majority of students in smaller schools. These advantages of smaller schools and classes revealed in various studies include higher attendance rates, greater participation in extracurricular opportunities, fewer behavior problems, more innovative teaching methods associated with higher student performance, frequent teacher interaction, and the graduation rate is higher in smaller schools.

Age and Condition of School Buildings

Earthman (2002) concluded through his survey that older buildings usually do not have the main attributes of a modern building that are associated with a positive learning environment. The age of the building should not be the important factor for influencing student performance, but the building components such as thermal quality and acoustical control are necessary for good student learning. Building quality may have less to do with age and more to do with the budget for the building. A lack of maintenance in an older building can ruin an otherwise high-quality building and funding limitations for a new building can result in inferior quality (Schneider, 2002).

Many researchers have used age of the building as a variable that might help explain student achievement. Research findings about the age of the building described in the staff information report for The Tennessee Advisory Commission on Intergovernmental Relations (2003) indicated that students had higher achievement scores in newer facilities, there were fewer disciplinary incidents in newer facilities, attendance records were better in new facilities, and social climate factors perceived by students were considerably more favorable in a new school. Earthman (2002) surmised from the researcher's results that students in modern buildings perform better on achievement tests than students in older buildings.

More recent studies have compared the building condition obtained through an assessment of building components or features as having a direct influence on student achievement. These studies are similar to studies that used the age of the building as a variable in correlating student achievement, but the data from building condition studies document more precisely the amount of differences in academic achievement of students in substandard buildings and those in functional buildings (Earthman, 2002). Researchers using building condition as a correlate to student achievement have found the same range of differences in achievement scores of students in substandard verses above standard buildings when controlling for socioeconomic differences between various school districts. Earthman (2002) concluded after the review of research studies about age of the building and building conditions affecting student achievement, the findings have demonstrated that the condition of the school building has a sizeable and measurable influence upon the achievement of students. The report by The Tennessee Advisory Commission on Intergovernmental Relations (2003) had also concluded from research findings that as the condition of the facility improved, achievement scores improved, promoted positive attitudes in students through stimulating environments, higher student achievement was associated with schools with better science laboratories, and well-maintained schools were associated with higher student achievement.

Twenty-first Century Learning Environments

The United States General Accounting Office (GAO) was concerned about whether America's schools have the physical capacity to support learning into the 21st century (GAO, 1995b). In 1995b, GAO reported that most of America's schools do not have the key technologies or the facilities required to support learning into the 21st century. GAO (1995b) stated that most schools were unprepared for the 21st century because at least three-quarters of schools did not have the system or building infrastructure to support modern technology, over half the schools reported unsatisfactory flexibility of instructional space, 40% of schools reported that their facilities could not meet the functional requirements of laboratory science or large-group instruction, and schools in central cities and schools with a 50% or more minority population were more likely to have more insufficient technology elements and a greater number of issues with lighting and physical security.

De Gregori (2011) explained that the physical environment must be intentionally designed to support a school's model for teaching and learning where the physical environment is integrated in the learning environment. This is accomplished with the active involvement and commitment of educators collaborating with designers to optimize how classroom spaces meet pedagogical goals. The process of designing public schools should embrace the participation of teachers, school administrators, and community members to work with architectural design professionals to create schools that are pleasing to the community and functional for teachers and administrators that will lead to higher student achievement (Heinhorst-Busby & Hunter, 2008). When considering the physical learning environment for the 21st century, educators are moving away from the large, factory-like schools that defined K-12 education during the 20th century (Sullivan, 2006). Lippman (2010) had envisioned 21st-century learning environments as places where the learner is engaged in self-directed and cooperative learning activities, and the physical environment is designed so that it is flexible to accommodate multiple ways of learning. The National Center for the Twenty-first Century Schoolhouse (2007) had emphasized the importance of approaching the planning and design process for 21st-century school facilities from the learner's point of view. Zubrzycki (2013) noted that research has shown that school buildings can affect students' morale and academic performance through school design that supports more open, flexible buildings aimed at creating a sense of community and collaboration. The Design for Learning Forum reported that flexibility was defined as the primary principle in 21st-century-designed schools that addresses multiple ways of learning in multiple environments (Sullivan, 2006). McCrea (2012) stated that the 21st-century smart classrooms must factor technological needs and a collaborative learning environment in the design of the basic shell, the teacher's space, and the students' independent and collaborative work areas. The shift in school design has tied together a more technological-driven, collaborative, student-centered approach to education for improving students' safety, engagement, and collaboration (Zubrzycki, 2013).

Fielding (2012) said that a 21st-century school configuration should reduce operational expenditures and also provide a safer and healthier educational environment. To reduce space wasted on corridors, Fielding (2012) has recommended establishing multiple learning environments which center on a commons space and provide many different sizes of educational areas rather than rows of classrooms. This type of configuration uses less square footage per student and creates a safer environment for learning through better supervision. The learning community of the 21st century should have distinct and varied spaces for lectures, group activities, and individual study. Fielding (2012) has the belief that reconfiguring schools into learning communities creates an atmosphere of inclusion and produces active learners equipped with the skills needed for successful futures.

The Partnership for 21st Century Skills (2011, Skills Framework section, para. 1) stated the following in their website overview about 21st-century learning environments:

- Creates learning practices, human support and physical environments that will support the teaching and learning of 21st-century skill outcomes;
- Supports professional learning communities that enable educators to collaborate, share best practices and integrate 21st-century skills into classroom practice;
- Enables students to learn in relevant, real world 21st-century contexts (e.g., through project-based or other applied work);
- Allows equitable access to quality learning tools, technologies and resources;
- Provides 21st-century architectural and interior designs for group, team and individual learning; and
- Supports expanded community and international involvement in learning, both face-to-face and online.

Today’s education has demonstrated a shift from a culture of teaching to a culture of learning that has required a change in focus and environment (Iowa Department of

Education, n.d.b.). To meet the needs of 21st-century learners, Iowa has implemented the Iowa Core that provides a world-class curriculum for all Iowa's kindergarten through 12th grade students. The Iowa Core provides an education that helps students succeed in today's rich, global economy by preparing students for the world of work and lifelong learning. The Iowa Department of Education (n.d.b.) has stated that the Iowa Core helps teachers take learning to a deeper level by focusing on a well-researched set of standards in literacy and mathematics, and essential concepts and skills in science, social studies, and 21st-century learning. Twenty-first-century learning in the Iowa Core refers to civic literacy, financial literacy, technology literacy, health literacy, and employability skills. The Iowa Core has identified the essential content and instruction of critical content areas that all students must experience. To be successful in the 21st century, six universal constructs or building blocks have been identified: (a) critical thinking, (b) complex communication, (c) creativity, (d) collaboration, (e) flexibility and adaptability, and (f) productivity and accountability. The Iowa State Board of Education has mandated that all school districts and accredited nonpublic schools are required to fully implement the Iowa Core in grades 9 through 12 by July 1, 2012, and grades kindergarten through 8 by the 2014-2015 school year. When a school has fully implemented the Iowa Core, the school will be engaged in an ongoing process of data gathering and analysis, decision making, identifying actions, and assessing impact around alignment and professional development focused on content, instruction, and assessment. This continuous improvement process has been specifically targeted toward improving student learning and performance.

STEM Education for Preparing a 21st-Century Workforce

For preparing a 21st-century workforce, President Obama had stated that the United States must equip many more students to excel in science, technology, engineering, and mathematics (White House Office of Science & Technology Policy, 2013). The president’s 2014 budget has invested $3.1 billion in programs across the federal government on STEM education for recruiting, preparing, and supporting STEM teachers; supporting more STEM-focused high schools and districts; improving undergraduate STEM education; and investing in breakthrough research on STEM teaching and learning (White House Office of Science & Technology Policy, 2013).

Business leaders in Iowa cannot find the science, technology, engineering, and mathematics talent to stay competitive in today’s global economy (Vital Signs - Change the Equation, 2013). Since 2003, eighth-graders in Iowa have made no gains on the National Assessment of Educational Progress (NAEP). Iowa has joined 44 other states in adopting high math standards through the Common Core State Standards and creating rigorous assessments aligned to those standards. Twenty-six states, including Iowa, have collaborated on the development of common “Next Generation” science content standards during 2013. Adopting rigorous standards in mathematics and science has created the foundation for promoting STEM and high expectations for all students.

The governor of Iowa released Executive Order 74 in 2011 that created the Governor’s STEM Advisory Council for bolstering STEM education and innovation for improving the state’s future economy (Iowa Governor’s STEM Advisory Council, 2012). The council’s office is headquartered at the University of Northern Iowa. The overarching goal of the STEM Advisory Council is boosting student interest and achievement in STEM and promoting STEM economic development. Assuring equitable access to STEM education programs for all Iowa students has been the focus of the council's mission. The council is made up of 40 dedicated leaders from across the state representing education, business and nonprofit sectors, legislators, state agency directors, and national STEM experts. Iowa Mathematics and Science Education Partnership and Iowa STEM Education Roadmap have also been working with the council for promoting STEM.

The National Science Foundation (NSF) has awarded Iowa a three-year, $1.2 million grant to the STEM Advisory Council for developing a coordinated statewide evaluation system that comprehensively assesses the educational and economic changes that occur throughout a long-term statewide STEM initiative (Iowa Governor's STEM Advisory Council, 2012). This project has been a collaboration of evaluation centers at the University of Northern Iowa, University of Iowa, and Iowa State University. The objectives of the Iowa STEM Education Evaluation (I-SEE) has been to generate best practices in developing and implementing evaluative strategies to examine statewide STEM initiatives; identify, develop, and sustain evaluative capacity and infrastructure; and create a system to examine statewide cultural change related to STEM. Ash (2013) stated that when STEM-focused schools strengthen their partnerships with both private companies and higher education partners, this will provide the kinds of high-tech, collaborative environments students need as they move on to college and the workforce.

Physical Learning Environment and Student Achievement

Through various studies and the review of other pertinent research studies, Earthman (2002) concluded that school facility conditions do affect student academic achievement. Earthman, Cash, and Van Berkum (1995), conducted a statewide survey of all high schools in North Dakota that examined the relationship between student achievement and the condition of the school building. The results of this study determined that the percentile rank scores of students were higher in the above-standard schools with good facility conditions. School building design features and components have also been determined to have a measurable influence upon student learning. Researchers have reported a negative impact upon student performance in buildings where temperature, lighting, acoustics, and age are deficient. The Green Schools Initiative through Global Green USA (2005) reported that the quality of school buildings has a direct impact on student performance after analyzing 14 studies comparing building age with student achievement showed that students in old buildings scored 5-7% lower than students in new buildings. Gibson (2012) conducted a study to determine whether newer school facilities encourage higher student achievement compared to older facilities. This study revealed that school achievement had an inverse association with school facility age, where newer schools perform at high levels of student achievement. The Tennessee Advisory Commission on Intergovernmental Relations (2003) reported that almost all the studies conducted over the past three decades have found a statistically significant relationship between the condition of a school and student achievement. Research findings in the Tennessee report (2003) showed that students had higher achievement scores in newer facilities, improving the condition of facilities improved achievement scores, thermal environment of a classroom has a significant relationship with student achievement, daylight in the classroom seemed to foster higher achievement, higher student achievement was associated with schools with pastel painted walls, higher student achievement was associated with schools with less external noise, and air quality affects the learning and health of students.

Many studies have analyzed how the condition of school facilities has affected student academic achievement, attendance, and behavior. Some studies have also analyzed how building design features can impact the physical learning environment. Cellini, Ferreira, and Rothstein (2008) noted that one of the difficulties in quantitative studies that focused on the effects of school facilities on student achievement was the inability to establish a clear causal relationship between the school facility and academic achievement. A few studies have provided information about the impact of a new school facility on student achievement. Two studies that analyzed the impact of new school facilities on student achievement were by Fritz (2007) and Shearer (2010). A study by Vandiver (2011) examined the impact of the quality of a high school facility on the educational environment by comparing student achievement results before the new facility to performance post the new facility. These studies have been summarized to help provide the foundation for this study.

Using a causal-comparative, quantitative research design, Fritz (2007) studied the effect of new school buildings on student achievement as measured by performance on Ohio sixth-grade proficiency subtests of math, science, reading, writing, and citizenship.

The purpose of this study was to determine if moving into a new school building would result in a significant increase in student achievement. A sample population of 26 school buildings was studied where the percentage of students who passed each subtest was collected two years prior to moving into and two years after moving into the new school building. Descriptive statistics were used to determine the difference between means for each subtest prior to moving into and after moving into the new building. Fritz (2007) determined that there was a significant increase in the reading and science subtests but there was not a significant increase in student achievement in the writing, citizenship, and math subtests. Fritz (2007) concluded that the increase in science results may have been due to science classrooms in new buildings providing better equipment and more floor space to handle the hands-on activities. The results for writing, citizenship, and math are inconsistent with the research results of earlier studies whereas the results for reading and science are consistent with earlier research results.

Shearer (2010) conducted a qualitative case study that explored a high school transition from an inadequate and substandard building to a new state-of-the-art facility to determine what the immediate effects of a new facility are on the academic environment. The researcher distributed surveys to all teachers after teaching at the new high school for four months and conducted follow-up interviews with teachers who agreed to be voluntary participants. This study relied upon a non-randomized convenience sample of classroom teachers from the selected high school to gather their perspectives about the transition into the new school building. Shearer (2010) discovered that despite the extreme contrast of conditions, the overwhelming majority of teachers who participated in the study did not observe a change in academic performance since moving into the new facility. It was noted that the short period of time that the study encompassed limited the scope of the results. Other than determining impact on academic performance, the most dramatic and observable impact of the new school facility was the shift in attitude and behavior of teachers within the building. Teachers expressed that the building does not make the teacher but the building helps to make the job of a teacher easier and more effective through the new facility and new equipment. Shearer (2010, p. 40) stated, “the very least that a teacher should expect from a school building is a minimum standard of safety and protection from environmental variables.” The transition to the new school was accompanied by equipment that had enabled teachers to use a wide range of learning activities that instilled enthusiasm for teaching. While this study was not able to determine a change in academic achievement, it determined that teacher attitude had improved substantially after moving into the new facility.

Vandiver (2011) conducted a mixed method research study to determine the relationship between a high school facility and the learning environment. Through questionnaires and interviews, the researcher collected information about the school facility and the learning environment. The learning environment in this study included student performance and achievement as characterized by the Texas Assessment of Knowledge and Skills (TAKS), the school climate and school culture, and teacher retention and teacher turnover. Vandiver (2011) compared student achievement results before the new facility to performance post the new facility. Student performance was based on TAKS in the areas of English language arts, mathematics, science, and social studies. Descriptive statistics were used to analyze the data using the independent z-test to determine the difference in student performance before vs. after the new facility. Vandiver (2011, p. 119) stated the following finding about the effect of educational facilities on student performance and achievement:

> The results were provided for the baseline year (2003-2004) and the overall (mean) performance for the post period (2004-2005 through 2008-2009). The results indicated that student performance was higher after the new facility in all four subjects and when considering all tests combined. The largest increase in student performance was seen for mathematics (22.0%) and the smallest increase was seen for English language arts (2.8%). However, English language arts performance was high prior to the new facility. These results also indicated that while only 48.0% of students passed all of the tests before the new facility, 65.0% of the students since the new facility passed all four tests. Overall, English language arts performance had remained relatively stable.

The results of Vandiver's study indicated that quality and educational adequacy of educational facilities were statistically significant when associated with student performance in the mathematics and social studies portions of the TAKS. Student performance was higher after the new facility in all four subjects when considering all tests combined. The quality and educational adequacy of educational facilities had a marginally significant increase in the percentage of students passing the science portion of the TAKS. Science results differed from Cash (1993) who reported that science achievement of students was higher in buildings with better-quality science facilities.

Research has shown that student achievement is affected by teacher working conditions. The Southeast Center for Teaching Quality (2004) reported that research available from systematic evaluations of working conditions has helped individual schools and districts understand that improving working conditions for teachers relates to student achievement. This information has shown that teacher working conditions are student learning conditions. Through research efforts conducted in North Carolina, South Carolina, and Georgia, other states have recognized: (a) teacher working conditions have considerable impact on teacher retention and student learning; (b) teachers must have the resources and support they need to serve all students; and (c) teachers need to work in environments that support their basic needs to support school reform efforts.

Earthman and Lemasters (2011) explained that the condition of the school building directly influences the attitudes of faculty, parents, and students. Attitude of teachers has been noted to be directly affected by conditions such as thermal control, adequate lighting and windows, modern science equipment, and controlled acoustical environment in well-maintained and modern buildings. Earthman and Lemasters (2011) noted that parents and community members develop a feeling about a building through their perception of how the administration cares or does not care about the condition of the buildings in which students are housed. The attitudes of faculty and parents have a major bearing upon the feelings students have about a building. All of these factors generate an attitude on the part of the students about their worth and value in society that impacts student achievement (Earthman & Lemasters, 2011). Research has provided evidence that in school buildings of good condition, students perform better when proper equipment is available, efficient environmental conditions are existent, and the building is clean and an inviting place to learn.

A study by The Wallace Foundation (2013) stated that there is an empirical link between school leadership and improved student achievement. Research has shown that most school variables, when considered separately, have small effects on learning (The

Wallace Foundation, 2013). Combining individual variables to reach a critical mass is the job of the principal for improving learning. The combination of quality teachers, physical learning environment, and school leadership variables has a significant effect on learning. The Wallace Foundation (2013) identified five key responsibilities of the school principal: (a) shaping a vision of academic success for all students, (b) creating a climate hospitable to education, (c) cultivating leadership in others, (d) improving instruction, and (e) managing people, data, and processes for school improvement. School leadership has been very important to how a school building is used to improve learning. Administrators have the responsibility to make decisions about the physical learning environment that are based on the vision of the school for improving learning.

Summary

The problems of poor ventilation, insufficient lighting, poor acoustics, and temperature control of classrooms are still affecting the condition of America’s school buildings today. These problems have been identified as causes for health issues, boosting absenteeism, and undermining teaching. The lack of a basic inventory of public school facilities from each state has made it difficult to determine the condition of the nation’s public school buildings and grounds. Without a basic inventory of public school facilities, it has been estimated that the investment needed to modernize and maintain public school facilities is at least $270 billion or more. School districts are faced with the dilemma of whether to invest millions of dollars to maintain outdated buildings or invest in new construction to meet the evolving needs of today’s learners. Another concern was the chronic deferred maintenance and repair of aging school buildings due to inadequate funding can lead to energy inefficiencies, unsafe drinking water, water damage, molding environments, poor air quality, inadequate fire alarms and fire safety, compromised building security, and structural dangers. The latest report on school building construction has indicated that 2012 was a relatively slow year for construction of new schools but there has been a major increase in spending for renovations and upgrading existing buildings.

Environmental conditions such as indoor air quality, acoustics, and lighting in many school facilities can have an adverse affect on student learning. The National Center for Educational Statistics reported that heating and air conditioning were the most frequently reported interferences with classroom instruction. Poor school design and facility conditions can lead to poor indoor air quality that affects one in five children in America's schools. Without proper ventilation, contaminants build up inside the building and cause irritated eyes, nose and throat problems, upper respiratory infections, nausea, dizziness, headaches, and fatigue. Studies have shown that natural light or daylighting in schools affects student performance, mental attitude, and class attendance. Acoustics has been proven to improve academic performance. Noise levels influence verbal interaction, reading comprehension, blood pressure, and the thinking process. Studies about overcrowded school buildings have indicated that students do not score as high on achievement tests as students in non-overcrowded schools and classrooms. A survey by Earthman (2002) has shown that older buildings usually do not have the main attributes of a modern building that are associated with a positive learning environment. Studies have indicated that students in modern buildings perform better on achievement tests than students in older buildings.

The 21st-century learning environments can best be explained where the physical environment is integrated in the learning environment. The learning environments of the 21st century are described as places where the learner is engaged in self-directed and cooperative learning activities, and the physical environment is designed so that it is flexible to accommodate multiple ways of learning. There has been a shift in school design that has tied together a more technological-driven, collaborative, student-centered approach to education for improving students' safety, engagement, and collaboration. Multiple learning environments that center on a common space and various sizes of educational areas have taken the place of rows of classrooms.

STEM education has equipped students to excel in science, technology, engineering, and mathematics for preparing a 21st-century workforce. Through the adoption of rigorous standards in mathematics and science in the Common Core State Standards, Iowa has created the foundation for promoting STEM and high expectations for all students. The governor of Iowa created the STEM Advisory Council for bolstering STEM education and innovation for improving the state's future economy. Partnerships with both private companies and higher education have enabled STEM-focused schools to provide the kinds of high-tech, collaborative environments students need as they move on to college and the workforce.

Various studies have proven that school facility conditions affect student academic achievement. The examination of the relationship between student achievement and the condition of a school building has determined that the percentile rank scores of students were higher in above-standard schools with good facility conditions. Gibson (2012) conducted a study to determine whether newer school facilities encourage higher student achievement compared to older facilities. Results of that study revealed that newer schools perform at high levels of student achievement. The Tennessee Advisory Commission on Intergovernmental Relations (2003) released research findings that students had higher achievement scores in newer facilities and improving the condition of facilities improved achievement scores. A qualitative study by Shearer (2010) indicated that the majority of teachers did not observe a change in academic performance since moving into the new facility but the attitude of teachers improved substantially. Cellini et al. (2008) noted the difficulty in establishing a clear causal relationship between the school facility and academic achievement. As indicated earlier, there have been many studies that have discovered a relationship between the physical learning environment and student achievement.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

Introduction

The purpose for conducting this research was to analyze middle school student achievement in mathematics and science where students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. For designing 21st-century learning environments, educators and architectural planners have been using the results from studies that link student achievement with the design of a school facility. Research has provided a better understanding for designing educational facilities to meet the learning needs for the 21st century. Educational facilities must meet the learning needs of students entering the technologically driven working environment. This study analyzed the effect of a new 21st-century-designed STEM middle school has on student achievement.

Setting

The setting for this study occurred in an Iowa school district at a middle school designed for 21st-century learning. This particular school was chosen for the study because of the uniqueness of transferring students from the old facility to the new 21st-century-designed STEM school. The old middle school was built in 1953 as a junior high school in the traditional design for the 20th century that embraced the teacher-directed whole-group instruction in classrooms. The 20th-century design of the multi-level old middle school is commonly referred to as the factory model school building with double-loaded corridors of self-contained classrooms leading to a centralized administrative center (Tanner & Lackney, 2006). Education in the factory model school building used repetition and uniformity of instruction. Conditions of the old middle school were considered poor because of deferred maintenance, lack of air conditioning, lack of instructional technology, facility features that limited instructional strategies, and noise pollution from the close proximity to a busy highway. The old middle school building closed at the end of the 2008-2009 school year and is on the same property site as the new school building. Currently, the old building is being used for district storage, but there has been discussion about razing the building.

Design of the new STEM middle school involved input from parents, teachers, and administrators for meeting the needs of 21st-century learners. The new school was built on the same property site in close proximity to the old building but was set back far from the busy highway for external noise control. Students and staff occupied the building during the fall of the 2009-2010 school year. Instead of a multi-level building, the new facility was designed to be one level to provide better accessibility for the physically disabled, better flow of students throughout the facility, and increased natural lighting for learning spaces. Learning spaces or pods were designed for each grade level that created learner-centered workplaces for a collaborative culture of students at work (Pearlman, 2010). During the first year, the new middle school had required modified dress standards for students.

Information from the 2010-2011 Annual Report has provided a good description of the students attending the new middle school. Percentages of student diversity at the new middle school were the following: 64% White, 28% African-American, 9%

Hispanic, 2% Asian, and 1% Native American. Grade enrollments were 191 students in sixth grade, 170 students in seventh grade, and 138 students in eighth grade. The average daily attendance during the 2010-2011 school year was 93.4%. Free or reduced lunch eligibility was 84.73%. The school involved in this study has a diverse student population, good student attendance, and a high percentage of economically disadvantaged students.

Research Design

This study analyzed middle school student achievement in mathematics and science where students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. Three research questions guided this study that examined the relationship between student achievement and the physical learning environment. Case study research with a mixed methods approach was conducted for this study due to the small sample set and the difficulty realized in studying a connection between the physical learning environment and student achievement. A mixed methods research approach was used to improve reliability and generality because case studies have been criticized for lacking reliability and generality. The research was conducted at one school using non-random/purposeful sampling to collect the research data. Non-experimental descriptive research using causal-comparative design was used for the quantitative portion of the study, and focus group interviews with teachers and administrators were used for the qualitative portion of the study.

Mixed methods research has helped to provide a broader view of a research problem by combining quantitative and qualitative data to provide greater understanding for informing decisions or answering questions (Stewart & Palermo-Biggs, 2013). Creswell and Plano Clark (2006) noted that to put both quantitative and qualitative data together as a distinct research design or methodology is considered a new approach. Mixed methods research was defined by Creswell and Plano Clark (2006) as a research design with philosophical assumptions as well as methods of inquiry. The philosophical assumptions of the methodology have provided the guidance for the collection and analysis of data and the mixture of qualitative and quantitative approaches in many phases in the research process. Quantitative data has been considered closed-ended information whereas qualitative data has consisted of open-ended information that researchers gather through interviews with participants. The combination of the use of quantitative and qualitative approaches has helped to provide a better understanding of research problems than either approach alone.

Merriam (2009) briefly defined a case study as an in-depth description and analysis of a bounded system. Creswell (1998) explained that a case study is an exploration of a bounded system or case over time through detailed, in-depth data collection involving multiple sources of information rich in context. The bounded system or the case being studied is bounded by time and place using purposeful sampling. For this particular study, the bounded system is the collection of student achievement data and focus group interviews at one middle school to study the effect a new 21st-century-designed STEM middle school has on student achievement. Case studies typically have sought to answer questions beginning with "how" or "why." The research questions for the focus group interviews in this study were designed to be open-ended questions using "how" and "why" to collect data.

Fraenkel and Wallen (2006) defined causal-comparative research as the investigative attempt to determine the cause or consequences of differences that already exist between or among groups of individuals. Causal-comparative research uses quantitative data in non-experimental studies where the group difference variable cannot be manipulated. The basic causal-comparative design has involved selecting two or more groups that differ on a particular variable of interest and comparing them on another variable or variables. This study used the analysis of causal-comparative research for comparing student achievement data prior to moving into and after moving into the new school building. Two cohort groups of students were identified that attended school at both facilities for grades 6-8. The discrete independent variable was the change in learning environment from the old school building to the new school facility designed for 21st-century learning, and the two continuous dependent variables were the student achievement scores from the Iowa Assessments in mathematics and science. The most commonly used statistical inference test in causal-comparative studies has been the *t*-test for determining differences between means (Fraenkel & Wallen, 2006).

Research Questions

The research questions used for this study were designed to explore the differences, if any, in student proficiency in mathematics and science prior to and after moving into a new facility, gain perceptions from teachers and administrators about the change in teaching strategies in the new STEM school, and to gain perceptions from teachers and administrators about whether student achievement was impacted from the change in the new physical learning environment.

1. To what extent, if any, does student proficiency on the Iowa Assessments in mathematics and science improve after moving into the 21st-century-designed STEM middle school?
2. How have teaching strategies changed from the old facility to the new 21st-century-designed STEM middle school?
3. How has student achievement been impacted because teaching has changed in the new 21st-century-designed STEM middle school?

Research Study Population

The targeted population for this study was the middle school students that attended school at an antiquated old school and then transferred to a new middle school built for 21st-century education. This particular middle school population was chosen as a non-random/purposeful sampling because of the uniqueness of transferring students from the old facility to the new 21st-century-designed STEM school. Grade span for both buildings was grades 6-8. The average number of students in grades 6-8 that attended school in the old building from 2006-2009 was 355 students. The new facility has an average number of 454 students in grades 6-8. For this study, two groupings of students were used for research purposes.

Two matched cohort groups of students were identified that attended school at both facilities for grades 6-8. Only the standardized test data for students that attended school at both facilities for grades 6-8 was used for this study to conduct a matched cohort data analysis. Group 1 was a cohort group of students that attended sixth and seventh grades in the old building then attended eighth grade in the new facility. Group 2 was a cohort group of students that attended sixth grade in the old building then attended seventh and eighth grades in the new facility. Group 1 had an average of 110 students from their sixth-grade year in 2007-2008 to their eighth-grade year in 2009-2010. Group 2 had an average of 128 students from their sixth-grade year in 2008-2009 to their eighth-grade year in 2010-2011. The number of students in cohort group 1 (see Appendix A Cohort 1 Mathematics and Science Data) that attended school at both facilities was 77 students, and the number of students in cohort group 2 (see Appendix B Cohort 2 Mathematics and Science Data) that attended school at both facilities was 81 students.

The educator participants in the study were building administrators and middle school teachers who had experience at both the old and new facilities. There were 14 middle school teachers and two administrators that met the criteria for this study.

Data Collection

Since the new facility is a STEM school, data regarding student academic achievement on the Iowa Assessments in mathematics and science were used to assess academic achievement. Mathematics tests were designed to emphasize the ability of quantitative reasoning and to think mathematically in a wide variety of contexts. Science tests assessed not only students’ knowledge of scientific principles and information but also the methods and processes of scientific inquiry.

STEM schools have focused on science, technology, engineering, and mathematics to help our nation's youth gain skills required to succeed in today's challenging world. Through STEM curriculum, students have learned to think critically, solve complex problems, and drive advancements in science and technology (Iowa Governor's STEM Advisory Council, 2012). STEM school students have been noted to be at an advantage when competing for the high-tech, high-wage jobs of the future.

The collection of student achievement data involved accessing data from the Iowa Department of Education through the EdInsight website (Iowa Department of Education, n.d.a.). EdInsight is Iowa's educational data warehouse that is designed to empower Iowa educators through data. EdInsight has provided the Iowa education community with consistent and accurate longitudinal information on education outcomes and the analytical tools needed to improve decision making and student success. EdInsight contains the assessment data from Iowa Testing Programs for all schools in Iowa. The Iowa Testing Programs (ITP) is the research, development, and outreach unit in the College of Education at the University of Iowa. Educational assessment through the ITP has been a process for obtaining information that is used for making decisions about students, teachers, curricula, programs, and educational policy.

The standardized tests of the Iowa Assessments, formerly known as the ITBS, were used to measure progress in the Iowa Core curriculum, monitor student growth, and track student readiness. The Iowa Assessments used to test students in mathematics and science are norm-referenced tests designed to compare student scores along a bell curve, with some students performing very well, most performing average, and a few performing poorly. Norm-referenced tests are most appropriate for making comparisons across large numbers of students or making important decisions regarding student placement and advancement. Proficiency in mathematics and science and the change in the physical learning environment from the old building to the new building are the variables used for this study. When analyzing the norm-referenced student achievement results from the Iowa Testing Program, this study did not take into account the variables of school dress code of the new facility versus no dress code of the old facility, age maturation of students for testing, and differences in teaching strategies among teachers. There are many variables that impact student achievement that could be considered for future studies.

Research Question 1

For the first research question that compared student achievement data, data from EdInsight provided information about individual students in the context of percent proficient on the Iowa Assessments in mathematics and science. The risks associated with using student achievement data in this study are non-existent. Student achievement data have not been connected in any way to individual student or teacher names. Mathematics and science are subtests used in No Child Left Behind (NCLB) determinations, now referred to as the Elementary and Secondary Education Act (ESEA). ESEA is the federal requirement for public school districts to report annually each student's level of proficiency in reading, math, and science to the parent or guardian. EdInsight has the capability of providing a report that will list individual students' National Percentile Ranks (NPR) on the Iowa Assessments for the specified year, building, and grade level. For purposes of NCLB, the achievement of Iowa students was described in NPR score ranges as low, intermediate, and high. Students with NPRs of 1-40 are in the low level, 41-89 are in the intermediate level, and values from 90-99 are in the high level. Each state is required to decide which levels of achievement are considered proficient. In Iowa, the low level is defined as “less than proficient,” and the intermediate and high levels together are regarded as “proficient.”

Research Questions 2 and 3

The final two research questions of this study involved conducting interviews with teachers and administrators to gain a deeper understanding of how the new school facility has impacted teaching and student learning. Before collecting data from administrators and teachers for this study, the Standard Application for Human Participants Review was submitted and approved by the Institutional Review Board (IRB) of the University of Northern Iowa that requested permission to collect research data from human subjects. The IRB has been responsible for protecting the rights of human participants engaged in research. IRB defined “research” in the federal regulations at 45 CFR 46.102(d) as “*a systematic investigation, including research development, pilot studies, testing and evaluation, designed to develop or contribute to generalizable (or transferable) knowledge.”* All projects defined by the IRB as “research” involving “human participants” must be reviewed and approved by the IRB before any research activities involving potential participants are initiated.

A request for permission to conduct research in the school district was also submitted and approved by the school district. The school district requires researchers to comply with school district policy 604.4-R2 Request For Permission To Conduct Research because of the many requests to conduct research in the school district.

All research can be said to carry some risk, including inconvenience at the very least. In almost all studies, participants run the risk that they will be inconvenienced and their valuable time used profitably or wasted. More common risks are potential psychological or privacy harms that actually do have a reasonable chance of occurring as a result of research participation. Discussion of sensitive topics has been noted to cause discomfort and anxiety when sharing feelings about levels of student achievement, particularly for teachers in mathematics and science. As principal investigator, every precaution to mitigate the risk of a potential breach of confidentiality was exercised.

After approvals from the IRB and the school district, the researcher met with the administrators of the school approved for this study to provide a brief overview of the proposed research study and the process for data collection to conduct the study. The administrators provided a list of potential participants who had worked at the old middle school and are currently working at the new middle school. Two administrators and 14 teachers were identified that had working experience in both buildings. After visiting with the building administrators, a recruitment meeting was scheduled to meet with all potential participants on the list to review aspects of the research project. The principal of the school notified potential participants that they would be contacted by the researcher to participate in the approved research project. An e-mail invitation (see Appendix D E-mail Invitation to Participate in Research Study) regarding research participation and meeting information was sent to the identified administrators and teachers with work experience in both buildings. Another e-mail reminder (see Appendix E E-mail Reminder about the Invitation to Participate in Research Study) was sent by the researcher approximately 24 hours prior to the scheduled recruitment meeting at the school. The recruitment meetings and interview sessions were conducted at the school in a room assigned by the principal. At separate recruitment meetings for the teachers and administrators, a PowerPoint presentation was used to explain the research project and the importance of participants' voluntary involvement. An informed consent document (see Appendix C for the Human Participants Review Informed Consent document) was presented to the study participants to explain the nature and extent of their participation in the project and confirm their agreement to participate in the study. The informed consent form was collected from willing participants and they were informed about the right to withdraw consent and terminate participation at any point during the study. The consent process was conducted in accordance with federal regulations. The acceptance documents have remained confidential and any follow-up conversations regarding acceptance or decline have also remained confidential. All communications with teachers and administrators in the study have emphasized confidentiality and the research study will in no way impact the staff. Immediately after receiving the informed consent forms from willing participants, interviews were conducted to collect data for the study. Interviews with voluntary participants were scheduled so as to not interfere with instructional time.

Participants during the interviews were informed that all research results would be treated respectfully with the utmost confidentiality. Participants' confidentiality was protected in the following ways: (a) summary of interview findings did not include any personal or work information that could possibly identify the participant in the study; (b) the interview process with administrators and teachers was audio-recorded and conversations were transcribed so that names were not used in the transcription to ensure complete confidentiality; and (c) during the interviews, the explanation of confidentiality, participants' rights, and impact/or lack of impact on individual participants was emphasized.

Interview questions were used to collect qualitative data to provide an enriched understanding about the transition from the old facility to the new facility and the impact of the 21st-century-designed school on teaching and learning. Qualitative research was useful for understanding the complex relationship between the school building and its occupants. An interview has been defined as a process where the researcher and the participant engage in a conversation focused on questions related to the research study. Merriam (2009) stated that interviewing is necessary when we cannot observe behavior, feelings, or how people interpret the world around them. The interview structure for this study was semi-structured (Merriam, 2009) where the questions were more open-ended to elicit views and opinions from participants to define the new physical learning environment in unique ways.

Data Analysis

Current research has indicated that student academic achievement improves with improved building conditions, and studies have also been conducted about the effects of school building planning and design on student achievement. Focusing on matched cohort data for student achievement results in one school where students experienced a change in the physical learning environment has provided more concise information about whether the physical learning environment of the new school did affect student achievement. This study will help to further add to the body of knowledge regarding the benefits of improving the physical learning environment to improve student achievement.

This case study used mixed methods research to analyze student achievement of students who experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed STEM school. Descriptive and inferential statistics were used to analyze the quantitative data for the first research question. A qualitative research design using interviews to collect data was used for the final two research questions. Interview questions were designed to gain an understanding of how educators have perceived the affects of the physical learning environment on teaching and learning. The goal of mixed methods research was to draw from the strengths and minimize the weaknesses of both quantitative and qualitative research designs (Johnson & Onwuegbuzie, 2004). Mixed methods research has allowed the researcher to mix or combine quantitative and qualitative research techniques, methods, approaches, concepts, or language into a single study. The quantitative data in this study used individual student NPR scores in mathematics and science from the Iowa Assessments. Qualitative data through interviews with the participants in the study provided an enriched understanding about the perceived impact of the new physical learning environment on teachers and students.

To analyze student achievement, Iowa Assessments data was obtained from the Iowa Department of Education through the state longitudinal data system called

EdInsight. EdInsight has provided Iowa educators the tools for deep data analysis for a more detailed picture of student achievement and the factors that influence student performance. Proficiency on the Iowa Assessments in mathematics and science were the two continuous dependent variables for student achievement in this study. The discrete independent variable was the change in the physical learning environment from the old middle school building to the new 21st-century-designed middle school building.

Quantitative data from the Iowa Assessments was loaded in the *Statistical Package for Social Science (SPSS)* for Windows© Version 20.0. SPSS has a broad range of capabilities that allows researchers to code, score, and analyze the data to produce numerical and graphical results for research studies. SPSS is a software program for performing statistical analyses in descriptive, parametric, and nonparametric inferential statistics. The predictive analytics of SPSS have allowed researchers to predict with confidence to make intelligent decisions, solve problems, and improve outcomes.

The first research question used the analysis of comparative research for comparing student achievement data prior to moving into and after moving into the new school building. SPSS software was used to conduct a causal-comparative, quantitative research design to explore the associations among variables. For this part of the study, the discrete independent variable was the change in learning environment from the old school building to the new school facility designed for 21st-century learning. The continuous dependent variables were the NPR scores from the Iowa Assessments for mathematics and science as reported on the EdInsight website. A matched cohort data analysis was conducted for sixth- and seventh-grade students who attended the old middle school then transferred to the new school to finish their middle school education. The matched cohort analysis provided student achievement information for the same students that attended both schools described in the study. A matched cohort is the same students over a period of time. For example, a matched cohort is the same students from sixth grade in 2007-2008, seventh grade in 2008-2009, and eighth grade in 2009-2010. Matched cohort data analysis began the last school year that sixth- and seventh-grade students attended the old middle school and ended during their eighth-grade year at new 21st-century-designed middle school.

Descriptive statistics were used to determine the mean and standard deviations for this data. The inferential statistics test used for this portion of the study was the paired-samples *t*-test to compare the difference between means of test scores prior to moving into the new building and means of test scores after moving into the new building. The paired *t*-test was used to compare the means of two sets of data from the same individuals or pairs of individuals (Cronk, 2008). Paired-samples *t*-tests were used to determine whether or not two scores are significantly different from each other. Statistical significance was determined by an alpha or p-value of .05. P-value is the probability of obtaining a test statistic at least as extreme as the one that was actually observed. This means that the finding has a 95% chance of being true or the finding has a 5% chance of not being true using a p-value of .05. For p-values of .05 or less, the scores are statistically significant or a high probability of a relationship between the dependent and independent variables. Values over .05 indicate that the scores are not significantly different or less likely of a relationship between the variables.

Data collection for research questions 2 and 3 used focus group interviews with administrators and teachers to gain an understanding and perception about the effect of the physical learning environment on teaching and learning. Interview questions (see Appendix F for interview questions) were designed to collect information about how the new learning environment designed for STEM curriculum has changed teaching strategies, student achievement, instructional technology, students' levels of motivation and engagement, and parental involvement. A focus group interview was conducted with voluntary participants who experienced the transition from the old facility to the new 21st-century-designed school facility. The common experience of the focus group allowed the participants to hear other responses and make additional comments beyond their own original responses. The objective of this interview technique was to gain high-quality data in a social context where respondents could consider their own views in the context of the views of others.

Separate interviews for teachers and administrators were conducted for those who worked in the old facility then transferred to the new school building. There were 14 teachers and two administrators identified who worked at both school buildings. All conversations and interview responses were treated with utmost respect and confidentiality. Conversations were audio recorded so that full transcriptions of the interviews could be used in the study. From the transcript, a summary of findings was included in the dissertation. Audio recordings of the interviews with administrators and teachers were destroyed after transcription was completed. The analysis of the transcriptions identified the common themes for each of the interview questions. Seven interview questions (see Appendix F for the interview questions used for the two focus interview groups) were used for both the teachers and administrators focus group interview sessions. A comparison of underlying themes was conducted for both focus group interviews. When developing the summary of findings, the confidentiality of all participants in the study was maintained.

Summary

Chapter 3 described the research methodology used for this study. The setting occurred in an Iowa school district at a new middle school that has STEM-focused curriculum. Middle school student achievement in mathematics and science was analyzed when students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. Three research questions guided the study for examining the relationship between student achievement and the physical learning environment. Case study research with mixed methods approach was used due to the small sample set. Non-experimental descriptive research using causal-comparative design was used for the first research question that analyzed student achievement data. The collection of student achievement data involved accessing data from the Iowa Department of Education through the educational data warehouse called EdInsight. Focus group interviews with teachers and administrators were used for collecting data for research questions 2 and 3.

CHAPTER 4

ANALYSIS AND RESULTS

Introduction

In the era of rising standards and expectations for student performance, students need as many of the elements of a good educational experience as possible (Duke, 1998). Research studies by Cash (1993), Earthman (2002), and Tanner (2008) have explored how the design of schools can affect student safety, teacher-student relationships, and the academic performance of students. A growing body of research has linked student achievement and behavior to the physical learning environment. Considering the billions of dollars invested in school buildings and the accountability for improving student achievement, there has been the lingering question about how the physical learning environment affects student achievement (Abramson, 2013).

The purpose of this study has been to analyze the effect on middle school student achievement in mathematics and science when students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. The setting for this study occurred in an Iowa school district at a new middle school designed for 21st-century learning. This particular school was chosen for the study because of the uniqueness of transferring students from the old facility to the new 21st-century-designed STEM school. The old middle school was built in 1953 as a junior high school in the traditional design for the 20th century that embraced the teacher-directed whole-group instruction in classrooms.

A description of the data analysis and specific findings within this investigation are described in this chapter. Mixed methods research was utilized in this case study to explore the relationship of a new 21st-century-designed middle school facility and student academic achievement in mathematics and science. The following research questions were used to shape the research design for this study:

1. To what extent, if any, does student proficiency on the Iowa Assessments in mathematics and science improve after moving into the 21st-century-designed STEM middle school?
2. How have teaching strategies changed from the old facility to the new 21st-century-designed STEM middle school?
3. How has student achievement been impacted because teaching has changed in the new 21st-century-designed STEM middle school?

Organization of the Data Analysis

This case study used the mixed methods approach to analyze middle school student achievement in mathematics and science where students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. Causal-comparative research design and focus group interviews were used in the data analysis of the three research questions.

This chapter is comprised of three major sections for the analysis of data. The first section of the data analysis addresses the first research question by providing non-experimental descriptive research data to determine means and standard deviations, and also the inferential statistics portion using paired *t*-test data for comparing the means of two sets of data from the two matched cohort groups. The second section addresses research questions 2 and 3 by providing the transcribed data from audio-recorded focus group interviews with the administrators group and teachers group. For research questions 2 and 3, themes were identified for each interview question for both focus groups, then common themes were identified between both focus groups. The final section provides an overall summary of the research findings.

Research Question 1

The first research question compares student achievement data in mathematics and science prior to moving into and after moving into the new school building. National percentile ranks on the Iowa Assessments in mathematics and science were used to analyze student achievement. Iowa Assessments data was collected from the Iowa Department of Education through the state longitudinal data system called EdInsight. EdInsight provides Iowa educators the tools for deep data analysis of student achievement and the factors that influence student performance.

A matched cohort data analysis was conducted for sixth- and seventh-grade students who attended the old middle school then transferred to the new 21st-century-designed STEM school. A matched cohort is the same students over a period of time. The matched cohort analysis provided student achievement information for the same students that attended both schools described in the study. Cohort group 1 students attended sixth and seventh grades in the old middle school from FY2008 to FY2009 then transferred to the new school for eighth grade during FY2010. Cohort group 2 students attended the old middle school for sixth grade during the FY2009 then transferred to the new middle school for seventh and eighth grades from FY2010 to FY2011. The number of students in cohort group 1 (see Appendix A Cohort 1 Mathematics and Science Data) that attended school at both facilities was 77 students and the number of students in cohort group 2 (see Appendix B Cohort 2 Mathematics and Science Data) that attended school at both facilities was 81 students.

The matched cohort data from the Iowa Assessments was loaded in the *Statistical Package for Social Science (SPSS)* for Windows© Version 20.0 to analyze the non-experimental descriptive research data to determine means and standard deviations and compute the inferential statistics using paired *t*-test data for comparing the means of two sets of dependent variables data. National Percentile Rank (NPR) scores on the Iowa Assessments in mathematics and science were the two continuous dependent variables, and the discrete independent variable was the change in the physical learning environment from the old middle school to the new 21st-century-designed middle school building. Tables for paired-samples statistics provide descriptive statistics information about means and standard deviations in mathematics and science for each of the matched cohort groups. Tables for paired-samples tests provide inferential statistics information about the paired-samples *t*-test to compare the difference between means of dependent variables. The tables for paired-samples tests provide the Sig (2-tailed) value that is referred to as the p-value. The p-value determines if the two condition means are statistically different. Statistical significance between the means of the paired-dependent variables was determined by an alpha or p-value of .05. This means that the finding has a 95% chance of being true or the finding has a 5% chance of not being true using a p-value of .05. For p-values of .05 or less, the scores are statistically significant or a high probability of a significant difference between the dependent variables. Values over .05 indicate that the scores are not significantly different or not much of a difference between the comparison of the dependent variables.

Cohort Group 1 Mathematics Analysis

Table 1 describes the basic descriptive statistics for paired variables statistics in cohort group 1 that is comprised of 77 students. Cohort group 1 students were in sixth grade and seventh grade at the old middle school from FY2008 to FY2009 then transferred to the new middle school for eighth grade during FY2010. Scores for mathematics variables are from the Iowa Assessment results in the Iowa Testing Programs. Pair 1 compares the Iowa Test of Basic Skills (ITBS) mathematics test results from the fall of 2007 to the spring of 2009 at the old school. During the FY2008 school year, the school decided to change from fall testing norms to spring testing norms in the Iowa Testing Programs. The mean for pair 1 FY2008 mathematics Iowa Test of Basic Skills/National Percentile Rank (ITBS/NPR) scores was 39.25, with a standard deviation of 27.083. The mean for pair 1 FY2009 mathematics ITBS/NPR scores was 39.23, with a standard deviation of 27.271.

For cohort group 1, Table 1 also compares the descriptive statistics for pair 2 mathematics NPR scores from the spring of 2009 at the old school to the spring of 2010 at the new school. The mean for FY2009 mathematics ITBS/NPR scores was 39.23, with a standard deviation of 27.271. The mean for FY2010 mathematics ITBS/NPR scores was 36.43, with a standard deviation of 27.774.

Table 1

Cohort Group 1 Mathematics Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	OLD1_MATH6_FY08_NPR	39.25	77	27.083	3.086
	OLD1_MATH7_FY09_NPR	39.23	77	27.271	3.108
Pair 2	OLD1_MATH7_FY09_NPR	39.23	77	27.271	3.108
	NEW1_MATH8_FY10_NPR	36.43	77	27.774	3.165

Table 2 contains inferential statistical information about the differences between two variables. Paired-samples *t*-tests determine whether or not two scores are significantly different from each other. In pair 1 calculations, student achievement at the old building compared the FY2008 mathematics NPR scores to FY2009 mathematics NPR scores. The calculated mean for pair 1 FY2008 mathematics ITBS/NPR scores was 39.25 (sd = 27.083) and the mean for pair 1 FY2009 mathematics ITBS/NPR scores was 39.23 (sd = 27.271). For pair 1, no significant difference from FY2008 mathematics ITBS/NPR scores to FY2009 mathematics ITBS/NPR scores was found ($t(76) = .009$, $p > .05$).

For pair 2, Table 2 compares the paired-samples *t*-test calculations for student achievement in seventh grade at the old building to the student achievement in eighth grade at the new building. The mean for pair 2 FY2009 mathematics ITBS/NPR scores was 39.23 (sd = 27.271) and the mean for pair 2 FY2010 mathematics ITBS/NPR scores was 36.43 (*sd* = 27.774). For pair 2, no significant difference from FY2009 mathematics ITBS/NPR scores to FY2010 mathematics ITBS/NPR scores was found ($t(76) = 1.792$, $p > .05$). The .077 significance level is close to the p-value of .05.

Table 2

Cohort Group 1 Mathematics Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	OLD1_MATH6_FY08_NPR - OLD1_MATH7_FY09_NPR	.013	13.148	1.498	-2.971	2.997	.009	76	.993
Pair 2	OLD1_MATH7_FY09_NPR - NEW1_MATH8_FY10_NPR	2.805	13.736	1.565	-.313	5.923	1.792	76	.077

Note: Statistical significance between the means of the paired-dependent variables is determined by an alpha or p-value of .05 or $p < .05$, two-tailed.

Cohort Group 1 Science Analysis

Table 3 describes the basic descriptive statistics for paired variables statistics in cohort group 1 that is comprised of 77 students. Cohort group 1 students were in sixth grade and seventh grade at the old middle school from FY2008 to FY2009 then transferred to the new middle school for eighth grade during FY2010. Scores for science variables are from the Iowa Assessment results in the Iowa Testing Programs. Pair 1 compares the ITBS science test results from the fall of 2007 to the spring of 2009 in the old school. During the FY2008 school year, the school decided to change from fall testing norms to spring testing norms in the Iowa Testing Programs. The mean for pair 1 science FY2008 ITBS/NPR scores was 39.04, with a standard deviation of 26.654. The mean for pair 1 FY2009 science ITBS/NPR scores was 38.65, with a standard deviation of 24.784.

For cohort group 1, Table 3 also compares descriptive statistics for pair 2 science NPR scores from the spring of 2009 at the old school to the spring of 2010 at the new school. The mean for FY2009 science NPR scores was 38.65, with a standard deviation of 24.784. The mean for FY2009 science ITBS/NPR scores was 43.04, with a standard deviation of 23.879.

Table 3

Cohort Group 1 Science Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	OLD1_SCI6_FY08_NPR	39.04	77	26.654	3.038
	OLD1_SCI7_FY09_NPR	38.65	77	24.784	2.824
Pair 2	OLD1_SCI7_FY09_NPR	38.65	77	24.784	2.824
	NEW1_SCI8_FY10_NPR	43.04	77	23.879	2.721

Table 4 contains inferential statistical information about the differences between two variables. Paired-samples *t*-tests determine whether or not two scores are significantly different from each other. In pair 1 calculations, student achievement at the old building compared the FY2008 science NPR scores to the FY2009 science NPR scores. The calculated mean for pair 1 FY2008 science ITBS/NPR scores was 39.04 ($sd = 26.654$) and the mean for pair 1 FY2009 mathematics ITBS/NPR scores was 38.65 ($sd = 24.784$). For pair 1, no significant difference from FY2008 science ITBS/NPR scores to FY2009 science ITBS/NPR scores was found ($t(76) = .188$, $p > .05$).

For pair 2, Table 4 compares the paired-samples *t*-test calculations for student achievement in seventh grade at the old building to the student achievement in eighth grade at the new building. The mean for pair 2 FY2009 science ITBS/NPR scores was 38.65 ($sd = 24.784$) and the mean for pair 2 FY2010 science ITBS/NPR scores was 43.04

(*sd* = 23.879). For pair 2, a significant increase from FY2009 science ITBS/NPR scores to FY2010 science ITBS/NPR scores was found ($t(76) = -2.312$, $p < .05$).

Table 4

Cohort Group 1 Science Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	OLD1_SCI6_FY08_NPR OLD1_SCI7_FY09_NPR	.390	18.205	2.075	-3.742	4.522	.188	76	.852
Pair 2	OLD1_SCI7_FY09_NPR NEW1_SCI8_FY10_NPR	-4.390	16.659	1.898	-8.171	-.608	-2.312	76	.023

Note: Statistical significance between the means of the paired-dependent variables is determined by an alpha or p-value of .05 or $p < .05$, two-tailed.

Cohort Group 2 Mathematics Analysis

Table 5 describes the basic descriptive statistics for paired variables statistics in cohort group 2 that is comprised of 81 students. Cohort group 2 students were in sixth grade at the old middle school during FY2009 then transferred to the new middle school for seventh grade in FY2010 and eighth grade in FY2011. Scores for mathematics variables are from the Iowa assessment results in the Iowa Testing Programs. Pair 1 compares the ITBS mathematics test results from the spring of 2009 at the old school to the spring of 2010 at the new school. The mean for pair 1 FY2009 mathematics ITBS/NPR scores was 38.56, with a standard deviation of 28.599. The mean for pair 1 FY2010 mathematics ITBS/NPR scores was 38.70, with a standard deviation of 26.617.

Table 5 also compares descriptive statistics for pair 2 mathematics NPR scores from the spring of 2010 to the spring of 2011 at the new school. The mean for FY2010 mathematics ITBS/NPR scores was 38.70, with a standard deviation of 26.617. The mean for FY2011 mathematics ITBS/NPR scores was 36.23, with a standard deviation of 23.328.

Table 5

Cohort Group 2 Mathematics Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	OLD2_MATH6_FY09_NPR	38.56	81	28.599	3.178
	NEW2_MATH7_FY10_NPR	38.70	81	26.617	2.957
Pair 2	NEW2_MATH7_FY10_NPR	38.70	81	26.617	2.957
	NEW2_MATH8_FY11_NPR	36.23	81	23.328	2.592

Table 6 contains inferential statistical information about the differences between two variables. Paired-samples *t*-tests determine whether or not two scores are significantly different from each other. In pair 1 calculation for mathematics, student achievement at the old school during FY2009 was compared to FY2010 student achievement at the new school. The calculated mean for pair 1 FY2009 mathematics ITBS/NPR scores was 38.56 (sd = 28.599) and the mean for pair 1 FY2010 mathematics ITBS/NPR scores was 38.70 (sd = 26.617). For pair 1, no significant difference from FY2009 mathematics ITBS/NPR scores to FY2010 mathematics ITBS/NPR scores was found ($t(80) = -.086$, $p > .05$).

For pair 2, Table 6 compares the paired-samples *t*-test calculations for student achievement in mathematics at the new building during FY2010 and FY2011. The mean for pair 2 FY2010 mathematics ITBS/NPR scores was 38.70 (sd = 26.617) and the mean for pair 2 FY2011 mathematics ITBS/NPR scores was 36.23 (sd = 23.328). For pair 2, no significant difference from FY2010 mathematics ITBS/NPR scores to FY2011 mathematics ITBS/NPR scores was found ($t(80) = 1.545$, $p > .05$).

Table 6

Cohort Group 2 Mathematics Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	OLD2_MATH6_FY09_NPR NEW2_MATH7_FY10_NPR	-.148	15.465	1.718	-3.568	3.272	-.086	80	.932
Pair 2	NEW2_MATH7_FY10_NPR NEW2_MATH8_FY11_NPR	2.469	14.384	1.598	-.711	5.650	1.545	80	.126

Note: Statistical significance between the means of the paired-dependent variables is determined by an alpha or p-value of .05 or $p < .05$, two-tailed.

Cohort Group 2 Science Analysis

Table 7 describes the basic descriptive statistics for paired variables statistics in cohort group 2 that is comprised of 81 students. Cohort group 2 students were in sixth grade at the old middle school during FY2009 then transferred to the new middle school for seventh grade in FY2010 and eighth grade in FY2011. Scores for science variables are from the Iowa Assessment results in the Iowa Testing Programs. Pair 1 compares the ITBS science test results from the spring of 2009 in the old school to the spring of 2010 in the new school. The mean for pair 1 FY2009 science ITBS/NPR scores was 38.37, with a standard deviation of 23.832. The mean for pair 1 FY2010 science ITBS/NPR scores was 45.95, with a standard deviation of 25.617.

For cohort group 2, Table 7 also compares descriptive statistics for pair 2 science scores from the spring of 2010 to the spring of 2011 at the new school. The mean for FY2010 science ITBS/NPR scores was 45.95, with a standard deviation of 25.617. The mean for FY2011 science ITBS/NPR scores was 42.69, with a standard deviation of 21.894.

Table 7

Cohort Group 2 Science Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	OLD2_SCI6_FY09_NPR	38.37	81	23.832	2.648
	NEW2_SCI7_FY10_NPR	45.95	81	25.617	2.846
Pair 2	NEW2_SCI7_FY10_NPR	45.95	81	25.617	2.846
	NEW2_SCI8_FY11_NPR	42.69	81	21.894	2.433

Table 8 contains inferential statistical information about the differences between two variables. Paired-samples *t*-tests determine whether or not two scores are significantly different from each other. In pair 1 calculations for science, student achievement at the old school during FY2009 was compared to FY2010 student achievement at the new school. The calculated mean for pair 1 FY2009 science ITBS/NPR scores was 38.37 (sd = 23.832) and the mean for pair 1 FY2010 science ITBS/NPR scores was 45.95 (sd = 25.617). For pair 1, a significant increase from FY2009 science ITBS/NPR scores to FY2010 science ITBS/NPR scores was found ($t(80) = -3.741$, $p < .05$).

For pair 2, Table 8 compares the paired-samples *t*-test calculations for student achievement in science at the new building during FY2010 and FY2011. The mean for pair 2 FY2010 science ITBS/NPR scores was 45.95 (sd = 25.617) and the mean for pair 2 FY2011 science ITBS/NPR scores was 42.69 (sd = 21.894). For pair 2, no significant difference from FY2010 science ITBS/NPR scores to FY2011 science ITBS/NPR scores was found ($t(80) = 1.659$, $p > .05$).

Table 8

Cohort Group 2 Science Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	OLD2_SCI6_FY09_NPR - NEW2_SCI7_FY10_NPR	-7.580	18.239	2.027	-11.613	-3.547	-3.741	80	.000
Pair 2	NEW2_SCI7_FY10_NPR - NEW2_SCI8_FY11_NPR	3.259	17.678	1.964	-.650	7.168	1.659	80	.101

Note: Statistical significance between the means of the paired-dependent variables is determined by an alpha or p-value of .05 or $p < .05$, two-tailed.

Research Questions 2 and 3

The administrators group and the teachers group were interviewed separately to gain perception from both groups about the impact the new physical learning environment has on teaching and student learning. The interview sessions began with collecting information about the years of experience as a teacher or administrator, years of experience in the school district, and years of experience at the old middle school. This experience data in figures 1, 2, 3, 4, 5, and 6 provides information about the length of time that these educators have worked together. For both groups, the same seven interview questions were asked to collect information about how the new physical learning environment has changed teaching strategies, student achievement, instructional technology, students' levels of motivation and engagement, and parental involvement. Interviewing in this qualitative investigation was considered semi-structured because the questions were flexible and less structured to explore the impact of the new facility on teaching and learning. Seven interview questions were designed to collect data for research questions 2 and 3. Research question 2 focused on how teaching strategies changed from the old building to the new building. Research question 3 focused on how student achievement was impacted by the changes in teaching strategies in the new building.

Focus group interviews were used for the administrators and teachers groups. The group interview format can be defined as a conversation with a purpose to collect data (Merriam, 2009). The common experience of the focus group allowed the study participants to hear other responses and make additional comments beyond their own original responses. The objective of the focus group interview technique is to gain high-quality data in a social context where respondents can consider their own views in the context of the views of others. Focus group interviews are advantageous when interviewees are similar and cooperative with each other (Creswell, 1998). An informed consent document (see Appendix C for the Human Participants Review Informed Consent document) was presented to the study participants to explain the nature and extent of their participation in the project and confirm their agreement to participate in the study. The consent form was collected from willing participants prior to the focus group interview session. All conversations and interview responses were treated with utmost respect and confidentiality. Conversations at the interview sessions were audio recorded with an iPad tablet so that full transcriptions of the interviews could be used in the study. After transcribing information from the interview session, themes were identified for each of the interview questions. An analysis of the transcriptions identified themes for each of the interview questions. Themes were identified in the order discussed at the interview and are not prioritized in ordinal position. A comparison of themes between both focus group interviews helped to determine the common themes for answering research questions 2 and 3.

Administrators Focus Group Interview

The new 21st-century-designed middle school has now been open for four years. The focus group interview with the two administrators was conducted on March 14, 2013, during a session of 40 minutes. A conference room at the new school was arranged for the interview. Due to the busy schedules of the administrators, there was limited time for the interview session so it was important to focus on the seven interview questions. The principal explained that he had the opportunity to select the administrative team for the new building. Both the principal and assistant principal were at the old middle school for one year prior to transitioning into the new building.

Administrator experience. The two administrators were asked about the total number of years of administrative experience. Figure 1 shows that the principal has 14 years' experience and the assistant principal has 15 years' experience as administrators.

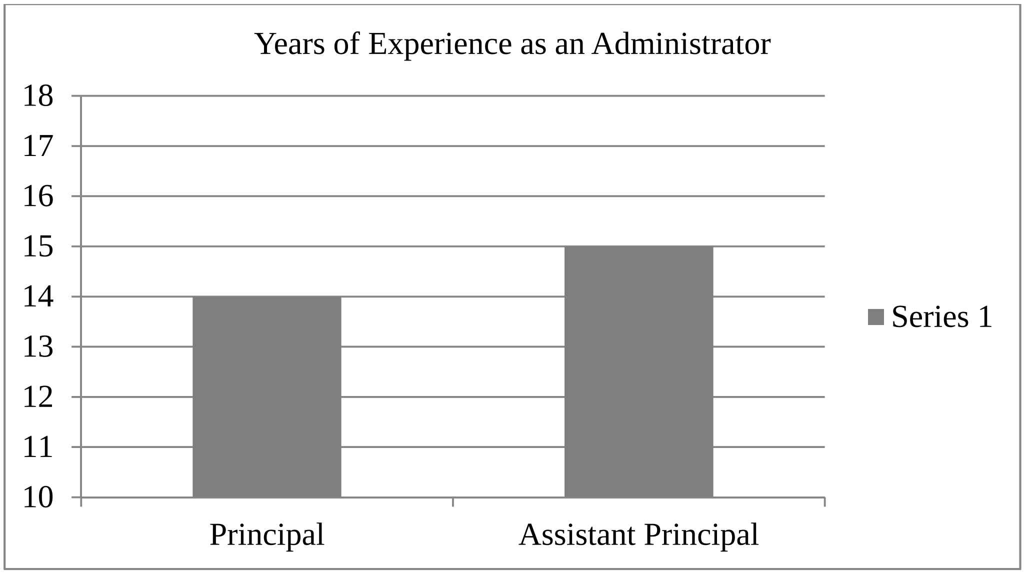

Figure 1 Administrators: Total Years of Experience as an Administrator

Next, the administrators were asked about the total number of years of experience in this school district. Figure 2 shows that the principal has 10 years' experience and the assistant principal has five years' experience working in the school district.

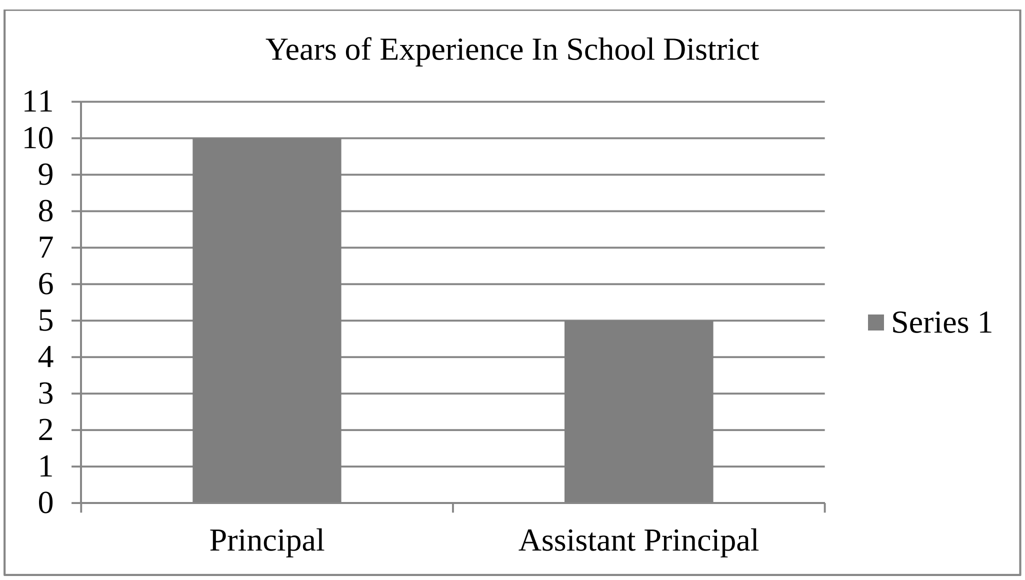

Figure 2 Administrators: Total Years of Experience in the School District

The final informational question about administrative experience was asking about the total number of years experience working at the old middle school. Figure 3 shows that both the principal and assistant principal have one year of experience working at the old middle school before transitioning to the new 21st-century-designed middle school.

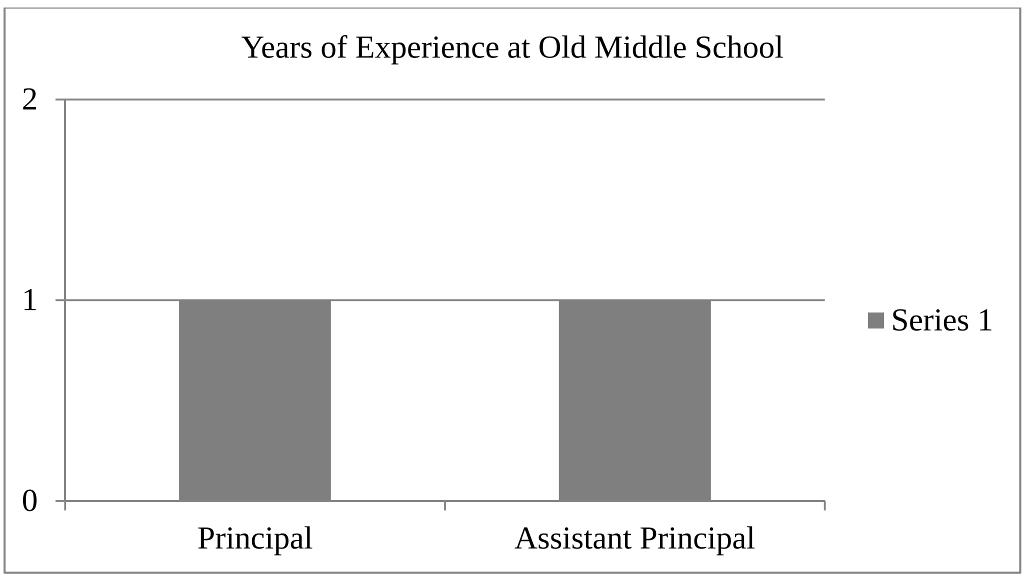

Figure 3 Administrators: Total Years of Experience at the Old Middle School

<u>Transcription of administrators focus group interview</u>. Conversations from the interview session were transcribed from the audio recordings. The following information contains the seven interview questions and the transcription of the conversation with the administrators in regard to the interview questions. Following the transcription of each

interview question is a list of themes identified in the order discussed at the interview and not prioritized in ordinal position.

Question 1: How has the new physical learning environment designed for STEM curriculum changed teaching strategies and techniques?

Building was not designed specifically for STEM but decided to implement STEM curriculum after design of the new school. Design of science classrooms and multiple technological hook-ups are now common to most new school construction. Design of this building has changed instruction, attitude of students, expectations of staff, and culture of the school. All of these variables are wrapped into the environment we're in. When the students see all the facilities, equipment, and resources needed to provide a high quality of instruction, the students tend to live up to our standards. The capabilities of this building as compared to the old facility are much higher. Promethean boards have been installed in every classroom, which has opened up all sorts of instructional capabilities for teachers. Lightspeed Technology sound systems have been installed in classrooms to balance the sound to allow students to hear better – no matter where they are seated. Teachers take advantage of this technology to make it possible for instruction to be at a higher level.

The school has integrated STEM throughout entire curriculum, including core curriculum, to offer every opportunity for students to explore science, technology, engineering, and mathematics in all courses. The physical environment has made it conducive for teaching STEM. Exploratory classes are taught in a lab outside the building where modular labs for flight simulators, sewing machines, etc., allow students to get hands-on STEM experiences. The school also offers a course on robotics where students program robots and run the robotic program in the building and integrate activities in the core curriculum. Teachers use spaces within the building, such as hallways and pod areas, to extend the learning space. There is a pod area for each grade level.

The following is a list of themes for interview question 1 identified in the administrator focus group interview:

- Design of the new building has changed instruction, attitude of students, expectations of staff, and culture of the school.
- Promethean boards have expanded teaching strategies.
- Lightspeed Technology sound system has improved the physical learning environment by enhancing the sound in classrooms that allows students to hear better.
- The new physical learning environment has been conducive for STEM to be integrated throughout the entire curriculum for expanding the exploration of science, technology, engineering, and mathematics in all courses.
- The new physical learning environment has learning pods that provide extended learning space for small- and large-group learning.

Question 2: How has the new physical learning environment affected learning behaviors and/or student achievement?

The difficult part of this question was that the physical environment was not the only thing that changed. Dress code and curriculum were also changed when entering the new building. We believe that the physical environment was a major contributor to establishing the culture and high expectations, making sure that everything we do is at a high-quality level. As for academic performance, this recipe of the new physical learning environment, dress code, and curriculum is not an overnight change. We have to build these skills into our students and raise expectations to change the culture over time. We've had some bumps in the academic results of the Iowa Testing Program, and several years we were stagnant in our results, but we are nowhere near to what we would consider acceptable. This is the first year that we have seen multiple data points that show that academic achievement is improving. In the past we have seen sporadic improvements and declines in different areas of academic achievement. This year, everything seems aligned, where disciplinary referrals have declined 50%, academic scores in benchmark tests and Skills Iowa Assessments have increased, and the in-house-created Common Form Assessments (CFA) have shown growth, which all point toward positive improvements in reading, mathematics, and science. We feel confident that we're moving in the right direction and we're hoping for improved results in the Iowa Testing Program. The district has done a correlation study with Skills Iowa results and how they compare to the predictable outcomes with the Iowa Testing Program, and the results show a tight correlation between the two programs for academic improvement.

The quantitative data for the Iowa Testing Program results is not where we want it to be. However if we look at our qualitative data, our anecdotal records indicate that students are more engaged in the classroom and students are doing more hands-on activities. Students talk about these activities and are going through a process of learning where they internalize what they have learned by applying it to their everyday lives. We see students applying the knowledge gained from STEM and core instruction. We're hoping for a strong correlation between the STEM and core instruction with the Iowa Testing Program. We have to remember that the standardized test results from the Iowa Testing Program is a snapshot of how students did on that particular day and does not give a full picture of students' academic progress. Along with the reduced disciplinary referrals, attendance has increased. When comparing attendance data at the old school with the new school, attendance has increased.

The following is a list of themes for interview question 2 identified in the administrator focus group interview:

- The physical learning environment was a major contributor to establishing the culture and high expectations in the new school.
- There have been sporadic improvements and declines in different areas of academic achievement.
- Disciplinary referrals have declined 50%.
- Anecdotal records from the staff have indicated that students are more engaged in the classroom and students are doing more hands-on activities.
- When comparing attendance data at the old school with the new school, attendance has increased.

Question 3: Do teachers have greater access to instructional technologies that assist with meeting learning objectives in the new school when compared to the old facility? Why/How?

There are many ways that teachers have greater access to instructional technologies because the new facility has the capability of supporting much more technology. Wireless access points throughout the building provide great flexibility for the use of technology devices, such as classroom computers, three laptop carts, and two well-stocked computer labs. Some teachers have submitted for grants from the Community Schools Foundation and received a class set of tablets. The old facility could not support all the technology that is currently available in the new facility to support instruction. The software capabilities of the Promethean boards have been a huge asset for teaching and lesson planning. Promethean boards have been instrumental in developing flip charts that has changed planning daily lessons.

The increased access to instructional technology has allowed for collaboration. When we have instructors teaching the same subject, they share documents through technology. Teachers collaborate to provide the most optimal learning experience for our students. Administrators have interviewed teachers through the technology of Skype and hired teachers from other states through technology.

The following is a list of themes for interview question 3 identified in the administrator focus group interview:

- The new facility supports wireless access points to provide greater flexibility for the use of technology, such as classroom computers, mobile laptop stations, computer labs, tablets, and Promethean boards.
- The software capabilities of Promethean boards have been a huge asset for classroom instruction and lesson planning.

- Increased access to instructional technology has allowed for more collaboration between teachers and sharing instructional documents to provide the most optimal learning experience for students.
- Administrators have used technology for interviewing teachers from other states.

Question 4: How has the new physical learning environment contributed to students' levels of motivation and engagement?

The administrators felt that students' experiences in school form their perception of the importance of education. When students feel that the school district does not portray a strong importance in education, then why should students feel that education is important? It's possible for a run-down school building to provide a good learning environment, but the initial feeling of students about the run-down conditions of a building indicate that the school district does not care about the learning environment. Students at this school do not feel this way because we try to set a good climate with the students through the actions of staff and classroom lessons, but the physical learning environment sets the standard. Students know that we are invested with what we do with them.

Design of the school building, such as integrating the design of learning pods, connecting classrooms to computer labs, and the structure of the career technical education rooms, has contributed to students' motivation and engagement at school. Within the regular core academic pods, each pod is designed in a horseshoe shape instead of a long, linear design. This pod design allows room in the middle of the pod as a common area to pull groups of students or entire classes out to change the learning environment, separate into smaller groups, and work with mentors. The pods' common areas have taken away the feeling of isolation that teachers feel in traditional classrooms and have allowed for interaction with other classes due to the close proximity to one another. The pods have a short hallway but not a huge gap between classrooms like traditional schools.

Design of the school's pods provides a sense of not having a single classroom but a feeling of a classroom without walls and with open boundaries that allows flexibility in the learning environment for individual, and small- and large-group learning. The pods create a collaborative learning environment that is integrated throughout the learning process at this school. When we were in school, we were taught so that we could go out and do later. Our students are programmed the opposite way where they do, so they can learn. Every opportunity has been provided to feed their interest in learning and to provide the optimal learning experience for them.

From the administration and interaction with teaching teams, the pods' common areas have helped with supervision of students and providing assistance to teachers. Administrators have used the pods to be engaged in many different ways with staff and students through classroom observations and walk-throughs. Teachers know that administrators are available in the pods for visiting classrooms and assisting teachers.

The pods are useful for providing space for collaboration and forming professional learning communities. Pods create a space outside the regular classroom for professional learning communities that establish interaction between students and teachers. The common areas of the pods have allowed for student space to work on projects and have improved teacher supervision of students. The new facility is designed to be flexible to adapt to different teaching and learning styles. There are whiteboards on the big sliding doors in the common areas of the pods, which have allowed teachers to provide instruction outside the classrooms. The pods have reduced student traffic back and forth to the classroom and have increased instructional time.

The following is a list of themes for interview question 4 identified in the administrator focus group interview:

- A positive climate with the students is determined by the actions of staff and classroom lessons, but the physical learning environment sets the standard.
- Design of the school building using pods, rooms connected to computer labs, and the structure of the career technical education rooms have contributed to students' motivation and engagement at school.
- The design of the pods has a common area for small student groups or entire classes that allows for more interaction and collaboration with other classes.
- Pods have created a collaborative learning environment that is integrated throughout the learning process.
- The new facility is designed to be flexible to adapt to different teaching and learning styles to motivate and engage students.

Question 5: How has the new facility affected parental and community involvement?

The community and parents use the facility in many different ways. Attendance at sporting events has increased because we have facilities that are comfortable and inviting for parents. The new facility accommodates seating for 300 whereas with the old facility, folding chairs had to be set up for sporting events. All those positive interactions with parents and community members at the school will come back to their overall opinion of education. We want to create as many positive interactions with the community and families as we can. Community groups may contract with the school to use school facilities for adult and youth basketball leagues in the gymnasiums, master gardeners in the greenhouse, and many other family-based organizations such as Family First and Strengthening Families that use the facilities in the evenings to work with groups.

The community uses the outside facilities of the school such as the track to help increase physical activity for adults and youth. The school building is not considered just a school but a community facility that is inviting for parents and community members. We want the community to take a vested interest in the school. The school is only as strong as the community, and a negative perception of the community reflects on the school. The new school facility is important for improving the community.

The school has a very strong and engaged group of partners in education that are community business partners that support the school. The school supports our partners in education by visiting their businesses that engages the community business partner in the learning process.

Attendance at the parent site council, which is similar to a parent-teacher organization, and parent-teacher conferences has been disappointing. The school is continually working on the improvement of engagement of parents in these activities. Some parents do not feel comfortable in these settings and the school is working to improve this. Attendance at parent-teacher conferences has been averaging about 60% and has not improved. Attendance at the parent site council has typically been low except when there is a controversial issue such as dress code for students. The site council is a parent-teacher organization that assists with the decision-making process for the school.

As the administration have taken a multi-prong approach for changing the culture within this building, the music program has increased parental involvement from hardly any parents attending music events to now standing room only. This is attributed to what is going on within the classroom and interaction between teachers and students.

The following is a list of themes for interview question 5 identified in the administrator focus group interview:

- Attendance by the community and parents has increased at extracurricular activities because the new school is more accommodating and inviting.
- Community groups have the opportunity to contract with the school for use of facilities.
- The school building is not considered just a school but also a community facility because the new school facility is important for improving the community.

- Community business partners support the school by extending the learning experience for students through tours and visitations.
- Attendance for the parent site council and parent-teacher conferences has not improved since moving into the new facility.
- Parental involvement in the music program has increased through classroom activities and interaction with teachers.

Question 6: What was the most noticeable change physically, mentally, or socially among students after the transition to the new building?

The building culture as a whole has been a noticeable change. Data such as the reduction in major and minor disciplinary referrals supports this and even the severity of referrals has decreased. Behavioral referrals have decreased significantly the past two years. Last year we were down 40% in disciplinary referrals from the year before and this year we are down 50% from last year. Making two years in a row in the reduction of disciplinary referrals tells us that not only to the de-escalating strategies used by teachers have been working, but the students themselves have internalized the importance of education and are reacting in different ways than they used to.

The stigma about the old school was the perception of being a bad school and parents would voluntarily transfer their child from the old school when entering fifth grade. Changing the perception and the culture during the transition to the new school has created an environment where students want to attend the new school. Now parents want to transfer their child to the new STEM school and students are excited about attending the new STEM school.

There are still negative perceptions throughout the community about schools on the east side. To change that perception, the school has invited community members and parents to tour the new school and see what is going on in the building.

The following is a list of themes for interview question 6 identified in the administrator focus group interview:

- The most noticeable change about the transition to the new building was the culture.
- Data has indicated that there is a reduction in major and minor disciplinary referrals.
- Changing the community perception associated with the old school during the transition to the new school has created an environment where students want to attend school and parents want to transfer children to the new STEM school.

Question 7: What was your involvement in the design of the new school? Is there anything you would change?

The principal could not think of anything to change in the new school. The involvement of the current administrative team was after the initial planning was made. The administrative team was able to work with the architect with furniture choices, sound systems, Promethean boards, and outlets in the classrooms to accommodate technological needs. We were very lucky with the timing when the school was planned because it was the time when the Young Foundation decided to be involved with the school district to build a greenhouse. The foundation knew that the new school was interested in moving toward STEM and decided to build the new greenhouse at the new school to enhance the STEM curriculum. The Dick Young greenhouse has been very beneficial for our STEM curriculum. The school has signed an agreement with the Iowa State University (ISU) Extension Service for deciding who is responsible for different parts of the greenhouse operation. The ISU Extension Service has an office in the greenhouse and are responsible for managing and running the greenhouse.

Typically as we talk about the physical learning environment, the school has changed the instructional environment and culture by providing professional development for integrating STEM into all classes and developing curriculum for STEM courses. The school offered courses that interested students. The school developed partnerships with the University of Northern Iowa, Iowa State University, and the University of Iowa for developing STEM courses. The local police department assisted with developing a forensics curriculum that allows students to have hands-on, real-life experiences.

The assistant principal did not have any ideas for changes in the new school, but moving into the new facility has been both a growing and a learning experience. When developing curriculum and changing the climate and culture of our school, it has been a learning experience for our staff. This learning experience will help other new schools in the design and implementation of STEM curriculum. The flexibility in the physical learning environment of this 21st-century-designed school has enhanced the delivery of instruction for our STEM curriculum. Being involved in the final design phase of the building has helped with the integration of classroom technology.

The teachers will have varied opinions about their involvement in the design of the school. Some teachers had a large amount of involvement, and the former principal allowed design input but did not integrate their suggestions in the school design. The architectural firm was very cooperative with integrating the current administration's ideas into the school design and correcting design issues. In summary, this facility was designed with flexibility through the learning pods, and the integration of technology into classroom instruction has been very beneficial for preparing students for 21st-century learning skills.

The following is a list of themes for interview question 7 identified in the administrator focus group interview:

- The administrative team did not have any ideas for changes in the new school.
- The administrative team was able to work with the architect for selection of furniture, sound systems, Promethean boards, and outlets in classrooms to accommodate technological needs.
- During the planning phase of the new school, a local foundation donated funding for a greenhouse to enhance the STEM curriculum.
- The flexibility in the physical learning environment of the new school has enhanced the delivery of STEM instruction.
- The architectural firm was very cooperative with the integration of the current administration's ideas into the school design and correcting design issues.

Teachers Focus Group Interview

The new 21st-century-designed middle school has now been open for four years. The focus group interview with the teacher group was conducted on March 14, 2013, during a session of 66 minutes. A conference room at the new school was arranged for the interview. Due to the busy schedules of the teachers, there was limited time for the interview session so it was important to focus on the seven interview questions. With a larger group, the interview participants tended to stray during the interview session when answering open-ended questions. Teachers interviewed for this focus group interview were teachers that had teaching experience at the old middle school then transferred to the new 21st-century-designed middle school. Fourteen teachers were identified that had teaching experience at both schools. One teacher declined to participate in the study because of a scheduling conflict.

Teacher experience. The 13 remaining teachers were asked about the total number of years of teaching experience. Figure 4 has indicated that the teacher with the least experience had seven years teaching experience and the most experienced teacher had taught 39 years. These 13 teachers have 233 cumulative years of teaching, which indicates an experienced and knowledgeable staff.

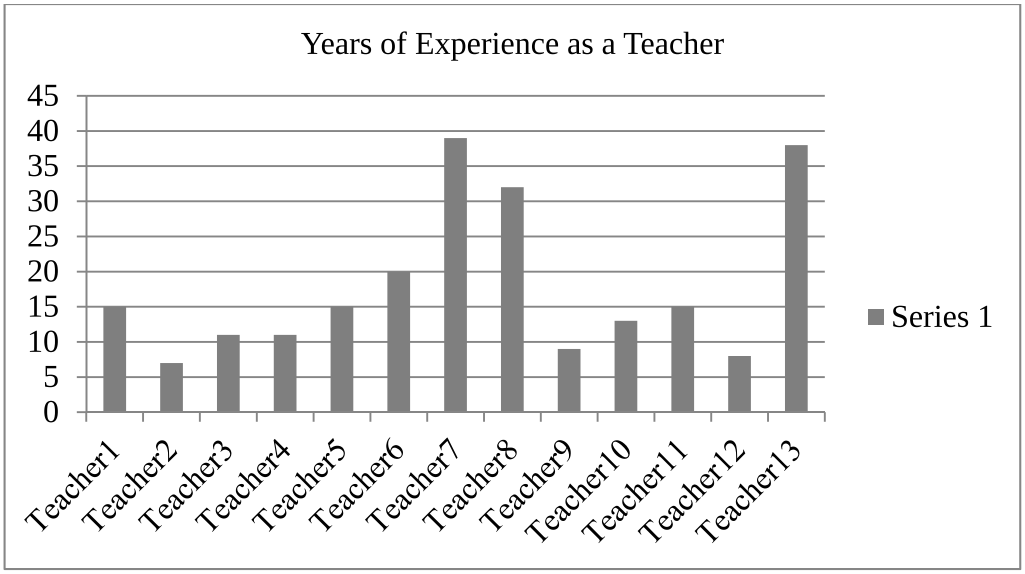

Figure 4 Teachers: Total Years of Experience as a Teacher

Next, the teachers were asked about the total number of years of teaching experience in this school district. Figure 5 shows that the teacher with the least experience in the school district has four years' experience and the teacher with the most experience in the district has 39 years' experience. For the teachers interviewed in this study, Figure 5 shows that all staff was tenured except for one teacher.

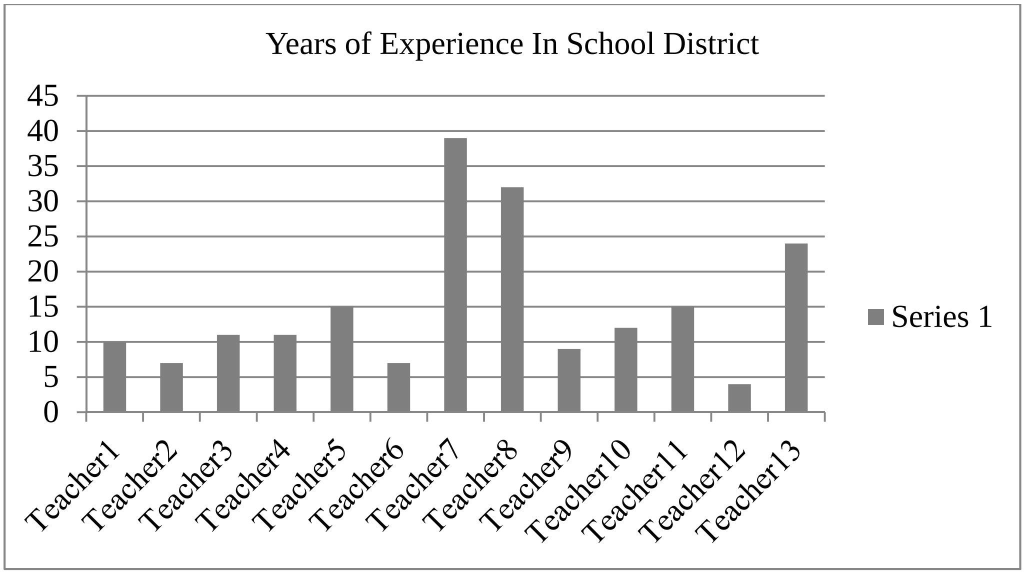

Figure 5 Teachers: Total Years of Experience in the School District

The final informational question about teaching experience was asking about the total number of years experience working at the old middle school. Figure 6 shows that one teacher had taught 32 years at the old middle school and three teachers had taught only three years at the old middle school before transitioning to the new 21st-century-designed middle school.

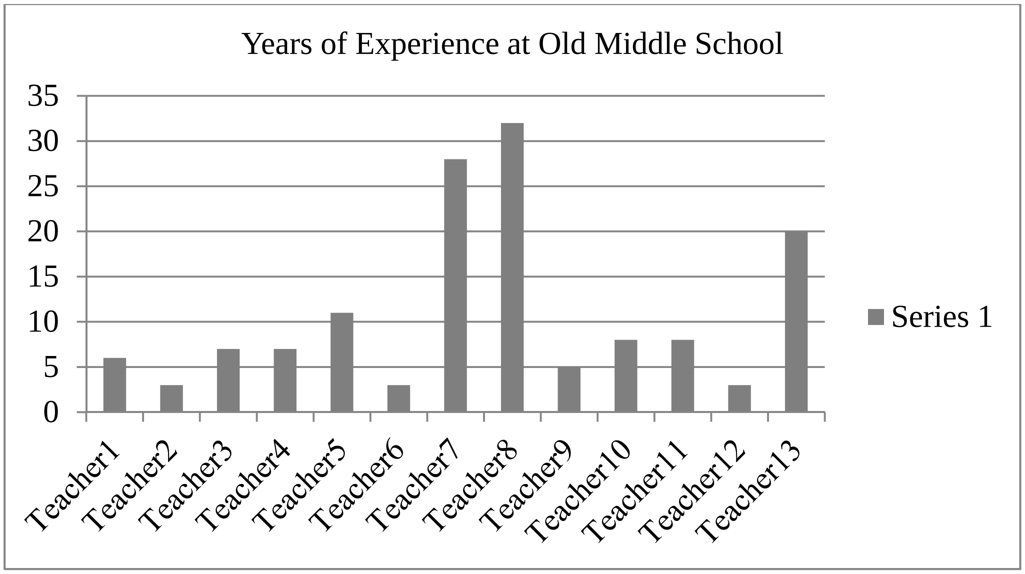

Figure 6 Teachers: Total Years of Experience at the Old Middle School

Transcription of teachers focus group interview. Conversations from the interview session were transcribed from the audio recordings. The following information contains the seven interview questions and the transcription of the conversation with the teachers in regard to the interview questions. Following the transcription of each interview question is a list of themes identified in the order discussed at the interview and not prioritized in ordinal position.

Question 1: How has the new physical learning environment designed for STEM curriculum changed teaching strategies and techniques?

The science room in the old building was originally a language arts classroom that did not have a sink, cabinets, and outlets for microscopes. After coming to the new building, the new science classroom felt like a professional learning environment that meets the learning needs of students. I was involved in locating the sinks, cabinets, and lab areas in the new science classrooms. In the new building, the science room has a roof exhaust fan but required the janitor to use a keyed switch to turn on the exhaust fan. A year later, I was given a key to switch on and off the exhaust fan during science experiments.

The gymnasium and locker rooms in the old building were very dingy. Nobody wanted to take showers in the old building because they had to shower together. The new building is much brighter and the shower rooms were designed for more privacy. The new gymnasium is much larger with improved acoustics.

The technology in the new building was one of the biggest improvements because the old building did not have Promethean boards and very little technology access to computers. Language arts and mathematics classrooms in the new building have the integrated classroom technology to assist in classroom instruction.

In the industrial technology area, many of my recommendations for the new building were applied but some were not. For instance, a lower exhaust hood for welding fumes and dust collection was not installed. I informed the architect about lower exhaust hoods but was told that the hoods would have to stay. I also wanted double exterior doors for moving projects and materials but was told that the double doors would break the air lock. Instead of double doors, a larger sidewalk was installed that doubled as a road for delivering materials. A larger door or small garage door was not installed to ease the delivery of materials because of building security. Since the exhaust hood or vent was not lowered, the sawdust goes up half-way and settles on the rafters.

For the computer applications and technology courses, technology was much improved in the new building. The wiring in the old building could not accommodate the updating of computers. It was difficult to move technology equipment in the old building because of the electrical issues. The technology was very slow because there was not much bandwidth, which limited use of computers. It was harder to teach in the old building because I was only able to tell students what buttons to push. In the new building, the Promethean boards enhance teaching through demonstrations. We also have software that shows thumbnails of each student's computer screen and allows me to help students from my computer. The computers were new when we entered this building and are now four years old. Even though the computers are four years old, the technology is very up to date. The bandwidth is much improved in the new building that allows our computers to operate much smoother. There has not been any instructional time lost due to technological problems.

Compared to the old building, air conditioning has been a huge improvement in the new building. In the old building, the windows were opened to cool classrooms. The new building has geothermal heating and cooling. Some rooms have problems with controlling the temperature, but the majority of the rooms have no problems.

For the counselor's office in the old school building, the office was within an office, which created a confidentiality issue when meeting with students and parents. The old office was also very small, which was not conducive for small-group meetings with students. Small-group meetings with students in the old school were in other classrooms or the library where it was difficult to have confidential discussions. The counselor's office in the new school is located away from classrooms with other offices but there is plenty of space in the office to conduct small-group sessions with students. To teach careers in the old building with three floors, it was difficult to move the laptop computers cart from one floor to another floor when the elevator was not working. Now in the new building, there are nice computer labs and everything is on one level for moving laptop carts. The old office was enclosed and did not have a window. The new office has a window that brightens the room for a good work environment. One teacher summed it up by saying the classrooms in the new school are brighter with more natural light, the sound system is better, and there’s better classroom technology.

For STEM education, the greenhouse has given our students more hands-on activities. Many of our students do not have experience in a setting for planting and growing plants. All core teachers had a STEM class in botany. For example, in the literacy class, the students learned about growing a salsa garden in the greenhouse.

The pod areas in the new school provide an open area to take students for co-teaching with another teacher. The pods assist with small-group instruction and provide flexibility for teachers in the delivery of instruction.

There are more storage areas in the new school for storage of curriculum materials for all teachers. Each science room has storage closets for storing science materials and projects.

In the old school building, punctuality and distance between some classes were concerns. When the library was on third floor and the lunchroom was on first floor in the old building, it was disruptive when students went through the halls to the lunchroom on a hot day when all the classroom doors were open. In the new building, everything is on one level and the building is air conditioned, which reduced the disruptive noise in hallways. The pods and a centrally located library helped to reduce travel through the hallways.

For special education and title programs in the old school, the teachers had to share classrooms and were also located on the lower level away from other teachers. Now in the new school, these programs are centrally located near the pods. The pods help provide more collaboration among the teachers to help students. Each pod has a teacher work area to provide a professional work environment. In the old building, the teacher work area or lounge was moved every year to any available space, including behind the stage.

In the new building, the science classroom near the greenhouse was designed to be locked and closed off to the community when the greenhouse is used by the extension service.

The librarian said that the Promethean boards enhanced teaching strategies and techniques through designing flipcharts, student presentations, and interactive lessons.

The following is a list of themes for interview question 1 identified in the teacher focus group interview:

- Compared to the old facility, the science room in the new school feels like a professional learning environment that meets the needs of students.

- The gymnasium and locker rooms in the new building have provided a learning environment that is brighter, that improved acoustics, and that increased privacy in the shower rooms.
- One of the biggest improvements that changed teaching strategies and techniques has been the integration of classroom technology to enhance instruction.
- Promethean boards have enhanced teaching through classroom demonstrations, student presentations, and interactive lessons.
- Air conditioning has been a huge improvement in comfort for the physical learning environment.
- The counselor’s office in the new school was designed for confidentiality and small-group discussions with students.
- The new greenhouse has been a major factor for enhancing STEM education through more hands-on learning activities.
- The design of the pod areas has promoted collaborative teaching, assisted with small-group instruction, and provided flexibility for the delivery of instruction.
- More storage areas were designed in the new school for storage of curriculum materials.
- The library is centrally located near the pods to reduce travel through the hallways and enhance classroom instruction.

- Special education and title programs are centrally located near the pods to provide more collaboration among the teachers for helping students.

Question 2: How has the new physical learning environment affected learning behaviors and/or student achievement?

The new building has a lot less hallway distractions for students in the classroom, which has had a positive impact on students inside and outside the classroom. Students are more involved with lessons. There is less hallway traffic in the new school, which has reduced hallway noise and distractions for students in the classroom. There are two main hallways in the new school, with smaller hallways in each of the learning pods that help to reduce student hallway traffic. The only time that students leave the pods is during the transition to exploratory classes.

The new physical learning environment has created a sense of professionalism amongst the teachers. The old building had a lot of graffiti and now the students have a sense of pride in the new building. The students that transferred from the old middle school to the new school appreciated what the school district did to provide a new physical learning environment for meeting the needs of 21st-century learners. These students also witnessed the construction process of the new school because the new school building was built on the same site as the old school.

For student achievement, the new school offers more options such as more classroom space available for co-teaching. The pod areas offer more space to deal with student behavioral issues instead of trying to find an empty room in the old school building. Pods offer space for learning communities where most of the instruction and behavioral issues are dealt with in the pod. The old building had long hallways with many blind spots that made it difficult to supervise students. With the design of learning pods within the new school, supervision of students was greatly improved and students do not need to move a long distance to reach their next class. The new school was designed with better visibility for supervising students that improved student behavior and academic achievement. The classrooms were designed to display posters and students' projects. Promethean boards assist with displaying lesson objectives and lesson assignments. The bulletin boards in the pod areas help with displaying posters and educational information. The school district was very willing to update instructional posters and other educational materials during the transfer from the old building to the new school building. The new school building was designed with better classroom lighting and more natural lighting in certain areas. There is one classroom in the new building with a very high ceiling and inadequate lighting. On a cloudy day, it is difficult for students to read and see materials on their desks. The room is very nice but the lighting needs to be improved.

The new school building is safer than the old school because all exterior doors are locked, visitors have to ring a buzzer to be admitted by the office, and there are security cameras. At the old building, anyone could enter the building off the streets and nobody would know who was in the building. The safety and security in the new building protects both the staff and students. Classroom doors have the classroom security locks that protect students and staff in the classrooms during a school building lockdown.

The energy efficiency of the new school has increased through automatic flush valves and faucets in restrooms. Eliminating paper towels in the restrooms has reduced paper waste. Motion sensors for room lights have also saved energy in the new school.

The following is a list of themes for interview question 2 identified in the teacher focus group interview:

- The learning pods have affected learning behaviors and student achievement by reducing hallway traffic and distractions, which has increased student engagement in classroom lessons.
- The physical learning environment has created a sense of professionalism amongst teachers and a sense of pride for the students.
- The pod areas offer more options for instruction and space for dealing with student behavioral issues.
- The new school was designed with better visibility for supervising students, which improves student behavior and academic achievement.
- Classrooms were designed to display posters and students' projects.
- Promethean boards assist with displaying lesson objectives and lesson assignments.
- Better lighting and more natural lighting was designed into the new physical learning environment to improve student achievement.
- School safety was improved through locking of exterior doors, buzzer for admittance, and security cameras.
- Energy efficiency was improved in the new physical learning environment.

Question 3: Do teachers have greater access to instructional technologies that assist with meeting learning objectives in the new school when compared to the old facility? Why/How?

Teachers remember the computer lab in the old school where the computers were outdated and used floppy drives. After being in the new school for four years, we tend to take the updated computer technology for granted. The new school has better internet, more computers, and more dependable equipment. Now the computers from four years ago need updating.

The new school has three mobile computer labs, four computers in every classroom, two computer labs, and each grade level has 30 computers on a cart. There is no problem finding a computer compared to the old school that had one computer per classroom. Now students do not need to transition to another room to use computers. The special education classes use iPads for some special needs children who have difficulty using a regular computer. A seventh grade classroom is using iPads in the classroom as a pilot program to determine the benefits in the classroom.

The old school had green chalkboards, mobile televisions that had to be moved from classroom to classroom, overhead projectors, and 16mm film projectors with screens that would fall down occasionally. Now every classroom has LCD projectors, Promethean Boards, and white boards. The updated technology in the new building has changed and enhanced teaching for teachers and learning for students. Every classroom has an electronic cabinet that has a laptop computer, DVD player, and Lightspeed sound system with a teacher microphone and speakers in the ceiling that are controlled by the teacher.

Flooring surfaces in the new school have carpeting in the classrooms to reduce noise and hard surface flooring in science and art classrooms.

The following is a list of themes for interview question 3 identified in the teacher focus group interview:

- Compared to the old school with a computer lab with outdated computers and one computer per classroom, the new school has better internet, more computers, and more dependable equipment.
- Teachers have greater access to instructional technologies through a pilot program using iPads, three mobile computer labs, four computers for every classroom, two computer labs, and each grade level has 30 computers on a cart.
- Each classroom has LCD projectors, Promethean boards, white boards, and an electronic cabinet that has a laptop computer, DVD player, and a Lightspeed system with a teacher microphone and ceiling speakers that are controlled by the teacher.

Question 4: How has the new physical learning environment contributed to students' levels of motivation and engagement?

The new physical learning environment had a huge impact in botany and STEM classes. Students are very motivated by the greenhouse once they understood what a greenhouse has to offer. Students' motivation and engagement in botany class increased with hands-on and outside activities. Students choose from seven STEM classes such as robotics, engineering, botany, chemistry, applied mathematics, etc. Students select their top three STEM classes that interest them, which is a motivational factor for students. Through the interest of students, robotics was offered as an after-school program. Students take elective applied STEM classes, five exploratory classes that include physical education, art, and career and technical education, or CTE, and the core curriculum classes.

The physical layout of the new school has caused students to be more engaged because of fewer distractions. When the windows were open in the old school, birds and wasps would enter the building creating disruption in the classrooms, and the highway traffic was very distracting. The climate-controlled new building does not have the distractions like in the old school and the new school building was built far enough from the highway to reduce traffic noise. When the new highway is constructed, the old middle school will be razed.

The school board has been very helpful in providing technology for the school that helps students to be engaged in school. Technology has provided quickness in learning new topics, some textbooks are online where they can be viewed on the Promethean board, and research topics can be googled using the Promethean board to show immediate results to students.

The librarian noted that students are motivated by the student-developed projects, which helps student to be more engaged in their learning. There is more space in the pod areas for students to work on projects.

The following is a list of themes for interview question 4 identified in the teacher focus group interview:

- STEM classes in the greenhouse have been very motivational for students.
- The new physical learning environment has accommodated the instruction of STEM classes such as robotics, engineering, botany, chemistry, and applied mathematics, which has been a very motivational factor for students.
- The physical layout of the new school has caused students to be more engaged because of fewer distractions.
- The new technologies of Promethean boards and online textbooks have increased the speed of researching topics of interest for the students.
- The library and the pods have provided more space for student-developed projects that have helped students to be more engaged in their learning.

Question 5: How has the new facility affected parental and community involvement?

In the beginning, many parents came to the new building. New families that moved into the district were also interested in the new school. The newness of the school building attracted many parents. During the first year at the new school, the counselor felt like a tour guide. After a tour of the new school, many parents were satisfied with the changes and sent their children to this school. The new school helped to increase student enrollment.

Community members also rent the school facilities for various reasons such as basketball leagues and greenhouse master gardeners. With the seating in the new gymnasium, the community is able to have basketball tournaments. The old gymnasium did not have seating for spectators. The visiting-school sports teams changed their attitude when visiting the new school because of the nice gymnasium, concession stand, and locker rooms.

Some parents sent their children to the new school specifically for the STEM education. The new school erased the stigma of the old school through the 21st-century-design and STEM implementation. More parents come in for eighth-grade promotion and concerts because of the nice facilities.

For parent-teacher conferences, more parents came in the beginning during the newness of the new building. After the newness wore off, parental involvement in parent-teacher conferences dwindled. The counselor pointed out that the attendance trend for parent-teacher conferences at middle schools decreases when compared to elementary schools. Elementary parent-teacher conferences are scheduled whereas middle school parents are invited to conferences.

The science teacher stated that parents were also drawn to the new school because of the greenhouse and the recognition that this school was one of the first STEM middle schools in Iowa. In the beginning, the greenhouse was the most popular draw for parents.

The attendance for the monthly meetings of the parent-teacher organization has been consistently low depending on the event. Parent attendance has increased for the reading event. The level of engagement of parents for certain events, like mathematics and reading night, Black history night, and holiday concerts, has increased because of the enticements, such as snacks offered at some events. The monthly parent-teacher meetings or site council meetings do not offer an enticement and consequently the attendance is low. Parent attendance increases at site council meetings when there is a controversial issue. An example of a controversial issue was when the school adopted a strict dress code. The current dress code is less strict since the school abides by the school district dress code. The school had its own dress code for three years before implementing the more relaxed district dress code. During the first year at the new school, the eighth-grade students fought the dress code the most. Teachers felt that the dress code has made a difference in student behavior and building climate. Along with the student dress code, the teachers also had a dress code. The teacher dress code has emphasized a sense of professionalism that has impacted students. Some young male students in eighth grade have begun to wear ties because of the role model of male teachers. Now the boys want to wear sweater vests and suspenders because they really want to dress nicely. The dress code for teachers has become a role model for students that has impacted students' self-esteem and the school climate.

The following is a list of themes for interview question 5 identified in the teacher focus group interview:

- The new facility has attracted many families, which has increased student enrollment.
- Community members may rent the school facilities for community recreational and adult learning events.
- Parents have been attracted to the new school because of STEM education, which has erased the stigma of the poorly performing old middle school.

- When the building was new, attendance at parent-teacher conferences increased but parental involvement decreased after time.
- Attendance at the parent site council has been consistently low unless there is a controversial issue.
- Parents have been more involved in student activities, such as mathematics and reading night, Black history night, and holiday concerts.

Question 6: What was the most noticeable change physically, mentally, or socially among students after the transition to the new building?

In the beginning, the students that transferred from the old school were very proud and protective of their new school building. Students were surprised that the school district would build such a nice facility for them. As students changed during the past two years, these students came from updated school facilities and air conditioning that has caused students to take this new school for granted. Current students have not experienced the poor facility conditions as have the students that transferred from the old school to this new school. Our current students appreciate the new school but not like the students who transferred from the old school. The school district has built several new elementary schools, new additions, and made many facility improvements throughout the district over the past years. Students have been very protective of their school, which is a source of pride that has reduced graffiti. The pods have provided flexibility for instruction that has induced more collaboration of students and staff and has helped students develop better social skills. The design of the new school has provided better flow of students between classes. Students have shown a real appreciation for the new learning environment. One teacher noted that the social behavior of middle school students was about the same as in the old building. Middle school students enjoy being with their peers.

The following is a list of themes for interview question 6 identified in the teacher focus group interview:

- Students who transferred from the old middle school were very proud and protective of their new school building.
- The pods have impacted students through flexibility of instruction, promoted more collaboration of students and staff, and have helped students develop better social skills.
- Design of the new school has provided better traffic flow and supervision of students between classes.

Question 7: What was your involvement in the design of the new school? Is there anything you would change?

During the design phase of the school, the design team listened to some staff members who are no longer at this school and some of the room designs were designed around their teaching strategies. For example, there is a science classroom designed around one teacher's theme that would not be considered by other teachers. The architectural designers would implement some of the recommendations of teachers but not all recommendations. One glitch in the design process was the old principal was involved in the majority of the design process, then the new principal arrived toward the end of the building design phase. The new principal thought the design process was completed, and nothing about the design was discussed until some of the classroom electrical and technology needs were discovered.

One teacher said there is a shortage of hallway lockers because of the increased student enrollment. Since the first year of occupying the new building, two students are assigned to each locker. Lockers are located in the pod areas and some hallways. Lockers in the pod areas are arranged in a C-shape for easy supervision. For classrooms in the long hallway, it is difficult for teachers to supervise students near the restrooms and in the pod area. This concern about a blind spot was brought to the attention of the design team but the architects said that the design was too far along to change.

Teachers in the special needs area said that the rooms were designed too small to accommodate the number of special needs students assigned to the classrooms. When the classrooms are too crowded, special needs teachers have to share a space in another classroom. Special needs classrooms should have been designed to be wider. The special needs classrooms are located on the end inside the building without natural light. Besides the special needs pull-out program for students, special needs teachers also co-teach in the regular classrooms so that special needs students are learning in the least restrictive learning environment.

Teachers would like to see regular bookshelves in the classrooms. There is classroom storage and cabinets to store books but the shelves are too deep to display books. Without book shelves, it is hard to have a classroom library.

The counselor would like the counselor’s office located closer to students or more centrally located to assist students. The counselor’s office is located in the main office area for confidentiality reasons. During the design process, the counselor had only requested a window in the office. The counselor was not involved in the design process. The counselor strives to ensure there is a separation between the counselor guidance of students and disciplinary action by the school administrators in the office area. Locating the counselor's office in the main office area was probably for the support of the other offices and confidentiality.

The new school was unprepared for the increased enrollment of middle school students. Class sizes have increased significantly. Teachers mentioned that they miss the auditorium in the old school building for large-assembly settings. It is difficult to have a student assembly in the gymnasium when physical education classes are scheduled. Teachers would like a large auditorium that could accommodate the entire student body for assemblies. All-school assemblies are held in the new gymnasium with bleachers where the sixth-graders sit on the floor and the seventh- and eighth-graders sit on the bleachers. Even the gymnasium cannot accommodate the entire population of students because the bleachers are only on one side of the gymnasium.

The stage area is located in the cafeteria, which has wonderful acoustics for band and orchestra performances, but there are not enough chairs to accommodate the large audience. The school is unable to use the stage during mid-day because of the cafeteria where it would require setting up and removal of chairs.

Teachers would change how the restrooms are designed. Boys and girls restrooms are side by side and teachers thought that the restrooms should be separated because the restrooms are designed with an open concept without doors. Teachers did understand that the restrooms are designed side by side to share the plumbing.

The teachers commented that the cooks thought that the kitchen was designed too small because there is less space to store food. The cooks were used to a large kitchen because they were the bakers for the school district.

A large-scale space for faculty meetings is a concern for the teachers. In the old building, teacher meetings were in the media center whereas in the new building teacher meetings are in the computer lab that is not large enough to accommodate the entire staff. Some teachers sit on the floor during teacher meetings. The library is not large enough for teacher meetings because there are only four tables and there is no Promethean board or pull-down screen for audio-visual presentations.

The librarian was involved in the design of the new school but a few suggestions were changed. After being in the new school for four years, the librarian would change the following: install task lighting over computer station and counter behind circulation desk, install brighter perimeter lighting to improve brightness on cloudy days, and provide more library seating.

Overall, the teachers enjoy the design of the new building with the pod areas that have changed the delivery of instruction through more collaboration and better supervision. The conference room in the office area is a nice room for teacher team meetings and provides a sense of professionalism. The gymnasium is double the size of the old gymnasium. There is a separate wrestling room near the locker rooms, which is considered a great convenience compared to the old school building.

The following is a list of themes for interview question 7 identified in the teacher focus group interview:

- During the design phase of the school, the design team listened to some staff members and some of the classrooms were designed around specific teaching strategies of teachers who are no longer at this school.
- The architectural designers implemented some of the recommendations of teachers but not all recommendations.
- Teachers suggested the following changes in the design of the new school:
  - The number of student hallway lockers needs to be increased because of the increased student enrollment.
  - The special needs classrooms should have been designed larger to accommodate the number of special needs students.
  - Regular bookshelves should have been installed in the classrooms instead of the shelves that are too deep to store books.
  - The counselor's office should be located closer to students or more centrally located to assist students instead of located in the main office area.
  - Increased enrollment has caused some overcrowding in the facility.
  - Teachers would like a large auditorium to accommodate the entire student body for assemblies.
  - The stage area is located in the cafeteria, which makes it difficult to use the stage during mid-day.

- Teachers would change the side-by-side design of the boys and girls restrooms without doors to restrooms that are separated.
- There is not an area large enough for faculty meetings to accommodate the entire staff because the computer lab and the library are too small.
- The library changes include task lighting over the computer station and counter behind the circulation desk, brighter perimeter lighting to improve brightness on cloudy days, and more library seating.

Common Themes for Interview Questions

Comparing the themes for each interview question between both focus group interviews determined the common themes for each interview question. Keywords such as culture, technology, STEM, pods, flexibility, community, and input were scanned to determine the common themes. Listed below are the common themes for each interview question.

1. How has the new physical learning environment designed for STEM curriculum changed teaching strategies and techniques?
    - Design of the new building changed instruction, attitude of students, expectations of staff, culture of the school, and provided a professional environment for staff and students.
    - Promethean boards have expanded teaching strategies by enhancing instruction through classroom demonstrations, student presentations, and interactive lessons.

- The new physical learning environment with the addition of the greenhouse has been conducive for STEM to be integrated throughout the entire curriculum for expanding the exploration of science, technology, engineering, and mathematics in all courses.
- Design of the learning pods has provided extended learning space for small- and large-group learning that has promoted collaborative teaching and provided flexibility for the delivery of instruction.

2. How has the new physical learning environment affected learning behaviors and/or student achievement?
    - The physical learning environment with the learning pods has established the culture and high expectations for creating a sense of professionalism for teachers and a sense of pride for students impacting learning behaviors, student engagement, and student achievement.
    - Design of the learning pods has offered more options for instruction, space for student activities, and better visibility for supervision of students that has reduced disciplinary referrals, improved student behavior, and increased student engagement in the classroom.
3. Do teachers have greater access to instructional technologies that assist with meeting learning objectives in the new school when compared to the old facility? Why/How?
    - Teachers have greater access to instructional technologies through the flexibility of wireless access points, classroom computers, mobile laptop

stations, tablets, computer labs, LCD projectors, DVD players, Lightspeed sound system, and Promethean boards.

- Promethean boards have been a huge asset for classroom instruction and lesson planning.
- Increased access to instructional technology has created a collaborative environment for teachers to share instructional documents to provide an optimal learning experience for students.

4. How has the new physical learning environment contributed to students' levels of motivation and engagement?
    - The physical layout of the new school with learning pods, library located near pods, rooms connected to computer labs, and structure of the career technical education rooms has contributed to fewer distractions thereby increasing student motivation and engagement.
    - The flexible design of the learning pods for small- and large-group instruction to meet various learning styles has created a collaborative and interactive learning environment for more engaged learning.
5. How has the new facility affected parental and community involvement?
    - The involvement of the community and parents has increased at extracurricular student activities such as mathematics and reading night, Black history night, and music concerts because the new school is more inviting and accommodating.

- The new school building is also considered a community facility by providing the community the opportunity to use the facility for community recreational and adult learning events.
- Enrollment at the new school has increased because parents are attracted by the STEM education program and the support of the STEM by community business partners.

6. What was the most noticeable change physically, mentally, or socially among students after the transition to the new building?
    - The most noticeable change about the transition to the new school was the culture of the building, where students were very proud and protective of their new building.
    - There has been a reduction of major and minor disciplinary referrals because the design of the new school has provided better traffic flow and supervision of students.
    - The flexible design of the new school through learning pods has promoted collaboration of students and staff and developed positive social skills for students.
7. What was your involvement in the design of the new school? Is there anything you would change?
    - During the design phase of the new school, teachers had input into the design of instructional areas, and the new administrators had input toward

the end of the design phase for the building furnishings and technological needs.

- The administrators did not have any suggestions for building changes, but the teachers expressed concerns about the building not meeting the needs of increased student enrollment, lack of area for entire student assemblies and faculty meetings, and the combination of the stage and cafeteria area.

Summary

The findings in this case study assisted with analyzing the effect on middle student achievement in mathematics and science when students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. A mixed methods research approach was used to provide a broader view of the research problem by combining quantitative and qualitative data to provide greater understanding for answering the three research questions. Causal-comparative research design using paired-samples *t*-tests analyzed the quantitative data, and focus group interviews with administrators and teachers were analyzed to determine common themes for the seven interview questions. For research question 1, student achievement data in mathematics and science from the Iowa Testing Programs was analyzed through descriptive and inferential statistics for two matched cohort groups of students who attended the old middle school then transferred to the new school. For research questions 2 and 3, focus group interviews provided data to gain an understanding and perception from administrators and teachers about the effect of the physical learning environment on teaching and learning. Interview questions (see

Appendix F for interview questions) were designed to collect information about how the new learning environment affected teaching strategies, student achievement, instructional technology, students' levels of motivation and engagement, and parental involvement. The next chapter will provide an interpretation and implications of the findings, and recommendations for future research.

CHAPTER 5

DISCUSSION AND CONCLUSION

Introduction

This chapter presents a summary of the study, findings of the research, conclusions, implications of the study, and recommendations for further research. This study analyzed the effect of middle school student achievement in mathematics and science when students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. The intent of this case research study was to determine whether middle school student achievement in mathematics and science improved when students moved from an antiquated school facility to a new 21st-century-designed school facility. “Does it matter where our children learn?” was asked by Duke (1998) when conducting a study about the challenges of higher standards and accountability facing public education in America. Duke (1998) defined the learning environment as the physical, social, and cultural context in which learning occurs. Learning is a behavior that can and does occur virtually everywhere, but this research study focused on the physical learning environment and whether it made a difference in student achievement.

The findings in this research study provided data about whether student achievement in mathematics and science was affected by the physical learning environment of a new school facility after transferring from an antiquated middle school facility. The quality of public school facilities was important to the discussion about the physical learning environment and student achievement.

Summary of the Study

Billions of dollars have been invested in school buildings, and the challenges of greater accountability for improving student achievement have posed the question about how the physical learning environment impacts student achievement. A growing body of research in recent years has provided evidence of a relationship between the conditions of school buildings and student achievement (Hunter, 2006). This study explored the impact of a new 21st-century-designed middle school facility on student academic achievement in mathematics and science. Today's education has demonstrated a shift from a culture of teaching to a culture of learning that has required a change in focus and environment (Iowa Department of Education, n.d.b.). The 20th-century traditional box-based classroom design differs from the 21st-century-designed school that creates a flexible learner-centered workplace for a collaborative culture of learning.

The review of literature in Chapter 2 summarized information about the condition of public schools, environmental conditions affecting the learning environment, 21st-century-designed schools, STEM education for 21st-century learning, and the relationship between the physical learning environment and student achievement. The environmental conditions of poor ventilation, insufficient lighting, poor acoustics, and temperature control of classrooms are still affecting the condition of America's school buildings today. The United States General Accounting Office (GAO) reported in 1995b that the nation had invested hundreds of billions of dollars in school infrastructure to create an environment where children can be properly educated. The 21st Century School Fund (2011) and Building Educational Success Together reported the difficulty in determining the condition of public school facilities because there was no national database of information on public school facilities. Without a recent basic inventory of public school facilities, the American Society of Civil Engineers estimated the investment needed to modernize and maintain public school facilities was at least $270 billion or more. School districts are faced with the dilemma of whether to invest millions of dollars to maintain outdated buildings or invest in new construction to meet the evolving needs of today's learners (Fielding, 2012). Another concern has been the chronic deferred maintenance and repair of aging school buildings due to inadequate funding that can lead to energy inefficiencies, unsafe drinking water, water damage, molding environments, poor air quality, inadequate fire alarms and fire safety, compromised building security, and structural dangers (Filardo et al., 2011).

Science, technology, engineering, and mathematics, or STEM, education has been considered vital for thriving in the 21st century for managing decisions of daily life or pursuing STEM careers (Iowa Mathematics and Science Education Partnership, 2012). To support 21st-century learning, designing the learning environment must support a school's model for teaching and learning where the physical environment was integrated in the learning environment (DeGregori, 2011). Zubrzycki (2013) has noted that school buildings affect students' morale and academic performance through school design that supports more open, flexible buildings aimed at creating a sense of community and collaboration. Concerning how the physical learning environment affects student achievement, various studies have determined that school facility conditions do affect student academic achievement. The Green Schools Initiative through Global Green USA

(2005) reported that the quality of school buildings has a direct impact on student performance after analyzing 14 studies. The analysis of these studies showed that students in old buildings scored 5-7% lower than students in new buildings.

This case study used the mixed methods approach to analyze middle school student achievement in mathematics and science where students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. The setting for this study occurred in an Iowa school district at a new middle school designed for 21st-century learning. This particular school was chosen for the study because of the uniqueness of transferring students from the old facility to the new 21st-century-designed STEM school. The following research questions were used to shape the research design for this study:

1. To what extent, if any, does student proficiency on the Iowa Assessments in mathematics and science improve after moving into the 21st-century-designed STEM middle school?
2. How have teaching strategies changed from the old facility to the new 21st-century-designed STEM middle school?
3. How has student achievement been impacted because teaching has changed in the new 21st-century-designed STEM middle school?

Descriptive and inferential statistics were used to analyze the quantitative data for the first research question. A qualitative research design using interviews to collect data was used for the final two research questions. The perceptions from 13 teachers and two administrators about the impact of the new facility on teaching and learning plus the student achievement data of 158 middle school students were the data collected for this study.

Since the new middle school in this case study is a STEM school, data regarding student academic achievement on the Iowa Assessments in mathematics and science were used to assess academic achievement. The collection of student achievement data involved accessing data from EdInsight, the education data warehouse from the Iowa Department of Education (n.d.a.). Proficiency on the Iowa Assessments in mathematics and science were the two continuous dependent variables for student achievement, and the discrete independent variable was the change in the physical learning environment from the old building to the new building.

The first research question used the analysis of comparative research for comparing student achievement data prior to moving into and after moving into the new school building. SPSS software was used to conduct a causal-comparative, quantitative research design to explore the associations among variables. A matched cohort data analysis was conducted for sixth- and seventh-grade students who attended the old middle school then transferred to the new school to finish their middle school education. The matched cohort analysis provided student achievement information for the same students that attended both schools described in the study. Two match cohort groups of students were identified for the study. Descriptive statistics were used to determine the mean and standard deviations for this data. The inferential statistics test used for this portion of the study was the paired-samples *t*-test to compare the difference between means of test scores prior to moving into the new building and means of test scores after moving into the new building. Paired-samples *t*-tests were used to determine whether or not the means of National Percentile Rank scores in mathematics and science were significantly different from each other. Statistical significance was determined by an alpha or p-value of .05.

Two focus group interviews were conducted with the two administrators and 13 teachers to collect data for research questions 2 and 3. This interview technique helped to gain an understanding and perception about the effect of the new school facility on teaching and learning. Focus group interviews were conducted with voluntary participants who experienced the transition from the old facility to the new 21^{st}-century-designed school facility. The objective of this interview technique was to gain high-quality data in a social context where respondents with a common experience could consider their own views in the context of the views of others. Interview questions (see Appendix F for interview questions) were designed to collect information about how the new STEM learning environment has changed teaching strategies, student achievement, instructional technology, students' levels of motivation and engagement, and parental involvement.

Research Findings and Conclusions

The first research question used the analysis of comparative research for comparing student achievement data prior to moving into and after moving into the new school building. Research questions 2 and 3 used qualitative research methods of focus group interviews to collect data from administrators and teachers about their perception of the effect of the new school facility on teaching and learning.

Research Question 1

To what extent, if any, does student proficiency on the Iowa Assessments in mathematics and science improve after moving into the 21st-century-designed STEM middle school?

Research question 1 inquired about whether student achievement in mathematics and science improved after moving into the 21st-century-designed STEM middle school. Matched cohort data analysis was conducted for two groups of students that attended the old middle school then transferred to the new middle school. A matched cohort is the same students over a period of time. Cohort group 1 of 77 students attended sixth and seventh grades at the old middle school then transferred to the new middle school for eighth grade. Cohort group 2 of 81 students attended sixth grade at the old middle school then transferred to the new middle school for seventh and eighth grades.

Paired-samples *t*-test compared the difference between means of NPR scores prior to moving into the new building and means of NPR scores after moving into the new building for both matched cohort groups. Paired differences of means from NPR scores in mathematics and science were used to determine significance of improvement in student achievement.

Cohort group 1 mathematics. Two pairings of data were used to analyze student achievement in mathematics. The first pairing was comparing mathematics achievement from the FY2008 school year with the FY2009 school year at the old middle school. The second pairing was comparing mathematics achievement from the FY2009 school year at the old middle school with the FY2010 school year at the new middle school.

For pairing 1, the means for mathematics NPR scores was 39.25 with a standard deviation of 27.083 during FY2008 and 39.23 with a standard deviation of 27.271 during FY2009 while attending the old middle school. Upon analysis of the paired *t*-test for pair 1 comparison of mathematics at the old middle school, the p-value of .993 was greater than .05, which indicated no significant difference in mathematics achievement. These results suggest that cohort group 1 students did not have a significant increase in mathematics achievement on the Iowa Assessments from FY2008 as sixth-graders to FY2009 as seventh-graders while attending the old middle school.

For pairing 2, the means for mathematics NPR scores was 39.23 with a standard deviation of 27.271 during FY2009 at the old middle school and 36.43 with a standard deviation of 27.774 during FY2010 at the new middle school. Upon analysis of the paired *t*-test for pair 2 comparison of mathematics at the old middle school with mathematics achievement at the new middle school, the p-value of .077 was greater than .05, which indicated no significant difference in mathematics achievement. The significance level of .077 was close to the p-value of .05, which would indicate a borderline significance of mathematics improvement. These results suggest that cohort group 1 did not have a significant increase in mathematics achievement on the Iowa Assessments from FY2009 as seventh-graders at the old middle school to FY2010 as eighth-graders at the new 21st-century-designed STEM middle school.

Cohort group 1 science. Two pairings of data were used to analyze student achievement in science. The first pairing was comparing science achievement from the FY2008 school year with the FY2009 school year at the old middle school. The second pairing was comparing science achievement from the FY2009 school year at the old middle school with the FY2010 school year at the new middle school.

For pairing 1, the means for science NPR scores was 39.04 with a standard deviation of 26.654 during FY2008 and 38.65 with a standard deviation of 24.784 during FY2009 while attending the old middle school. Upon analysis of the paired *t*-test for pair 1 comparison of science at the old middle school, the p-value of .852 was greater than .05, which indicated no significant difference in science achievement. These results suggest that cohort group 1 students did not have a significant increase in science achievement on the Iowa Assessments from FY2008 as sixth-graders to FY2009 as seventh-graders while attending the old middle school.

For pairing 2, the means for mathematics NPR scores was 38.65 with a standard deviation of 24.784 during FY2009 at the old middle school and 43.04 with a standard deviation of 23.879 during FY2010 at the new middle school. Upon analysis of the paired *t*-test for pair 2 comparison of science at the old middle school with science achievement at the new middle school, the p-value of .023 was less than .05, which indicated a significant difference in science achievement. These results suggest that cohort group 1 had a significant increase in science scores on the Iowa Assessments from FY2009 as seventh-graders at the old middle school to FY2010 as eighth-graders at the new 21st-century-designed STEM middle school.

Cohort group 2 mathematics. Two pairings of data were used to analyze student achievement in mathematics. The first pairing compared mathematics achievement from the FY2009 school year at the old middle school with the FY2010 school year at the new middle school. The second pairing compared mathematics achievement from the FY2010 school year with the FY2011 school year at the new middle school.

For pairing 1, the means for mathematics NPR scores was 38.56 with a standard deviation of 28.599 during FY2009 at the old middle school and 38.70 with a standard deviation of 26.617 during FY2010 at the new middle school. Upon analysis of the paired *t*-test for pair 1 comparison of mathematics, the p-value of .932 was greater than .05, which indicated no significant difference in mathematics achievement. These results suggest that cohort group 2 students did not have a significant increase in mathematics achievement on the Iowa Assessments from FY2009 as sixth-graders in the old middle school to FY2010 as seventh-graders at the new 21^{st}-century-designed STEM middle school.

For pairing 2, the means for mathematics NPR scores was 38.70 with a standard deviation of 26.617 during FY2010 and 36.23 with a standard deviation of 23.328 during FY2011 at the new middle school. Upon analysis of the paired *t*-test for pair 2 comparison of mathematics achievement at the new middle school, the p-value of .126 was greater than .05, which indicated no significant difference in mathematics achievement. These results suggest that cohort group 2 did not have a significant increase in mathematics achievement on the Iowa Assessments from FY2010 as seventh-graders to FY2011 as eighth-graders at the new 21^{st}-century-designed STEM middle school.

Cohort group 2 science. Two pairings of data were used to analyze student achievement in science. The first pairing compared science achievement from the FY2009 school year at the old middle school with the FY2010 school year at the new middle school. The second pairing compared science achievement from the FY2010 school year with the FY2011 school year at the new middle school.

For pairing 1, the means for science NPR scores was 38.37 with a standard deviation of 23.832 during FY2009 at the old middle school and 45.95 with a standard deviation of 25.617 during FY2010 at the new middle school. Upon analysis of the paired *t*-test for pair 1 comparison of science, the p-value of .000 was less than .05, which indicated a significant difference in science achievement. These results suggest that cohort group 2 students had a significant increase in science scores on the Iowa Assessments from FY2009 as sixth-graders in the old middle school to FY2010 as seventh-graders in the new 21st-century-designed STEM middle school.

For pairing 2, the means for science NPR scores was 45.95 with a standard deviation of 25.617 during FY2010 and 42.69 with a standard deviation of 21.894 during FY2011 at the new middle school. Upon analysis of the paired *t*-test for pair 2 comparison of science achievement at the new middle school, the p-value of .101 was greater than .05, which indicated no significant difference in science achievement. These results suggest that cohort group 2 did not have a significant increase in science achievement on the Iowa Assessments from FY2010 as seventh-graders to FY2011 as eighth-graders while attending the new 21st-century-designed STEM middle school.

<u>Conclusion</u>. Mathematics achievement for cohort group 1 did not improve significantly from sixth grade to seventh grade at the old middle school. From seventh grade at the old school to eighth grade at the new middle school, there was borderline improvement. The means of NPR mathematics scores were fairly consistent during sixth

and seventh grades but a slight increase during eighth grade in the new middle school. The overall statistical results indicate that the physical learning environment of the new 21st-century-designed middle school did not influence mathematics achievement for this group of students.

Science achievement for cohort group 1 did not improve significantly during sixth and seventh grades at the old middle school but there was significant improvement as eighth-graders at the new middle school. The means of NPR science scores decreased from sixth grade to seventh grade but increased significantly from seventh grade at the old school to eighth grade at the new school. The results indicated that the physical learning environment of the new 21st-century-designed middle school was statistically related to science achievement for this group of students.

Mathematics achievement for cohort group 2 did not improve significantly from sixth grade at the old middle school to seventh and eighth grades at the new middle school. The means of NPR mathematics scores were fairly consistent from sixth grade to seventh grade but dropped slightly during eighth grade in the new middle school. The statistical results indicate that the physical learning environment of the new 21st-century-designed middle school did not influence mathematics achievement for this group of students.

Science achievement for cohort group 2 improved significantly from sixth grade at the old middle school to seventh grade at the new middle school. The means of NPR science scores decreased slightly from seventh grade to eighth grade. The results indicated that the physical learning environment of the new 21st-century-designed middle school was statistically related to science achievement for this group of students.

The Green Schools Initiative through Global Green USA (2005) reported that students in old buildings scored 5-7% lower than students in new buildings. Results of a study by Earthman, Cash, and Van Berkum (1995) reported that the percentile ranks of students were higher in above-standard schools with good facility conditions. Gibson (2012) revealed in his study that school achievement had an inverse association with school facility age where newer schools perform at high levels of student achievement. Research findings in the Tennessee Advisory Commission on Intergovernmental Relations (2003) school facilities report showed that students had higher achievement scores in newer facilities.

The results of this study are not consistent with the results of Earthman et al. (1995), Gibson (2012), and the Tennessee Advisory Commission on Intergovernmental Relations report (2003). In this study, the percentile ranks for both cohorts were higher in science but there was no improvement in mathematics for both cohorts. The mathematics and science results are inconsistent with the research conducted by Vandiver (2011). Vandiver (2011) reported that the largest increase in student performance was in mathematics and there was a marginal increase in science. Fritz (2007) conducted a study analyzing student achievement results after moving into a new school building and determined that there was a significant increase in science subtests but not a significant increase in mathematics subtests. The results of this study are consistent with the results of the study by Fritz (2007). Cash (1993) explained that science achievement of students was higher in buildings with better-quality science facilities and equipment.

Research Question 2

How have teaching strategies changed from the old facility to the new 21st-century-designed STEM middle school?

Research question 2 focused on how teaching strategies changed from the old building to the new building. Qualitative research through focus group interviews was used to collect perceptions from administrators and teachers. Interview questions 1, 3, and 7 (see Appendix F for interview questions) related to research question 2.

In the literature review from Chapter 2, Yeoman (2012) reported that the problems facing America's school buildings are not always visible – poor ventilation, insufficient lighting, poor acoustics, and hot and cold classrooms are causes for health issues, boosts absenteeism, and undermines teaching. The conditions of the old middle school severely limited teaching strategies whereas the new school was described by the teachers as a professional learning environment. The old middle school had electrical issues, technological problems, temperature control issues, accessibility issues due to multiple levels and a non-working elevator, lack of storage, and no air conditioning. Lack of air conditioning and open windows caused issues with insects, dirt, humidity, birds, and traffic noise from a major highway that interfered with classroom teaching and student learning. Lackney (1999) noted that the location and siting of schools is of critical importance for reducing noise to provide an environment effective for teaching and learning. Schneider (2002) reported that outside noise such as traffic noise causes increased student dissatisfaction with their classrooms, and excessive noise causes stress in students. The science room in the old school did not have a sink, cabinets, and outlets. Cash (1993) discovered that science achievement was lower in buildings with lower-quality science facilities. The old middle school did not have adequate lighting, natural daylighting, and acoustics that are necessary for a conducive learning environment. As previously noted in the literature review, the 2000 Heschong Mahone Group study on daylighting showed that students with the most classroom daylight progressed 20% faster in one year on math tests and 26% faster on reading tests than students who learned in environments that received the least amount of natural light (Global Green USA, 2005; Lyons, 2001; Schneider, 2002). The Southeast Center for Teaching Quality (2004) reported that teacher working conditions have considerable impact on teacher retention and student learning. Teaching and learning conditions in the old facility were hampered by poor environmental conditions.

Teaching strategies changed from the old middle school to the new 21st-century-designed middle school because of updated technology integrated into the design of the new facility. The United States General Accounting Office (1995b) reported that most of America's schools were unprepared for the 21st century because at least three-quarters of schools did not have the system of building infrastructure to support modern technology. Teachers expressed that the old school had antiquated technology to support classroom teaching and learning. The increased access to instructional technology at the new middle school has created a collaborative environment for teachers to share instructional documents to provide the optimal learning experience for students. McCrea (2012) emphasized that 21st-century smart classrooms must factor technological needs and a collaborative learning environment in the design of the basic shell of the school building. Teachers have greater access to instructional technologies through the flexibility of wireless access points, classroom computers, mobile laptop stations, tablets, computer labs, LCD projectors, DVD players, Lightspeed sound system, and Promethean boards. Teachers and administrators had emphasized how Promethean boards have expanded teaching strategies, enhanced instruction through classroom demonstrations, and assisted with student presentations, interactive lessons, and lesson planning. The Lightspeed Technology sound system was installed in the new facility to enhance the sound in classrooms that has allowed students to hear well. Earthman (2002) emphasized that the prerequisite for effective learning is the ability to clearly hear and understand what is being spoken. To improve academic performance, it is important to have good acoustics to allow students to clearly hear in the classroom.

Design of the new building has changed instruction, attitude of students, expectations of staff, culture of the school, and provided a professional environment for staff and students. In the literature review from Chapter 2, Fielding (2012) said that the learning community of the 21st century should have distinct and varied spaces for lectures, group activities, and individual study. Design of the learning pods has provided extended learning space for small- and large-group learning that has promoted collaborative teaching and provided flexibility for the delivery of instruction. Zubrzycki (2013) noted that school design of 21st-century school facilities must support open, flexible design aimed at creating a sense of community and collaboration. Learning pods were designed for each grade level around a centrally located library. The pods have reduced student behavior problems through better supervision of students and provided a collaborative learning environment.

Teaching strategies at the new school were impacted with the implementation of STEM curriculum. In Iowa, the Governor’s STEM Advisory Council’s (2012) overarching goal has been to boost student interest and achievement in STEM and promote STEM economic development. The new physical learning environment with the addition of the greenhouse has been conducive for STEM to be integrated throughout the entire curriculum for expanding the exploration of science, technology, engineering, and mathematics in all courses. The greenhouse has been used for several classes to integrate STEM into core curriculum classes. Middle school teaching strategies in the new school have changed through teaching STEM classes such as botany, applied computer technologies, culinary arts, electricity and electronics, mechanical engineering/robotics, chemistry, ecology, and interior design. The flexibility of the learning pods in the new 21st-century-designed school has enhanced the delivery of instruction for STEM curriculum.

As previously noted in the literature review, De Gregori (2011) stated that the physical environment must be intentionally designed to support a school’s model for teaching and learning where the physical environment is integrated in the learning environment. Heinhorst and Hunter (2008) also said that the process of designing public schools should embrace the participation of teachers, school administrators, and community members to work with architectural design professionals. During the design phase of the new school, teachers had input into the design of instructional areas for enhancing the delivery of instruction. The new administrators had input toward the end of the design phase for the building furnishings and the integration of classroom technology. Teachers had expressed concerns about the new building not meeting the current needs of increased student enrollment, lack of areas for entire student assemblies and faculty meetings, and the combination of the stage and cafeteria area. The combination of the stage and cafeteria has limited the use of the stage during the school day.

Conclusion. The educators interviewed for this study were considered experienced and veteran educators. The teacher interview group had an average of 17.9 years of teaching experience and the administrators had an average of 14.5 years of administrative experience. Both administrators had one year of experience in the old building prior to moving to the new middle school.

Teaching and learning conditions in the old facility were hampered by poor environmental conditions. Teachers and administrators were involved in the design process to offer input into the instructional areas of the new building. Improving working conditions has been related to student achievement because teacher working conditions are student learning conditions (The Southeast Center for Teaching Quality, 2004). The new middle school provided improved environmental building conditions that influenced how teachers teach.

Technology has been a major factor in the new school that has changed teaching strategies. Teachers have greater access to instructional technologies through the flexibility of wireless access points, classroom computers, mobile laptop stations, tablets, computer labs, LCD projectors, DVD players, the Lightspeed sound system, and Promethean boards. McCrea (2012) stated that 21st-century smart classrooms must factor technological needs and a collaborative learning environment in the design of the basic shell of the school building. The technology of Promethean boards has enhanced teaching strategies by providing teachers with the tools, skills, and resources needed for improving learning productivity. Promethean boards have created a collaborative learning environment that engages learners through digital media and real-world activities. The technology of using the Lightspeed sound system in classrooms has helped teachers present lessons so that all students are able to hear better.

Learning pods in the new school were highly touted as a major factor for changing teaching strategies. Learning pods have provided extended learning space for small- and large-group learning that has promoted collaborative teaching and flexibility for the delivery of instruction. Sullivan (2006) stressed the importance of addressing multiple methods of learning in multiple environments such as the flexible use of learning pods. Lippman (2010) stated that 21st-century learning environments must be flexible to accommodate multiple ways of learning where the learner is engaged in self-directed and cooperative learning activities.

The implementation of STEM curriculum in the new school was another major factor for changing teaching strategies. The governor of Iowa has emphasized the importance of STEM education for improving the state’s future economy (Iowa Governor’s STEM Advisory Council, 2012). The design of the new school and the addition of the greenhouse were conducive for integrating STEM throughout the entire curriculum for expanding the exploration of science, technology, engineering, and mathematics in all courses.

In conclusion, the findings of research question 2 confirmed that teaching strategies have changed due to the new 21st-century-designed STEM middle school. Teaching strategies have changed dramatically from the old facility to the new 21st-century-designed middle school building because of updated technology, improved environmental conditions, design of the learning pods, and implementation of STEM curriculum. The new facility was designed to be flexible that offered opportunities for teachers to teach collaboratively with other teachers. The new facility also provided an environment that facilitated student-led projects, provided the ability to teach small and large groups of students in the learning pods, integrated technology into lessons, and assisted with the implementation of STEM curriculum. These findings concurred with Lippman (2010) who stated that 21st-century learning environments must be flexible to accommodate multiple ways of learning where the learner is engaged in self-directed and cooperative learning activities. Technology was a major factor for changing teaching strategies that also concurred with McCrea (2012) who stated that 21st-century smart classrooms must factor technological needs and a collaborative learning environment in the design of the basic shell of the school building. After moving into the new school, teachers appreciated the professional environment that was designed to assist teachers in the delivery of lessons and promote learning for students. In closing, Shearer (2010) stated that teachers expressed that the building does not make the teacher, but the building helps to make the job of a teacher easier and more effective through the new facility and new equipment.

Research Question 3

How has student achievement been impacted because teaching has changed in the new 21st-century-designed STEM middle school?

Research question 3 focused on how student achievement was impacted by the changes in teaching strategies in the new building. Qualitative research through focus group interviews was used to collect perceptions from administrators and teachers. Interview questions 2, 4, 5, and 6 (see Appendix F for interview questions) related to research question 3. When discussing student achievement, teachers provided input about the effect of the new building on student performance and behavior but avoided how student achievement on district assessments was impacted.

The administrators and teachers concluded that the new physical environment was a major contributor to establishing the culture and high expectations for teaching and learning. High expectations of the staff have impacted learning behaviors, student engagement, and student achievement. Instructional technology, student-led projects, STEM courses, and instructional use of the greenhouse have contributed to the motivation and engagement of students. To provide a positive learning environment for improving student achievement, the new building has provided better visibility for supervising students, provided flexible-instructional space for collaborative teaching in the pod areas, and provided updated technology. For providing a safe learning environment, the new building has a security system with cameras for monitoring the building and allowing visitors to enter the building. In the literature review from Chapter 2, Fielding (2012) stated that a 21st-century school configuration should provide a safer and healthier educational environment. Fielding (2012) also recommended reducing wasted space on corridors by establishing multiple learning environments that center on a commons space, which improves supervision and creates a safer environment. Classroom doors have classroom security locks to protect students and staff from intruders. Teachers felt that the design of the new school building and the security system have provided a safe, positive learning environment that contributes to improving student achievement.

The administrators reported that the move to the new building included implementing a new dress code and a new curriculum focused on STEM, which also contributed to the culture of the school. The interview session with the teachers provided input about the effect of the new building on student performance and behavior but avoided how student achievement on district assessments was impacted. Administrators explained that monitoring and increasing academic performance has been a progressive process. Over the past few years, results of the Iowa Assessments have increased in some areas and some years showed stagnant growth. The administrators expressed that the results for the Iowa Assessments were not at the desired level. As previously noted in the literature review, Shearer (2010) discovered that despite moving into the new state-of-the-art facility, the majority of educators in the study did not observe a change in academic performance. Recently, multiple data points have indicated that academic achievement is improving but it has been a slow process. Past student achievement results have shown sporadic improvements on the Iowa Assessments. The school conducted a correlation study to compare Skills Iowa results with the predictable outcomes of the Iowa Assessments. The results of that study showed a tight correlation between the two programs for academic improvement. Skills Iowa is an optional web-based technology tool available to Iowa schools for assessing student performance in reading comprehension, vocabulary, mathematics, language, library skills, and science in grades 3-12. Administrators were hopeful for future improvement in the Iowa Assessments because of the decline in disciplinary referrals and improvement of academic scores in the Skills Iowa Assessments and Common Form Assessments (CFA). The Common Form Assessments is an in-house-developed assessment program to monitor student achievement.

Teachers and administrators emphasized how the learning pods have had a positive impact on teaching, learning, and student behavior. The new physical learning environment with the learning pods has established a culture for high expectations creating a sense of professionalism for teachers and a sense of pride for students. Design of the learning pods has offered more options for instruction and space for student activities. The learning pods have provided better visibility for supervision of students that has reduced disciplinary referrals, improved student behavior, and increased student engagement in the classroom. The flexible design of the learning pods for small- and large-group instruction to meet various learning styles has created a collaborative and interactive learning environment for more engaged learning. In the literature review, Sullivan (2006) reported that flexibility was the primary principle in 21st-century school design that addresses multiple ways of learning in multiple environments. Zubrzycki

(2013) also noted that school design needs to support more open, flexible buildings aimed at creating a sense of community and collaboration. The learning pods in the new school have provided a sense of community, promoted collaboration of students and staff, and developed positive social skills for students.

The most noticeable change physically, mentally, or socially among students after the transition to the new building was the culture of the building, where students were very proud and protective of their new building. Zubrzycki (2013) had reported that the design of school buildings can affect students’ morale and academic performance. The administrators felt that climate and culture were contributors to how well students will perform in the classroom. The design of the new school has provided better traffic flow and supervision of students, which has reduced major and minor disciplinary referrals. The physical layout of the new school with learning pods, library located near pods, rooms connected to computer labs, and structure of the career technical education rooms has contributed to fewer distractions thereby increasing student motivation and engagement.

The new school building has been considered a community facility because of the opportunities to use the facility for community recreational events, adult learning events, and extracurricular student activities. Extracurricular student activities in the new school have been affected by increased parental involvement. Parental and community involvement has increased at extracurricular student activities such as mathematics and reading night, Black history night, and music concerts because the new school is more inviting and accommodating. Parental involvement in school activities has helped to emphasize the importance of education to students. Enrollment at the new school has increased because parents have been attracted by the STEM education program and the support of the STEM program by community business partners. As previously noted in the literature review, Ash (2013) stated that STEM-focused schools must form partnerships with both private companies and higher education partners to provide the high-tech, collaborative environments for students. Parents look at schools that will provide the best learning environment for preparing their children for college and the workforce.

Conclusion. Data from research question 2 confirmed that teaching strategies changed in the new 21st-century-designed middle school building because of updated technology, improved environmental conditions, flexible design of learning pods, and the implementation of STEM curriculum. Research question 3 investigated how student achievement was impacted by the change of teaching in the new middle school.

From the interview sessions, it was determined that the new physical learning environment was a major contributor for establishing the culture and high expectations in teaching and learning. Instructional technology, student-led projects, STEM courses, and instructional use of the greenhouse have contributed to the motivation and engagement of students for improved student performance. The flexible design of the learning pods for small- and large-group instruction to meet various learning styles has created a collaborative and interactive learning environment. Learning pods have also reduced distractions, provided better supervision of students, and provided multiple ways of learning, which all contribute to better student performance. The new physical learning environment has created a sense of professionalism for teachers and a sense of pride for students.

Duke (1998) explained that the challenges in education include demands for higher standards and greater accountability, improved school security and student safety, new technology, stronger relationships between teachers and students, and greater parental and community involvement in schools. When Duke (1998) studied the influence of a new school facility on student learning, he discovered that the influence of the school settings is frequently subtle, sustained, and quite difficult to measure with precision. During the transition from the old school to the new school, the administrators had difficult challenges of changing the educational climate, implementing STEM curriculum, enforcing new student dress standards, and improving student achievement. When discussing the impact on student achievement by the new school facility, the administrators expressed optimism in the progress of improving academic results in the Iowa Testing Program. Teachers confined their responses about student achievement to the changes in student behavior, climate within the new facility, and design features that impacted their teaching.

The design features of the new school facility with updated technology and equipment has helped teachers to be more effective. Duke (1998) noted that not only good teachers or up-to-date instructional materials improve student performance, but a complex array of direct and indirect influences affect learning. The physical learning environment has been considered an indirect influence on learning. Duke (1998) noted that the features of the physical learning environment may not always directly influence test scores and graduation rates, but they still exert an impact on learning indirectly. Information from the interviews claimed that the new middle school has provided an inviting school environment that has increased student attendance, increased enrollment, reduced disciplinary referrals, and increased parental involvement in extracurricular activities for students. The learning environment of the new middle school has helped to facilitate the improvement of student performance indirectly.

Administrators explained that improving academic performance is not an overnight change when combining the variables of the new physical learning environment, new student dress code, and STEM curriculum. The results of the Iowa Testing Program have been stagnant the past few years at the new school, but recent data points have indicated that academic performance is improving. It has been a slow process but the administrators have been constantly analyzing student performance through qualitative data, anecdotal records, and results from a correlation study. The decline in disciplinary referrals and the improvement of academic results in the classroom have provided the optimism for increasing student achievement on the Iowa Assessments. The administrators in this study have a vision of academic success for all students that required changing the educational climate of the school. Without the vision of the administration to provide guidance for improving teaching and learning, the new school building would simply be another traditional school. The Wallace Foundation (2013) stated that one of the key responsibilities of the school principal was to shape a vision of academic success for all students. Increasing student achievement has been a complex process involving parents, teachers, and the administration. The administrators have provided the guidance and vision for educational improvement.

In summary, administrators reported that student achievement has been stagnant when comparing student achievement results of the old school with the new school. However, research question 1 reported improved student achievement in science, which concurred with the research results by Fritz (2007). Overall, research question 3 results about the impact on student achievement differed from the research results of Gibson (2012), Vandiver (2011), Global Green USA (2005), and the report by the Tennessee Advisory Commission on Intergovernmental Relations (2003). Research findings in the Tennessee report indicated that students had higher achievement scores in newer facilities. The Green Schools Initiative through Global Green USA (2005) reported that students in old buildings scored 5-7% lower than students in new buildings.

Duke (1998) noted that the features of the physical learning environment may not always directly influence test scores, but the physical learning environment still exerts an impact on learning indirectly. The impact of the 21^{st}-century-designed school on student achievement may not have been immediately noticed, but the indirect influences of the new school were immediately noticed by parents, staff, and students. Teachers and administrators have gained enthusiasm and a sense of professionalism, students have gained a feeling of pride, and parents have become more involved in extracurricular student activities due to the inviting environment of the new school.

Implications

The Tennessee Advisory Commission on Intergovernmental Relations (2003) released a report that showed a strong implication from research studies that the quality of facilities has an effect on student attitudes toward school, self-esteem, security, comfort, and pro-social behavior, which affects learning and achievement. Evidence has been established that shows a close relationship between the physical environment and how well students and teachers perform in that environment. There has been a void in educational research in Iowa that analyzes the effects of the physical learning environment on learning and teaching. Studies have indicated how inadequate conditions affect the teaching abilities of teachers and the ability for students to learn.

This case study has implications for school districts as schools meet the challenges of rigorous academic standards, accountability for improving student achievement, and budget constraints. Science achievement was the only dependent variable that proved to have a statistically significant relationship to the 21st-century-designed facility. Science laboratories in this study had updated technology and equipment to assist with current teaching strategies for a STEM-focused learning environment. For that reason, school leaders should be guided to further study relationships that could provide direction in the design, construction, and maintenance of school facilities.

When school districts consider whether to renovate an existing facility or construct a new school building, school administrators can use this research and the research of others for making decisions for future facilities. This research along with research of others will bolster school districts' efforts with communities for appropriating funding for the renovation of existing facilities, construction of new buildings, and equipping schools with technology to facilitate learning.

The results of this study will help provide focus on the aspects of how student learning may be affected by the design or construction of new school buildings. The results from research question 1 indicated that administrators must realize the importance of designing quality science classrooms with updated technology and equipment for improving student performance during the renovation and construction of school facilities. Administrators must consider how updated technology, environmental conditions, and learning pods affect teachers and students in the learning environment when planning for new school facilities. For preparing a 21st-century workforce, communities must have 21st-century-designed school facilities that facilitate instruction of STEM and equip students to excel in science, technology, engineering, and mathematics. As indicated by The Wallace Foundation (2013), educational leadership has a major impact for improving learning, and the decisions made about the physical learning environment affect teachers' abilities to teach and the learning of students.

Future Research

The importance of school buildings has long been recognized as a fundamental element of our society. Through research, our understanding of the relationship between school buildings and student learning is strengthened. The focus of this case study using a mixed methods approach was to determine if there was improvement in student achievement in mathematics and science when students transferred from an old middle school building to a new 21st-century-designed middle school. A mixed method research approach was used to improve reliability and generality for this case study. Due to the small sample size of this study, future studies could expand the study population to include more school buildings to analyze student achievement when there is change in the physical learning environment. Using a larger sample size for comparing quantitative research results of student achievement from various school facilities would provide better generalizations to the broader universe of school facilities.

Parallel studies could be conducted in other school districts to determine the impact of a new school facility on student achievement. Results of parallel studies will improve reliability of information for providing insight for school leaders, planners, and architects about the effects of a new school building on student achievement.

Future researchers could conduct a study comparing student achievement in STEM-focused buildings to student achievement in traditional-curriculum-based buildings. The difference in design features between STEM schools and traditional schools would have to be analyzed for determining impact on student achievement.

Qualitative research approach could be used to assess the effects on teaching and learning that are present when moving from an old to a new school building. Individual and focus group interviews and surveys with educational personnel and students could be used to collect perceptions about specific issues associated with moving to a new school and the effects on student achievement. A climate survey could also be used to collect perceptions about the impact a new physical learning environment has on student achievement.

A study could be done to study the relationship between student achievement and 21st-century school building design features. Further research could explore which school design features support effective teaching and learning. It would be interesting to discover how specific design features of new school buildings impact student performance. Further study on the topic of the relationship between academic achievement and school facilities is warranted.

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APPENDIX A

COHORT 1 MATHEMATICS AND SCIENCE DATA

Group 1 - Mathematics and Science National Percentile Rank (NPR) Scores for Students FY08 to FY10

	Old Middle School				New STEM School	
Group 1 Student Number	Math 6 Fall (Nov 7, 2007)	Sci 6 Fall (Nov 7, 2007)	Math 7 Spring (Mar 30, 2009)	Sci 7 Spring (Mar 30, 2009)	Math 8 Spring (Mar 29, 2010)	Sci 8 Spring (Mar 29, 2010)
101	46	66	37	54	43	53
102	80	93	67	74	58	67
103	96	96	87	85	71	78
104	54	66	68	66	48	63
105	15	28	10	10	4	22
106	1	24	8	1	1	29
107	43	46	64	54	58	60
108	37	32	52	8	30	32
109	10	1	20	27	1	19
110	36	32	45	27	28	29
111	43	43	37	21	32	7
112	29	8	4	27	27	38
113	94	90	96	89	96	78
114	85	59	84	48	62	56
115	21	36	5	10	1	7
116	41	32	20	48	34	46
117	2	6	1	8	5	5
118	17	15	19	37	23	13
119	41	50	39	59	39	38
120	76	56	88	85	85	74

(table continues)

Group 1 Student Number	Old Middle School Math 6 Fall (Nov 7, 2007)	Sci 6 Fall (Nov 7, 2007)	Math 7 Spring (Mar 30, 2009)	Sci 7 Spring (Mar 30, 2009)	New STEM School Math 8 Spring (Mar 29, 2010)	Sci 8 Spring (Mar 29, 2010)
121	23	6	24	24	27	41
122	37	24	5	37	4	26
123	31	24	30	27	20	7
124	7	24	6	1	5	10
125	41	62	15	37	30	53
126	67	36	53	21	39	82
127	5	19	10	6	8	32
128	53	62	43	92	52	74
129	54	53	57	59	59	82
130	24	6	34	17	27	19
131	43	43	51	44	43	53
132	17	8	43	59	50	50
133	77	56	77	78	82	67
134	29	40	19	48	25	41
135	32	28	29	30	32	60
136	31	36	49	8	42	41
137	54	53	41	41	48	60
138	63	28	73	37	33	35
139	1	28	27	41	5	35
140	98	90	82	78	91	92
141	25	73	24	63	22	44
142	7	19	10	27	4	10
143	21	50	20	30	26	38
144	33	36	20	44	18	44
145	97	96	96	85	94	82
146	19	4	14	27	8	41
147	39	8	32	17	15	41
148	58	50	64	34	46	44

(table continues)

Group 1 Student Number	Old Middle School: Math 6 Fall (Nov 7, 2007)	Sci 6 Fall (Nov, 7, 2007)	Math 7 Spring (Mar 30, 2009)	Sci 7 Spring (Mar 30, 2009)	New STEM School: Math 8 Spring (Mar 29, 2010)	Sci 8 Spring (Mar 29, 2010)
149	38	46	56	30	61	44
150	17	19	13	21	15	19
151	13	4	15	24	11	1
152	8	6	6	4	2	16
153	81	93	84	78	92	70
154	29	11	22	21	20	19
155	21	8	2	17	1	16
156	52	66	45	44	34	50
157	48	40	32	37	43	53
158	90	90	91	85	98	92
159	31	15	45	54	46	60
160	13	40	17	10	14	35
161	97	99	99	92	94	92
162	49	32	33	51	68	50
163	50	43	74	37	65	53
164	19	8	9	10	51	53
165	4	36	31	30	22	16
166	25	8	28	48	27	41
167	56	90	51	63	69	92
168	14	28	4	8	2	5
169	52	32	37	21	30	50
170	8	19	24	10	8	26
171	56	43	51	59	58	53
172	90	53	84	51	92	56
173	11	36	10	21	17	41
174	4	11	24	41	10	7
175	49	28	64	17	17	32
176	36	50	30	21	27	35
177	8	11	41	21	10	19

APPENDIX B

COHORT 2 MATHEMATICS AND SCIENCE DATA

Group 2 - Mathematics and Science National Percentile Rank (NPR) Scores for Students FY09 to FY11

	Old Middle School		New STEM School			
Group 2 Student Number	Math 6 Spring (Mar 30, 2009)	Sci 6 Fall (Mar 30, 2009)	Math 7 Spring (Mar 29, 2010)	Sci 7 Spring (Mar 29, 2010)	Math 8 Spring (Mar 28, 2011)	Sci 8 Spring (Mar 28, 2011)
201	77	51	61	69	65	71
202	29	26	5	33	27	29
203	10	15	9	26	10	7
204	59	51	4	4	54	36
205	89	75	81	88	79	80
206	19	15	12	17	37	15
207	36	59	49	97	44	61
208	9	36	18	45	28	29
209	7	26	13	21	5	29
210	18	19	9	21	31	21
211	2	15	18	26	11	36
212	55	43	61	42	66	39
213	82	80	78	73	54	68
214	55	48	46	54	61	49
215	46	48	54	69	27	61
216	40	9	2	30	8	26
217	78	64	55	66	61	58
218	36	36	45	33	31	39
219	42	30	47	54	27	43
220	61	55	67	85	59	46
221	30	19	35	58	24	52
222	1	1	9	8	5	21
223	44	19	41	45	31	36

(table continues)

Group 2 Student Number	Old Middle School: Math 6 Spring (Mar 30, 2009)	Old Middle School: Sci 6 Fall (Mar 30, 2009)	New STEM School: Math 7 Spring (Mar 29, 2010)	New STEM School: Sci 7 Spring (Mar 29, 2010)	New STEM School: Math 8 Spring (Mar 28, 2011)	New STEM School: Sci 8 Spring (Mar 28, 2011)
224	84	68	90	54	68	80
225	18	12	9	35	15	36
226	9	22	32	48	37	11
227	17	40	12	45	16	39
228	80	55	73	91	59	58
229	8	22	1	17	21	15
230	32	33	13	48	29	18
231	19	33	18	26	25	36
232	17	33	28	23	30	43
233	2	48	49	69	16	29
234	75	68	73	85	48	80
235	90	72	89	58	76	74
236	72	97	58	48	66	86
237	65	15	44	30	34	26
238	14	7	18	26	29	26
239	4	26	12	10	7	3
240	52	33	45	45	52	43
241	40	30	41	66	46	29
242	6	33	9	39	22	26
243	41	55	53	45	45	65
244	14	12	22	26	2	26
245	15	19	28	21	12	21
246	4	33	24	23	12	15
247	24	33	10	39	34	43
248	7	48	12	58	8	39
249	1	15	1	4	1	21
250	40	7	25	39	12	52
251	20	55	33	48	22	36
252	51	48	34	73	46	74
253	2	26	18	39	15	18

(table continues)

Group 2 Student Number	Old Middle School: Math 6 Spring (Mar 30, 2009)	Old Middle School: Sci 6 Fall (Mar 30, 2009)	New STEM School: Math 7 Spring (Mar 29, 2010)	New STEM School: Sci 7 Spring (Mar 29, 2010)	New STEM School: Math 8 Spring (Mar 28, 2011)	New STEM School: Sci 8 Spring (Mar 28, 2011)
254	99	80	84	81	77	78
255	68	80	67	85	69	80
256	1	12	15	10	20	36
257	73	33	66	45	48	29
258	24	9	21	6	27	15
259	24	19	32	30	36	21
260	10	5	3	2	11	26
261	55	36	54	62	56	58
262	61	55	65	58	47	49
263	75	84	88	81	79	61
264	46	59	69	77	64	61
265	18	19	11	17	1	26
266	30	64	51	85	52	46
267	75	40	90	42	72	61
268	44	19	41	66	12	43
269	18	30	41	17	15	7
270	29	59	28	6	22	39
271	77	80	51	77	64	74
272	68	40	43	62	45	61
273	1	2	15	35	8	11
274	55	88	80	94	69	89
275	20	9	24	33	34	46
276	20	12	22	10	16	43
277	94	84	90	77	80	80
278	79	43	56	66	55	36
279	11	15	35	30	8	43
280	84	64	92	91	83	86
281	16	30	8	35	15	33

APPENDIX C

HUMAN PARTICIPANTS REVIEW INFORMED CONSENT

UNIVERSITY OF NORTHERN IOWA
HUMAN PARTICIPANTS REVIEW
INFORMED CONSENT

Project Title: An Analysis of the Effect of a 21st-Century-Designed Middle School on Student Achievement

Name of Investigator(s): Gary D. Schwartz, Educational Leadership doctoral student, University of Northern Iowa

Invitation to Participate: You are invited to participate in this research project conducted through the University of Northern Iowa. The university requires that you give your signed agreement to participate in this project. The following information is provided to help you make an informed decision about whether or not to participate.

Nature and Purpose: Current research has indicated that student academic achievement improves with improved building conditions, and now studies are being conducted about the effects of school building planning and design on student achievement. To broaden the research studying the relationship between the physical learning environment and student academic achievement, the principal investigator will analyze middle school student achievement where students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility.

Explanation of Procedures:

- A meeting will be scheduled at your school after classes are dismissed at the end of the school day to meet with potential participants to explain the importance and purpose of the research study. The consent process will be conducted in accordance with federal regulations. Staff involvement and data collection procedures will be explained to potential participants. Informed consent will be sought from each willing participant in the study. After informed consent forms are submitted to the principal investigator, an interview with voluntary participants will be scheduled so that the time will not interfere with instructional time.

- Interviews will be scheduled at your school building and will be conducted only with teachers and administrators who worked in the old facility then transferred to the new school building. One interview session with teachers and one interview session with administrators are needed to collect data from educators about the effect on student achievement after a change in the physical learning environment. There are approximately fifteen teachers and two school administrators who have worked at both school buildings. Interview questions for the teachers and administrators will collect information about how the new learning environment designed for STEM curriculum has changed teaching strategies, student achievement, instructional technology, students' levels of motivation and engagement, and parental involvement. The principal investigator will use a focus group interview with the educators because all respondents have experienced the transition from the old facility to the new 21st-century-designed school facility. The common experience of the focus group will allow the participants to hear other responses and make additional comments beyond their own original responses. The objective will be to gain high-quality data in a social context where respondents can consider their own views in the context of the views of others. The expected duration of each person's participation in the study is the one scheduled interview session to collect the needed data.

- All conversations and interview responses will be treated with utmost respect and confidentiality. Conversations will be tape recorded, and full transcriptions of the interview will be shared with participants electronically when transcription is complete. The transcript will be forwarded as a Word document, and participants will have the option and freedom to eliminate components that they would prefer not to have included in the final transcript. From the transcript, a summary of findings will be included in the dissertation. Recordings of interviews with administrators and teachers will be destroyed after transcription is completed. The summary of findings will maintain confidentiality of all participants in the study.

Discomfort and Risks: There is minimal risk, or the risks are no greater than those of day-to-day life.

Benefits and Compensation: Individual participants will receive no direct benefits from involvement in this study. At the conclusion of my dissertation defense, study participants will be presented with a gift card from Amazon in appreciation for their contribution toward the research study. The gift cards will assist with purchasing instructional materials.

Confidentiality: Information obtained during this study that could identify you will be kept confidential. Signed informed consent forms will be maintained for inspection for 3 years. Recordings from interviews will be destroyed after transcription is completed to ensure confidentiality. The summarized findings with no identifying information may be published in an academic journal or presented at a scholarly conference.

Right to Refuse or Withdraw: Your participation is completely voluntary. You are free to withdraw from participation at any time or to choose not to participate at all, and by doing so, you will not be penalized or lose benefits to which you are otherwise entitled.

Questions: If you have questions about the study or desire information in the future regarding your participation in the study, you may contact Gary D. Schwartz at 515-262-5697 or the project investigator's faculty advisor Dr. Robert Decker at the Department of Educational Leadership, University of Northern Iowa, at 319-273-2443. You can also contact the office of the IRB Administrator, University of Northern Iowa, at 319-273-6148, for answers to questions about rights of research participants and the participant review process.

Agreement: I am fully aware of the nature and extent of my participation in this project as stated above and the possible risks arising from it. I hereby agree to participate in this project. I acknowledge that I have received a copy of this consent statement. I am 18 years of age or older.

___________________________________ _____________________

(Signature of participant) (Date)

____

(Printed name of participant)

___________________________________ _____________________

(Signature of investigator) (Date)

___________________________________ _____________________

(Signature of instructor/advisor) (Date)

Note: <u>One copy of the entire consent document</u> (not just the agreement statement) must be returned to the principal investigator and a <u>scanned copy e-mailed to the participant</u>. Signed consent forms must be maintained for inspection for at least 3 years.

Please return your signed copy in the stamped envelope provided to: Gary Schwartz, 3613 Brook Run Drive, Des Moines, Iowa 50317. Once all signatures are procured, you will receive a scanned copy of the consent form with signatures through your school e-mail.

APPENDIX D

E-MAIL INVITATION TO PARTICIPATE IN STUDY

To (name of potential study participant):

My name is Gary Schwartz, and I am a doctoral candidate in the Educational Leadership program at the University of Northern Iowa. I am presently engaged in conducting research for my doctoral dissertation, which will study the effect on middle school student achievement where students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility. The academic achievement of students is a high priority for all educators, and my study will broaden the research studying how the physical learning environment might have an influence on the academic success for students. The title of my study is: "An Analysis of the Effect of a 21st-Century-Designed Middle School on Student Achievement."

I am aware of your very busy schedule, but in order to successfully conduct this valuable research, I need your assistance. I would request that you participate in this research project conducted through the University of Northern Iowa. A meeting has been scheduled at your school on Thursday, March 14, at 2:45 p.m., to explain the purpose of the research study, staff involvement, and data collection procedures. After explanation of the research study, the interview will be conducted with willing participants.

The study will use information from interviews conducted with teachers and administrators who worked at the old middle school then transferred to the new 21st-century-designed middle school. Interview questions will be about how the new learning environment designed for STEM curriculum has changed teaching strategies, student achievement, instructional technology, students' levels of motivation and engagement, and parental involvement.

When I have completed the study, the results will be disseminated through the University of Northern Iowa. The school district will receive the results of the study upon the acceptance of the dissertation with the Dissertation Committee and the University of Northern Iowa.

The “Human Participants Review Informed Consent” form is attached and will also be distributed at the meeting that will inform you of the nature and extent of your participation in the research project. For willing participants, the signed forms will be collected at the meeting. If you wish not to participate in this research, you are free to withdraw from participation.

Thank you in advance for your invaluable help with this project. If you have any questions, please e-mail me at gpschwartz@mchsi.com or call my cell phone at (515) 402-8700.

Sincerely,
Gary Schwartz

APPENDIX E

E-MAIL REMINDER TO PARTICIPATE IN STUDY

This is a reminder about the meeting scheduled today, Thursday, March 14, requesting your participation in a research study. I am conducting a study that will analyze the effect on middle school student academic achievement where students experienced a change in the physical learning environment, from an aging school facility to a new 21st-century-designed school facility.

I am aware of your very busy schedule, but would request that you participate in an interview that will collect information about how the new learning environment designed for STEM curriculum has changed teaching strategies, student achievement, instructional technology, students' levels of motivation and engagement, and parental involvement. All conversations and interview responses will be treated with utmost respect and confidentiality.

When I have completed the study, the results will be disseminated through the University of Northern Iowa. The school district involved will receive the results of the study upon the acceptance of the dissertation with the Dissertation Committee and the University of Northern Iowa.

Thank you in advance for your participation with this project. If you have any questions, please e-mail me at gpschwartz@mchsi.com or call my cell phone at (515) 402-8700.

Sincerely,
Gary Schwartz

APPENDIX F

INTERVIEW QUESTIONS

An Analysis of the Effect of a 21st-Century-Designed

Middle School on Student Achievement

Interview Questions
Administration/Teachers

1. How has the new physical learning environment designed for STEM curriculum changed teaching strategies and techniques?
2. How has the new physical learning environment affected learning behaviors and/or student achievement?
3. Do teachers have greater access to instructional technologies that assist with meeting learning objectives in the new school when compared to the old facility? Why/How?
4. How has the new physical learning environment contributed to students' levels of motivation and engagement?
5. How has the new facility affected parental and community involvement?
6. What was the most noticeable change physically, mentally, or socially among students after the transition to the new building?
7. What was your involvement in the design of the new school? Is there anything you would change?