A SYNTHESIS OF STUDIES PERTAINING TO BUILDING CONDITIONS, STUDENT ACHIEVEMENT, STUDENT BEHAVIOR, AND STUDENT ATTITUDE

by

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ABSTRACT

The relationships between building condition and student achievement, student behavior, and student attitude were investigated by reviewing research. A synthesis of research studies from 1998 through 2008 was completed. A matrix was replicated from Lemasters’ 1997 study that identified the researchers used in each study. The matrix presented each author and the areas each author researched.

The first task was to determine if a substantial amount of research was available from the time period between 1998 through 2008. Current research through journals, research reports, briefs, and theses and dissertations supported this. The main research question examined if current relationships existed between building conditions and student achievement, student behavior, and student attitude by synthesizing several studies from 1998 through 2008. The results of the studies within this time period presented many new phenomena and also either substantiated or refuted findings in the previous syntheses conducted by Weinstein (1979), McGuffey (1982), and Lemasters (1997).

Over one hundred pieces of literature were reviewed that supported a preponderance of evidence, which broadened the field of focus to include certain variables that affect student achievement, student behavior, and student attitude. There
were 54 studies to be synthesized and included some independent variables presented in Lemasters’ study, as well as the variables of lighting, acoustics, school age, density, climate conditions, design features, teachers, attendance, attitudes, miscellaneous studies, and building conditions.

There were 35 dissertations reviewed that involved the dependent and independent variables mentioned above. Student academics, student perceptions and attitudes, and behavioral statistics were analyzed within each study. Each analysis of studies included the author of the study, the title of the document, the purpose of the study, the sample population used in the study, the statistical methodology used, the independent and dependent variables identified, and the findings and conclusions. The studies were formatted in a matrix and identified the number of studies in which the dependent variables of student achievement, student attitude, and student behavior.

The majority of all 54 studies involving building conditions and independent variables, from 1998 through 2008, had a direct influence on student achievement, student behavior, and student attitude. Newer, well maintained, schools had a positive influence on the dependent variables, while older, less cared for, and non-modernized schools had an adverse relationship to student achievement, student behavior, and student attitude.

The results of the previous three syntheses in 1979, 1982, and 1997, along with the results of the findings in this study supported and indicated that building condition was directly related to student achievement, student behavior, and student attitude.
DEDICATION

This study is dedicated to my parents Marva and Larry, my wife Patty, and my two children Spencer and Lauren. My family was the rock that pushed me to complete this study. Many sacrifices and much family time were given up to attain my goal of writing this study. There comes a time in life where one just has to say, “get it done” but in this study I think I achieved more than I thought I could. This would have never happened without the support and encouragement of all of my family.
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Dr. Twiford was essential over the past four years in providing a foundation for the cohort. He did an excellent job as an instructor, a mentor, and sometimes even as a guidance counselor. I knew from the first class I took with him that my educational experience was going to be a good one. I knew he would push us to achieve our dreams. I am much appreciative of him co-chairing my study.

I am in much debt to Dr. Linda Lemasters for allowing me to replicate the framework of her 1997 study. I was so impressed with the attention to detail in her study. Not only did she allow me to expand from her synthesis, she also was a part of my committee, and her feedback and support was invaluable.

I also want to give my sincere thanks to Dr. Carol Cash. She is also a pioneer of school building conditions and student achievement. She is sincere and kind in her words of support, and I extend my gratitude to her for serving as a committee member for my study. I really had a dream team committee for my study.
I want to thank Dr. Patrick Russo, the former superintendent for Hampton City Schools, for his encouragement and support in my pursuit of this degree. Dr. Russo was instrumental in recommending me for the cohort, and he supported me professionally through four years, as I finished this degree. This took a lot of sacrifice and hard work and Dr. Russo had faith that I would succeed in my studies and then lend my expertise to Hampton City Schools.

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CHAPTER 1
INTRODUCTION

Research is a means to expand the knowledge available on any subject. Research begins with a question that evolves into a clear goal and outlines a study. The question then becomes more defined as the investigation purports certain hypotheses. Hypotheses then develop as to why a phenomenon is occurring or as to what variables are involved with the phenomenon and how these variables have had affected outcomes. Research requires a vast collection of sources and data that will eventually either accept or reject a hypothesis. Research is not simply a gathering of key components. Rather, research is the collection, analysis, and interpretation of sources and data.

Many examples of research exist. Consider the actions of principals during a school emergency. A researcher could put forth a hypothesis concerning the actions of the principal and develop a research plan to gather data, and eventually develop some conclusions about the action that the principal took. This would give focus to a singular problem the researcher wants to explore. Questions such as why experienced principals act differently than inexperienced principals could lead to specific data that would be collected, analyzed, and interpreted in order to formulate a theory of how principals act in such situations. This is just one of many ways research can be used to answer questions of phenomenon.

Compiling and synthesizing research are specialized ways of expanding the knowledge base. Compilation is a work formed by the collection and assembly of pre-existing materials or data that are selected, coordinated, and arranged in such a way that
the resulting work, as a whole, constitutes an original work of authorship. The term compilation includes collective work (Wilson, 2000). Researchers can compile a variety of topics. In the simplest of terms, a dictionary of terms used in a specific field could be compiled, possibly in education or school law.

Researchers synthesize research to draw conclusions from several sources and then choose to summarize sources in order to capture common characteristics from topics of interest. Research synthesis can accomplish two fundamental tasks. These are learning from combining studies and learning from comparing studies (Cooper & Hedges, 1994). A synthesis allows for not only a compilation and comparison of studies, but also for a deeper analysis that allows research to be analyzed for similarities and differences, as well as specific variables that have an impact on the problem.

In the area of school facilities, previous efforts have been made by Weinstein (1979), McGuffey (1982), and Lemasters (1997) to synthesize the research. The research of these authors spanned nearly thirty years. The works of Weinstein and McGuffey encompassed a broader field of research than that of Lemasters. Weinstein and McGuffey included in their research many studies that investigated overcrowded classroom conditions, age of the buildings, open space classrooms, and design building components. The work of these two authors pre-dated the large surge of research studies devoted to the relationship between school building condition and student achievement and behavior. Lemasters focused her synthesis only upon the research dealing with the relationship between school building condition and student achievement and behavior. Her research
provided a unique perspective on the influence of physical environment upon the users of a building to the fields of education and architecture.

Each of these researchers conducted a synthesis of the research available to them at the time of their work. Weinstein and McGuffey looked at the entire field of school facilities and identified the most salient studies upon which to report. Lemasters specifically analyzed student achievement and the affects of several independent variables, involving building conditions. Collectively, over three hundred studies were analyzed and compiled by these researchers.

Weinstein (1979) conducted the first major synthesis of research on the topic of educational facilities and student achievement. Her synthesis revolved around three major issues. They included studies of specific environmental variables, ecological studies of spatial behavior, and studies of open space review. Her synthesis compiled over 175 sources and approximately 100 studies were reviewed. Weinstein stated that it would appear that the physical environment in the conventional classroom had little impact on achievement.

Several recommendations were made from Weinstein’s study. The first recommendation was to establish the need to continue research in the future. This research alerted others of the importance of the physical environment and changes that occur and evolve related to how classrooms are structured. The foundation was set for further exploration of the physical environment and for specification of what would be deemed an appropriate physical environment.
McGuffey (1982) completed the second synthesis in the area of facilities. The research synthesis in this study reported on the impact of building conditions, configuration of the building, and certain variables that impact educational outcomes. McGuffey organized the synthesis around approximately 74 studies. He noted that there was limited research available during this time period. Approximately 16 variables were used to complete this synthesis.

The findings and conclusions of McGuffey’s synthesis were divided by variables. The first variable was building condition. He noted that it was reasonable to conclude that a building’s age, thermal factors, and color had a statistically significant impact on student achievement. The synthesis revealed that school facilities affect student performance, although the variance of student achievement accounted for was very small. The last conclusion stated that obsolete and inadequate school facilities detract from the learning environment, while modern, controlled physical environments enhance it.

Lemasters compiled the most recent synthesis of research in school facilities in 1997. Lemasters conducted a synthesis on specialized research that pertained to the relationship between school facilities, student achievement, and student behavior. She synthesized 53 studies completed between 1987 and 1997. There were numerous variables researched such as facility age, lighting, and thermal environment that were analyzed in relationship between student achievement and building conditions.

From the findings, Lemasters concluded that school facilities that were well maintained had positive impact on student achievement. The review showed the
importance of the physical environment and indicated that student achievement and behavior were directly related to building condition. School facilities that were well maintained positively influenced students, whereas poorly maintained facilities negatively influenced student learning.

Full-spectrum fluorescent lighting with ultra-violet content had a positive affect on student health. Lemasters also concluded that the control of the thermal environment was important to successful student achievement. The last major finding of her study stated that non-instructional noise had an adverse impact on the student learner. Privacy and student attitudes were mentioned in this synthesis, but research was limited during this time period.

There was little research dealing with student attitudes and the impact that attitude or privacy may have had in relationship to student achievement. Weinstein briefly discussed the possibility that positive attitudes and behaviors from students may result in higher achievement. Lemasters also had limited information on this type of influence in her synthesis. She did reveal some research on student attitude and privacy, but the number of studies during the 1990’s also was limited.

Research studies on the morale and attitudes of students as a dependent variable were limited. As a result, further investigation is needed when these variables are compared to building conditions. One may compare the attitude of a student in a more modern or well-maintained school, with the attitude of a student in an older, less functional school. This theory may provide insight that older buildings that are not as
well kept may negatively impact student attitudes and student achievement. Negative attitudes about school may also possibly affect drop out rates in high school students.

The last synthesis completed by Lemasters was eleven years old. Due to the proliferation of research in this area of facilities and student achievement in the last decade, there is compelling reason to conduct another synthesis. A new synthesis of research dealing with the relationship between school facilities, student achievement, student behavior, and student attitude will provide the educational field with a current body of knowledge, trends, and research.

There have been close to three hundred studies included in the three syntheses of research through the work of Lemasters in 1997. A more current synthesis is now needed to determine the advantages or disadvantages of constructing schools in a certain manner and ascertaining a facility’s influence on optimal student achievement. This focus could give rise on the part of local school authorities to improve school facilities which may, in turn, promote student wellness and healthy attitudes, compel students to continue their education throughout their adolescent years, and reduce drop out rates.

It is the intent of the researcher to continue to broaden this field by focusing on current facility related variables that affect student achievement and educational outcomes. It is also the intent of this study to continue to reinforce current studies that analyze certain variables that affect student outcomes.

Statement of the Problem

The last completed synthesis of facility related research was completed in 1997. There is an eleven-year period where considerable new research was completed.
Because of the increased production of new studies in the field of school facilities, there needs to be a new synthesis of this particular area of research to update the current body of knowledge. This synthesis will allow for the discovery of any new phenomena that have occurred over this ten-year period. Newer studies under different settings may produce different results regarding student achievement, behavior, and attitude when analyzing building conditions.

The research question for the proposed synthesis allows for an in-depth study that reviewed and synthesized all of the research dealing with the condition of school building and the variables of student achievement, student behavior, student health, and student attitude toward school buildings from the period of 1998 through 2008. The proposed research study provided an analysis and synthesis of studies that either would or would not substantiate the relationship between school building conditions and student achievement, behavior, and attitude. Lemasters’ 1997 study was replicated to research current studies and her meta-matrix was replicated to allow a compilation of current research in this field.

Significance

All relevant research studies need to be synthesized to advance the level of knowledge in every discipline and area of study. A synthesis of research on school facilities dealing with the relationship between building condition and student performance, attitudes, and behavior would be useful by increasing knowledge about the influence the physical environment had upon the users of buildings.
The topic of school building condition and the effects on student achievement, student behavior, and student attitude was important because there had been only three major syntheses on facilities, and their impact on learning, behavior, and attitude. The main reason why this study was important is because there have been trends spanning from the early 1980’s through today that indicate school facilities do have an impact on student achievement. A new synthesis would advance the knowledge base by exploring new trends and studies that have occurred from 1998 through 2008. This would give educators, superintendents, school board members and architects current perspectives and research findings that had been conducted over the past eleven years.

There was also a need to continue this type of research through a synthesis by following Lemasters’ recommendations in her study. School facilities, and research around this topic, need to be further investigated because studies in this era, between 1998 and 2008, fully incorporate the “No Child Left Behind Act”, as well as the measurement of Adequate Yearly Progress in schools. In Virginia, the Standards of Learning tests have been the accountability tool that measure accreditation and school performance. Through these new measures, a current synthesis may present new phenomena that have occurred due to the new age of accountability in schools.

Scope of the Study

This study focused on studies that have been completed from the time period of 1998 to 2008. All of the studies included an analysis of the relationships between building conditions and some or all of the following factors involving student achievement, student behavior, and student attitude. Studies dealing with design
features and variables will be included in the research. Research studies using both quantitative and qualitative data will be included in the synthesis.

Lemasters’ 1997 meta-matrix (table 3, p. 204) was replicated for the research that had been conducted since 1998. The meta-matrix identified the researcher, the area of research that was conducted, the independent and dependent variables of the research, and a framework for areas that have yet to be researched.

Limitations

As in Lemasters’ 1997 synthesis, this study will not encompass the total scope of school facility research. Further, studies dealing with design features have been included in this study. It may be possible that not all studies may have been found. There was strict adherence to many descriptors used to find studies from 1998 through 2008, however, every attempt was made to locate and compile all related studies that could be found.

The research may also have been limited to studies that incorporated empirical data that may prove one piece of research to have more validity than others. The methodology used by each researcher was carefully examined for the type of research method used, the sample size of the research, and the findings explained in the research. Some studies were limited in their application due to the lack of some of the specified variables. Only those research studies that utilized the grade span of preK-12 as the population were included in the synthesis. School divisions may have different reporting procedures as well for their student academic data. Since this varied from state to state, the type of academic performance data and how it was reported varied.
Methodology

Research studies used for this synthesis were obtained from several recognized sources. Each study identified and involved school building condition and student achievement, student behavior and student attitude. Sources used included the National Clearinghouse for Educational Facilities, the United States Department of Education, the Council of Educational Facility Planners International, Dissertation Abstracts, The Education Resources Information Center, Pro Quest and other Internet sources, and guides to periodic literature such as Google and various University web sites.

The main sources mentioned above were significant sources. The National Clearinghouse for Educational Facilities, the United States Department of Education and the Council for Educational Facility Planners International were direct resources that involved recent studies involving building condition, statistics on school information, the impact of learning when related to building condition, and numerous journal articles and references for the related topic of building condition and student achievement, student behavior, and student attitude. References were also gathered by reviewing journals, interviewing fellow peers, and from other literature reviews.

Dissertation Abstracts and the Education Resource Information Center allowed searches by author, topic, and time frame. The studies to be researched were directly related to the time period from 1998-2008. These expansive databases allowed searches to be conducted by certain key words that was interchanged. These databases allowed searches by descriptors and were done in such a manner as to find all pertinent studies during this time period. Dissertation Abstracts lends the capability to search all
unpublished dissertations. This allowed for a compilation of dissertations from universities across the United States.

Studies were thoroughly sorted and organized as in Lemasters’ study. Each study selected included the stated purpose of the study, the research design employed in the study, the sample population, the instrumentation used to gather data, the statistical methodology, and the findings of the study. Good research incorporates all of the variables mentioned above. In order to create the best possible compilation of studies, this study had to first meet the criteria of identification of the independent variables dealing with building condition, as well as the dependent variables of student achievement, student behavior and student attitude. Each study reviewed should have had a research methodology that incorporated quantitative or qualitative research and then drew conclusions from the findings of each study. Studies deemed to have more of a relationship with design features were included in the synthesis, because new studies on design features may have a direct relationship to student achievement, behavior, or attitudes. The importance of the relationship between the condition of the school building and student performance was crucial to the success of this study.

Each study was presented in the exact format used in Lemasters’ synthesis. The name of the researcher was identified, the title of the document was clearly identified, the statement of the problem was included, the hypothesis stated, the methodology was identified, the population of the study was identified, the independent and dependent variables were identified in the study, and the conclusions and findings were presented.
This format was used for each research study or piece of literature selected and reviewed. The reviews were then compiled and organized by the identified independent variables to include color, maintenance, age, classroom structure, climate conditions, density, noise, and lighting. The studies were formatted into a table, which identified the number of studies correlated to the dependent variables of student achievement, student behavior, and student attitude. The synthesis analyzed techniques, population, methodology, and instrumentation.

Once each of the independent and dependent variables were reviewed and analyzed in chapter two and three, Lemasters’ meta-matrix was replicated to summarize all of the information from the studies, which included all of the comprehensive findings. The summary of findings was made in chapter four. The summary provided an analysis of each independent variable and outlined each study and the findings. This was done for each independent variable of color, maintenance, building age, classroom structure, climate conditions, density, noise, lighting and building conditions.

The conclusions of the proposed study were based on the synthesis and finalized the information that the studies provided. The preponderance of evidence for any finding or conclusion resulting from the synthesis of studies relied upon the quality and quantity of research studies. When research findings that resulted from the synthesis were reported, they were considered evidence that a relationship did or did not exist between the variables of school building condition, student achievement, student attitudes, and student behavior. Findings or conclusions of this study also provided a position that will
either substantiate or refute positions from the three previous syntheses of McGuffey (1982), Weinstein (1979), and Lemasters (1997). Recommendations for further study were also provided based upon the results, findings, and conclusions from the synthesis. The evidence was weighed from each study. The researcher then carefully made conclusions based upon the research reviewed.

Definition of Terms

For the Purposes of this research, the following definitions were applied.

1. **Student achievement**: was defined as measures of academic achievement as represented by standardized achievement tests or state mandated achievement tests. Student achievement was typically measured through performance on standardized tests scores.

2. **Student behavior**: was defined as the total number of discipline infractions recorded by teachers or other school authorities and reported by the school division. These infractions may include detention, some type of Saturday school or remediation, in school suspension, alternative placement or out of school suspensions. These infractions may range from minor offenses such as tardies, uncooperative behavior, insubordination, and disorderly conduct, to more severe cases of inappropriate behavior. The higher offenses may have included fighting, weapons and drug possession, assault on staff, bomb threats, or any other offense that may have led to immediate suspension or expulsion.
3. **Student attitude:** was defined as student responses to any type of instrument designed to measure attitudes, moods perceptions, feelings, or morale. These measures may have included the feelings and or culture that a student may have had based upon building condition.

4. **Age:** was defined as the construction date of a school building.

5. **Maintenance:** was defined as the repair and general upkeep of a school building.

6. **Density:** was defined as the space available in a student classroom or the size of a school building.

7. **Color:** was defined as the visual aspects found in a student classroom or school with regard to variations of white and pastel colors.

8. **Light:** was defined as the type of lighting systems used in a classroom or school such as ultra-violet, ambient, omni, or spot lighting.

9. **Climate conditions:** was defined as the variations of room temperatures that may be found in a student classroom or a school building.

10. **Classroom structure:** was defined as any environmental influence in a student classroom or a school building.

11. **Noise:** was defined as direct or indirect sounds that may be found in a student classroom or in or around a school building.

12. **Facilities:** was defined as any of the school buildings in which preK-12 grade students are housed for instructional purposes.
13. **Socio-economic status:** was defined as a student’s or student’s family social or financial information based upon free or reduced lunch status.

14. **Synthesis** was defined as compiling all available research, which included the independent variables of building condition such as age, maintenance, color, classroom structure, density, climate conditions, lighting, noise and the dependent variables of student achievement, student behavior, and student attitude.

**Organization of the Study**

This non-traditional dissertation has been organized into four chapters. Chapter 1 contains the introduction, statement of the problem, significance, scope of the study, limitations, methodology, definition of terms, and the organization of the study.

Chapter 2 contains the critical reviews of the studies by independent and dependent variables.

Chapter 3 contains the critical reviews of the studies only pertaining to school building conditions.

Chapter 4 contains the analysis, summaries and findings, the final conclusion of the syntheses, and meta-analysis. This chapter provided conclusions, present recommendations from the researchers themselves from their work, recommendations for future study, and research within the topic of building condition, student achievement, student behavior, and student attitude.
CHAPTER 2
CRITICAL REVIEWS

Introduction

Considerable research has been produced over the past decade dealing with the relationship between the school building and student academic achievement, health, attitudes, and attendance. There has also been some exploration into the health and productivity of teachers as it relates to classrooms. For the most part the researchers who have completed such studies have shed more light on how the physical environment influences the inhabitants of the school building.

Most of the research has been related to the possible relationship between school facility conditions and student achievement, but other strains of research have been very noticeable. Researchers completing these studies have looked at various building components that might produce an influence on student productivity. Some of the studies have been completed in Europe, but have application in the United States.

One group of studies includes a single building component or feature that is compared to student achievement. Much of the early research on the influence of school facilities used only one building component or feature as the independent variable. Some of the components that have been used are the thermal environment, lighting, acoustics, windows, classroom furniture, and science equipment. The researchers who have completed these studies produced a considerable amount of data about the positive and negative influence the physical environment has upon student health and productivity.
In contrast to a single building component that is used as the independent variable to compare with student achievement, there is a large group of researchers who have developed research studies in which they compared the total building condition to student achievement, behavior, and health. In these studies, the condition of the school building was assessed using an evaluative instrument designed to determine the condition of the school building or classroom. These instruments for the most part were developed using previous research to identify items to be included in the assessment instrument. Other researchers have assessed the building condition by using architectural or engineering instruments to determine the condition of the building. A considerable corpus of research findings have been developed by these studies.

Another group of researchers have produced important studies by investigating the relationship selected design features of a building might have upon student health and productivity. These studies have served to illustrate the importance of some design features that should be included in any new facility. Researchers completing these studies have used design features, rather than the total condition of the school building, as the independent variable that influences student and teacher productivity. Findings from these studies have helped architects and engineers in designing new buildings or renovating existing buildings.

While most of the researchers who have completed studies such as described above have used standardized academic achievement tests as a measure of student productivity, some researchers have used measures of student or teacher health to make the comparison between satisfactory and unsatisfactory school buildings. Such studies
are very important because the findings serve to illustrate possible negative influence to students and teachers attending buildings that are not in good condition. The findings of these studies can be extrapolated to the idea that the negative influence unsatisfactory school building conditions have upon the health of students also showed an influence upon their academic performance.

In this same vein of thought, some researchers have stated that student absence from school negatively affects their academic achievement. Thus, these researchers use a measure of student attendance as the dependent variable when comparing students in both satisfactory and unsatisfactory buildings. Several important studies have been completed recently using attendance as a surrogate for student achievement. In light of the fact that many states now report student achievement in terms of percent of students passing the examination, which many researchers regard as less accurate than raw scores, there may be an increase in the use of student attendance as a measure representing achievement.

This chapter is divided into seven sections representing seven of the eight major strains of research completed during the past decade. The first strain of research contains studies where researchers have used a single building component or feature as the independent variable, such as lighting, temperature, acoustics, or age. In the second strain of research, studies that have design features as the independent variable, as contrasted to building condition, is presented. The third strain of research contains studies where the school building condition may influence student attitude as opposed to student achievement. The fourth strain of research contains two studies where student attendance is used as the measure of difference between students attending satisfactory and
unsatisfactory buildings. Student attendance in these studies serves as a mediating factor in expressing student achievement. In other words, if students have poor attendance they usually do not learn the material presented that day and fall behind the other students, unless remedial efforts are put into place. In many studies, attendance has been used as a confounding variable often times serving as a control measure. In the two studies included here, however, attendance is used as a measure for student performance. The fifth strain of research contains studies that investigated the density of school buildings. The sixth strain of research contained studies that were labeled miscellaneous and could not fit into another category. In the seventh strain, studies are presented where researchers have evaluated a school building by means of engineering or architectural assessments to ascertain its physical condition and used that measure as the independent variable to compare the achievement of students in satisfactory and unsatisfactory buildings when considering teachers.

Analysis and Critical Reviews of Studies

The studies in this analysis were all concerned with the relationship between the three dependent variables of student achievement, student behavior and student attitude. The analysis of studies will allow educational professionals and building staff and personnel to see what current research has been established from 1998-2008. Several independent variables were categorized, such as: lighting, density, acoustics, design factors, and age of a school building. Some of these independent variables will be referred to multiple times in the reviews. The dependent variables of attendance and attitudes were also addressed in this chapter. As in Lemasters (1997) study, the first
reference to a study will be the complete description and all other citations will only address the other subsequent independent variables related to the study.

The dependent and independent variables used by each researcher are noted in the meta-matrix. The dependent and independent variables are clearly identified in the meta-matrix, and establishing a relationship or lack of relationship between the independent and dependent variables, as well as the significance or lack of significance found in each study, are shown. The following is a synthesis of the research by using eight independent variables found in studies from 1998-2008.

**Lighting**

Classroom lighting significantly plays a role in student performance and achievement. Improving lighting systems have shown improvements in tests scores, as well as reduced discipline problems. The Heschong Mahone Group (1999) showed in their research studies that daylight enhances better student achievement compared to classrooms without daylight. There has also been discussion on the effects of full spectrum lighting in the classroom, but many researchers and their studies from 1998 believe that daylight provide the best lighting conditions.

**Heschong Mahone Group (1999)**

The first study was on the relationship between day lighting and human performance. The Heschong Mahone Group (1999) conducted a day lighting and sky lighting study in three school districts. One school district was used in each state of California, Colorado, and Washington. The study analyzed the influence of day lighting and sky lighting on student achievement, specifically on the Iowa Test of Basic Skills for
math and reading in Washington, as well as grade level tests focused around school division curriculum in California and Colorado.

The population of the study included elementary school students in each of the three states. The school districts of Orange County, California; Seattle, Washington; and Fort Collins, Colorado was used for the study. Approximately 21,000 students were included in the study and over 2,000 classrooms were evaluated for their day lighting amounts, windows and sky lighting.

The test scores on the Iowa Test of Basic Skills and grade level tests in California and Colorado were used for student achievement. All student scores revolved around performance in math and reading. Classroom codes for day lighting and sky lighting were also used. Each of the classrooms was issued a code for lighting. A code of zero to one signified no lighting or minimal lighting in the classroom, where a code of five signified the best day lighting source possible. Other variables such as class size, school size, population, and socio-economic status were also controlled for in the data analysis.

The data were manipulated in several sets of multivariate linear regression analyses and stepwise regressions. The used data set of academic test performance in reading and math along with coded scores for window and sky lighting and day lighting were used in the analysis. The independent variables for the study included day lighting, sky lighting, windows, and control variables. The dependent variable was student achievement and was measured in the study by included reading and math test scores. A
total of twelve models were constructed with the data, which included four from each school district.

The results of the study were different in each of the districts. The school district of Capistrano, which was located in Orange County California, was the only school district that was able to look at pre-test and post test score data along with the coded scores of the independent variables of windows, sky lighting, and day lighting. This portion of the study found that students that had optimal amounts of day lighting progressed 20 percent faster on math tests and 26 percent on reading tests in one year compared to students in classrooms with the least amount of day lighting in their classrooms.

Students in classrooms with large windows, compared to smaller windows, were found to progress 15 percent faster in math and 23 percent faster in reading compared to students in classes without windows or small windows. The authors noted that only post-test score data were used in evaluating data in Colorado and Washington. Even with the variation of not comparing pre and post-test data, reading and math progress were significant in these counties where there was prevalent day lighting. The variance ranged from 7 to 18 percent compared to classrooms with less day lighting. Students in classrooms with sky lighting also showed 19-20 percent progress in reading and writing scores compared to students in classrooms that had no skylight. The regression analyses in all twelve models showed statistical significance when regressing day lighting and sky lighting with reading and math test scores. The significance ranged from .000 to .003 in all analyses, with the alpha set at p< .05. Day lighting and sky lighting were significant
on the influence on student progression and performance in all of the studies. The authors noted a valid predictable effect of day lighting on student performance.

Limitations of the study possibly included not all variables being accounted for in the study. The authors stated socio-economic status was controlled for, but the results of the variance of (SES) are not similar to findings in most other studies where SES accounts for a high amount of variance with student performance. The exact type of windows, sky lights and daylight capacities were not consistent across all school districts in regards to size, design and amount. The lack of control of lighting, as the independent variable, would also be considered a strong limitation.

Samuels

In the next study, which examined light, mood, and performance at school, Samuels (1999) provided a detailed report on his study that examined the relationship of full fluorescent lighting in classrooms compared to classrooms that were not equipped with full fluorescent lighting. The purpose of the study was to evaluate the extent to which full spectrum fluorescent lighting in schools affects student mood and performance in Australian schools.

The sample population of the study included 312 students in the 1998 field research group and 328 students in the 1999 field research group of elementary students from Seven Hills West Primary School, in Australia. Students were grouped solely based on the condition of the lighting of the eight classrooms that had full spectrum fluorescent lighting and the four classrooms used in the school that had standard cool white illumination in the classroom.
Data obtained from the two-field research approach included two-sample populations. The sample student populations were used over the two separate years. Four control rooms were randomly selected in the school. These four rooms had had lamps replaced while students were on a break from school. Experimental rooms had been selected by the virtue of choice. These classrooms were previously damaged by water and were refurbished with full spectrum fluorescent lighting. Samuels considered the selection of the school, rooms, teachers, and students to be random.

The teachers observing the students in the classrooms did data collection and assessments. The Psycho-Biological Assessment Scale (PBAS) was used to gain data from both the control group and the experimental group. The PBAS had 35 items on the assessment scales that related to and evaluated mood, attentiveness, behavior and Seasonal Affective Disorder Syndrome (SAD).

The methodology of the study included a univariate and multivariate analysis of variance. Samuels defined alpha for this study as $p < .05$ as indicating significance, and $p < .01$ as highly significant and $p < .000$ or $.001$ as being very highly significant. The PBAS instrument data on student performance were obtained from the teachers.

The results and the conclusions from the multivariate analysis, using the results of the PBA instrument showed a statistical significance of $p < .000$. This was deemed very highly significant between the control group and the experimental group when all 35 variables were taken together. Samuels noted that the means in every variable in the experimental group were smaller than the means in the control group. He concluded that full spectrum fluorescent lighting has the effect of improving student performance. A
univariate analysis of variance was also used in the study and the results indicated statistical differences between groups except for the variable of routine, which did not reach significance.

Samuels also noted that lower levels of illumination could cause depression of the nervous system, low arousal rate, emotional depression, lethargy and headache, lack of attentiveness, and an increase in distraction or inattentiveness. The more daylight or daylight simulation of artificial lighting that can be provided, the better student attentiveness will be, as well as mood, satisfaction, behavior, health and performance of students are likely to be.

Limitations of the study include the small population of students for the study. It should be noted that not all variables were considered in this study. Thus, socio-economic status, ethnicity and family dynamics, and state of health were not considered in this study. The inclusion of these confounding variables in the study may have made a difference on the results of the study if they were incorporated.

Dorgan

The effects of lighting and cooling system improvements on student test performance were researched by Dorgan (2001). The researcher examined the relationship between renovation status and student achievement results from standardized tests, promotion rates, student discipline, and attendance of students and teachers. The relationship of all of the fore mentioned variables were considered when analyzing the effect on non-renovated schools compared to renovated schools. The null hypothesis for
the study was that no changes would occur between the differences in student scores in non-renovated school to renovated schools.

There were several data components that were assessed in the study. Student academic achievement data were taken from the Texas Assessment of Academic Skills (TAAS) and primarily focused on passing scores of reading, writing, and math academic achievement. This TAAS provided assessment data from students in kindergarten through twelfth grade. Student information regarding attendance, discipline and promotion were also found in the Texas Educational Agency (TEA). Teacher and student demographic data were also accounted for. Teacher demographic data included a teacher’s average years of experience, total years of experience, teachers delineated by program, and the status of advanced degrees. Student demographic data included a student’s gender, ethnicity, free and reduced lunch status, limited English proficiency, and students by program.

The study encompassed 31 schools out of 240 schools in the Houston Independent School District, in Texas. Student data were used in all grade levels for the study. The TAAS data came from a mix of achievement scores in elementary school students through high school students. The data from the TAAS were analyzed two years prior to a school’s renovation and then three years after the school’s renovation, accounting for five years of student achievement data in non-renovated schools compared to renovated schools.
A Smirnov Test Statistic was used to identify the two data sets of renovated and non-renovated figures. A comparison of those figures between the data sets was done to ensure that they had identical distribution functions of each of the samples. The author used a chi-square analysis, Pearson correlation coefficient, and least squared linear regression to account for all variables.

The chi-square analysis accounted for an association between school renovation and student performance. The value was p< .05. The association was not found to be statistically significant in the least squared linear regression. There was a significant relationship in reading in sixth and tenth grade students and in math in third, fourth, and tenth grade students, and in eighth grade students in science. The relationship identified was from a comparison of data between the renovated and non-renovated schools but it was not statistically significant. The strength of the study was that there was a large population for the study that was diverse by grade level. The statistical methodology was also diverse. Weaknesses of the study included a limited effect or correlation between lighting or cooling systems and student achievement. The null hypothesis was accepted that there was no difference between achievement scores of students in renovated and non-renovated schools.

The study was limited by the ability to match data in various grade levels based on the TAAS. The reading test was given in grades three through eighth, and tenth grade, but the writing tests were only given to fourth, eighth, and tenth grade students. This being noted, the accuracy of the data is questioned. There was no physical environment
measurement for this study, but the researcher used the renovation process as the independent variable.

Wei

The relationship between day lighting quality and quantity for school buildings in Hong Kong, China were studied by Wei (2002). The purpose of the study was to understand the relationships between the quality and quantity of day lighting in schools in Hong Kong. The researcher’s hypothesis was that interrelationships existed between qualitative measures related to student satisfaction and selected measures of day lighting in occupied environment.

The sample population of the study included 1,330 local students from thirty-five classrooms. Eight secondary schools were used in new territories of Hong Kong. The population of the study was not described sufficiently to state the specific age of the sample and how the relationship exists between categorizing secondary schools in Hong Kong compared to the United States.

Data on the condition of the building included information collected through a field survey questionnaire using a Post Occupancy Evaluation (POE). This information was collected and used in a qualitative way. The data fore mentioned in the study was manipulated by using methods of factor analysis, multivariate analysis, regression analysis, and a hierarchical model that was used in quantitative means for the study.

The methodology used for the study was a mixed method study that included qualitative and quantitative data. The dependent variables used in the study included student satisfaction and student behavior. The variables were measured by subjective
responses on a survey instrument, as directly impacted by the independent variables of the amount of daylight in class, day light on student desks, brightness in the classroom, glare, view, brightness on the desk and the blackboard, sunlight in the class, gender, visibility on horizontal spaces, and the glare from vertical services.

The results of the study showed that there was sufficient day lighting in most classrooms in Hong Kong. Wei identified issues with one-sided daylight present in the classrooms, which allowed the availability of sunlight in only one side or area of the classroom. The blackboards in the classrooms, that had a glare from daylight, were major concerns of students according to subjective student responses identified in a survey instrument that was administered in the study. Brightness and the amount of daylight in the classroom was identified as the most powerful independent variable, which accounted for 57% of the variance of overall student satisfaction of daylight. A stepwise regression of variables showed that the daylight amount in the classroom explained 50% of the variance with overall satisfaction of daylight.

Non-day lighting related physical characteristics were not presented or identified in the study, which may have been considered a limitation. The physical range conducted may have provided different results based upon the physical properties in Hong Kong schools in relationship to what may be considered a comfortable classroom environment. This study only used secondary schools in the sample population and SES was not clearly defined or accounted for in the study, which may have been a limitation. Wei also noted the differences in classroom sizes, number of students, and the overall educational programs may have influence over the overall results.
Heschong Mahone Group (2003)

The Heschong Mahone Group (2003) conducted a follow up study from their previous study involving daylight in California, Washington and Colorado. This, the most current study focused on windows and classrooms and was a study that examined student performance and the indoor environment. The purpose of the study was to see if daylight and other indoor environment variables such as acoustics and climate conditions have an impact on reading and math in the Fresno Unified School District, in California. This study replicated their previous 1999 study. The Heschong Mahone Group wanted to see if similar results would be found in a different school district in California. They also wanted to see if more daylight in classrooms is associated with faster student learning while using the same methodology used in the previous study.

The study was conducted in two phases. The first phase analyzed the differences of well lighted and marginally lighted classrooms and their effect on student achievement. Phase two consisted of other indoor variables that were accounted for such as acoustics and thermal conditions. Phase one and two compared the academic performance in math and reading in elementary aged children in grades three through sixth. The sample population included over 8,000 students in grades three through sixth in thirty-six schools, as well as between 450-500 classrooms in the Fresno Unified schools district in California.

The data used in the study included the dependent variables of student achievement through district wide assessment tests in reading and math. The independent
variables consisted of day lighting, acoustics, and thermal conditions identified through the indoor environment in the classroom. Explanatory variables were identified as student and teacher demographics and school site characteristics and they were controlled in the study. Confounding variables were also identified as view related distractions, glare in the classroom, operable windows, thermal comfort, indoor air quality and acoustics.

A multi-linear regression analysis was used to analyze the differences and statistical significances of all of the variables presented in the study. The data were gathered and regressed from student academic data through assessments, school characteristic data, and numerous independent variables dealing with the indoor classroom environment.

Surveys were also used to identify classroom conditions and a daylight code was also used in the study that included a Likert scale that ranged from one to five. A scale score of one identified a classroom that had minimal daylight, where a scale score of five identified a classroom that had even balanced daylight.

The results of phase one of the analysis showed a significant difference in reading and writing scores of students in well day lighted classrooms and those students in marginal day lighted classrooms. Primary windows facing east, classrooms with a view, no operable windows in the classroom, and lack of window control were all significant indicators of performance. The statistical significance levels of the conditions above ranged from .000 to .006, with p< .05. When achievement data were examined separately, by content areas, math performance was influenced by window tint and sun penetration. Classrooms with no primary window walls, window areas above the
doorways, and window areas from the desks to the door influenced reading performance in a negative way and these influences were distracting in the classrooms.

In phase two, the authors issued 116 surveys and observed approximately forty classrooms. This phase expanded more on the influence of other indoor environment variables. The researchers concluded that the overall classroom conditions accounted for 1.5 to 2 percent of the variance of student performance. Although significant, this is a low amount of variance.

The summary of both phases of the study continues to substantiate the importance of the visual environment and the relationship to student learning. The authors noted one main indicator of the visual environment that would enhance performance and that being the ability to have some type of view out of a window. Several negative influences were also identified that hinders the learning environment. The first indicator was having glare in the classroom. This was identified as most important in math, especially when a teacher is working on a chalkboard or white board and there is a glare on it. The second negative indicator is the influence of direct sunlight into a classroom. This was identified as causing a glare in the classroom and thermal discomfort. The last identified negative indicator was the inability for the classroom teacher to have control of their windows in the classroom. The fact that all classroom design features, as well as classroom arrangements could not be controlled for, may have been a large factor in the results of the study.

Battles
Battles (2006) investigated the use of full spectrum lighting to enhance academic achievement, sense of well being, and on task behavior in the special education population. There was no specific research questions listed in the study, only four hypotheses. The author explored how and if any affects that full spectrum lighting has upon the academic achievement of special education students, of on-off task student behaviors, student attendance rates, and the effects of a student’s sense of well being.

The methodology of the study included a static group comparison. The statistical package of social sciences was used and a MANOVA, ANOVA, and a single and two-tailed test were used. Pre and post academic test score data was analyzed. Information was also collected from special education teachers and paraprofessionals, as well as student attendance data.

Two groups of special education students were used for the study. One group had six weeks of instruction using regular cool white fluorescent lighting. The second group had three weeks of instruction using regular cool white fluorescent lighting and three weeks of instruction using full spectrum fluorescent lighting. The dependent variables in the study were student achievement, student behavior, and student attitude through perceptions of self and others, and student attendance. The independent variable was exposure to full fluorescent lighting.

The population used in the study consisted of six resource classrooms from two middle schools in the southeastern region of the United States. Eighty-eight students were used. Thirty-five students were used in the control group and fifty-three students were
used in the experimental group. The student’s ages ranged from twelve to fifteen years old.

The findings of the study showed no statistical significant differences between groups when comparing pre-tests and post-tests. The findings of the study had mixed and inconclusive results as related to the impact of lighting on student achievement of special education students. The findings of the study did show that student behavior was better in classrooms in the group that had split effects of three weeks of fluorescent lighting and three weeks of full spectrum fluorescent lighting.

The group exposed to full spectrum lighting had less incidents of off task behavior compared to the control group. Attitudes of students and a sense of positive thoughts of students showed no significance between groups. Attendance of students was not statistically significant between groups as well.

The author noted several limitations of the study. The first limitation was the limit of randomization of the special education students. The author noted that this was a factor that could not be controlled. It was also noted that teaching styles and methods varied due to the individualized needs of the special education students. The physical structure and the variance of light in the school or the classroom was a limitation. The last limitation involved only two middle schools in Tennessee being used and the result of the sample could not be generalized to a population from another geographical region. The short length of time students participated in the study would also be considered a limitation.

Temperature

The proper temperature in the classroom is a very important condition for
successful student learning. In research studies dating back as far as a half century ago, the findings have indicated the temperature in the classroom is one of the most important elements to student achievement. The range of acceptable temperature in a classroom is very narrow, yet very necessary for students sitting in the classroom. The influence on school and classroom climate and temperature conditions were explored in this section. There were three studies that were presented. The studies varied in their diversity as they explored temperature conditions in student classrooms, adverse effects of temperature and climate, and how they had an effect on certain illnesses. Student exposure to adverse temperature conditions were also identified as a contributing factor to student asthma and other respiratory illnesses. Two of the studies were based in Denmark and Sweden, which showed an international importance of the effect of temperature exposure and the impact on students in schools across the world.

**Smedje and Norback**

The relationship of the effects of student asthma and adverse indoor air exposure was investigated at select schools in Sweden by analyzing adequate and inadequate ventilation systems. Smedje and Norback (2000) hypothesized that the incidences of allergies and asthma would be lower in students that were exposed to new ventilation systems compared to older ventilation systems that were found in older schools.

Exposure factors were also explored in this study. These factors included air pollutants and allergens that may have adversely affected the health of student over a period of time.

The population of the study included first, fourth, and seventh grade students. There were a total of thirty-nine schools identified for the study. The average school size
ranged from a minimum of fifty students up to five hundred students. Once the schools were selected for the study, classes in those schools were randomly selected. The total population of first grade students was 615. The fourth grade sample included 657 students, and the seventh grade sample included 762 students. The total population of student for the study was 2034 students.

The authors used several pieces of data for their investigation. The first piece of data was attained through a questionnaire instrument. There was a pre-questionnaire and post questionnaire that was administered to students over a two year period. The questions on the survey instrument requested information on the student’s home environment, diseases they have had, personal information, any diagnosis of asthma from a physician, and the family environment. This portion of the survey instrument asked if family members smoked or had any respiratory issues.

The other set of data involved measures of student exposure to various environmental factors. Approximately 51 classrooms were visited and evaluated over the two years when the study was being conducted. Several factors were accounted for in the exposure data. They included room temperature, the level of humidity, levels of carbon dioxide, dust, and any other compounds found in the classrooms. An Assman psychrometer was used to assess room temperature and humidity. A Riken and Sabata assessment instrument recorded levels of Carbon Dioxide and dust in student classrooms. Mold and bacteria were assessed by using a CAMNEA method. This method is a scientific means to analyze levels of mold and bacteria through incubation. The last piece
of data included the use of newer or older ventilation systems in the classrooms and in the schools.

The authors chose to analyze the results of personal factors and exposure when compared to newer and older ventilation systems. The statistical methodology used to address these variables was a McNemar Test. This test took the exposure rates and the personal factors of the students and compared both groups of classrooms that had newer systems to older systems. A Mann-Whitney Test was utilized to analyze the differences in measured exposures in newer ventilation systems to older ventilation systems in the classrooms. A multivariate method was conducted through the SPIDA statistical package. Variables were analyzed separately and against each other in multiple regressions. The significance level was p< .05 for the study.

The results of the study identified several key indicators of deterioration. Home factors such as water damage, moldy conditions, and the odor of mold were prevalent in approximately twelve percent of the sample in 1993 and thirteen percent of the sample in 1995. The presence of pets in the home was also significant. Over 60 percent of the students stated they had an animal that had fur on it. These animals contributed to allergies and respiratory issues among some of the students that had reported that they had an animal in the home.

The authors also noted some significant results on the psychosocial analog rating scale that was administered. It was noted that general satisfaction in schools decreased from .76 in 1993 to .72 in 1995. Stress levels of staff and students increased between 1993 and 1995. The climate of the individual schools also decreased over the two year
time period. The deterioration factors all mentioned above were statically significant with
p< .001. In regards to incidences of symptoms over time, asthma continued to increase
among students in older buildings, but asthma symptoms and respiratory illness were
notably reduced in schools that had newer ventilation systems.

This international study is important because the study gauged climate conditions
on student wellness, behavior, and attitude. The study had a few limitations that included
the varied climate in Sweden. The authors also identified that information bias may have
been involved with student and parent perceptions and attitudes, based on the survey that
was completed for the study. The population of the study could also be identified as small
compared to other research studies.

Perez, Montano, and Perez

The next study involved Westview High School in Portland, Oregon. The study
originated from several students complaining about the fluctuation of temperatures in
their classrooms. Perez, Montano, and Perez (2005) conducted an investigation at their
high school analyzing the impact of adverse classroom temperature and its relationship to
student performance.

Six freshmen classes served as the population or sample for the study. The
researchers stated the null hypothesis as being that students would pay more attention in
class when the environment was deemed neutral, which was not being too hot or too cold.
The student class and age was held constant, as only ninth grade students were used in
the study.
The study was organized into two phases. The premise for this first phase was that students would engage in certain activities under various classroom temperatures. These activities included student identification, recreation, and naming basic shapes and colors, as well as solving basic math equations. These activities were measured through three different diagnostic tests administered to students. These tasks were conducted under variable stages of temperature control in the six classes. Six randomly selected science classes were used with the students in each class having no knowledge of the various tests and activities they were expected to perform. Teachers offered incentives for the students to perform at their highest levels on all three of the diagnostic tests. Each class stayed in the room for 10 minutes to get their bodies acclimated to the room temperature.

In phase one, the room temperatures were adjusted for temperature by manipulating heat in the class by using hot plates. Classrooms were cooled by opening windows and placing ice in sinks. The study format in phase one was evaluated for methodology by the Beaverton Hillsboro Science Expo team. The Expo team noted that the tests on students did not have a strong enough measure on student’s attention. The temperatures manipulation in phase one did not have enough diversity to be extreme at the cold or hot end of the study. This identification would influence the results of the diagnostic tests. This being recognized, phase one results showed that room temperature was not a significant impact on the test scores of the students.

Phase two of the student study involved several changes, at the recommendation of the Expo evaluators, that made the study more appropriate for analyzing the effect of classroom temperature on a student’s attention span. In phase two, the student research
team sampled the tests on attention. Portable classrooms were also used in this phase, compared to science classrooms in phase one. This change was made due to the ability of controlling the temperature, and the air conditioning, through a thermostat.

The results of the study for phase one revealed that temperature had a clear effect on student performance and achievement. The cold setting group had a temperature set at 70.5 degrees Fahrenheit, which yielded an 86.7 percent test score percentage. The control group temperature, which was set at 72.5 degrees Fahrenheit, yielded an 86.9 percent test score percentage. The heat setting group had a temperature set at 73.6 degrees Fahrenheit, which yielded the lowest test score percentage at 82.7 percent test score percentage. The results of phase one were inconclusive based upon the lack of control of temperatures in the classrooms.

The results of the study for stage two included drastic temperature changes in the classroom. The classroom conditions were defined as cold, control, and hot. The performance of the students was drastically different in the performance tasks of identification and re-creation of shapes and colors, and basic math equations through manipulation. The results of a performance tasks in a cold classroom setting of 61 degrees Fahrenheit resulted in 76 percent of students passing the test. The control group was set at 72 degrees Fahrenheit, which resulted in a 90 percent test score pass percentage. The heat test group had a classroom setting of 81 degrees Fahrenheit which yielded a 72 percent test score percentage. These results showed more significance in the results compared to phase one, which again showed the impact of adverse climate conditions on student performance.
The study had several limitations. The first being that the same room was not used for each group. The four different classrooms had different class arrangements, posters and settings that may have influenced a student’s attention span. The rooms also had varied amounts of noted sunlight, which may have influenced attention span and performance. The tests were also given at varied times during the day and by different test givers. Some of the classes had distractions such as student disruption that may have influenced the results of being attentive.

**Wargocki, Wyon, Matysiak, and Irgens**

The effects of classroom air temperature and outdoor supply rates on the performance of schoolwork by children was researched by Wargocki, Wyon, Matysiak, and Irgens (2005). The purpose of the study was to determine whether classroom temperature and outdoor air supply rates had an effect on school performance of children in Denmark and to what extent the effects of poor indoor environmental quality (IEQ) had on adults in offices and children in schools.

Two classes of elementary school children in fourth grade participated in the study. The average year, in which the schools were built, that the children were housed in, ranged from 1950 to 1963. Less than fifty children, between the two classes, participated in the study.

The data used in the study incorporated behavioral data from experiments that were conducted over a four-week time period. Classroom temperature was reduced in each classroom from 23-28 degrees Celsius down to 20 degrees Celsius. Outside air
supply rate was increased from 180 m3/h to 800 m3/h in a blind 2x2 crossover design. It was noted that the teacher and student routines over the four weeks were not altered.

The classroom teachers collected the academic and behavioral data. This was satisfied through academic performance tests, which were gauged by speed and through behavioral logs that were kept by the teacher and the child’s parents. Accuracy on the tests was gauged by speed and was given in fifteen-minute increments. The academics taught throughout the four weeks included adding, subtracting, and dividing numbers, the checking of columns against each other, sentence comprehension, proof reading and editing of text, and proof reading of text with voice commands and errors.

The methodology used in the study included the statistical package of social sciences (SPSS) that analyzed classroom climate and student performance. A one-way and two-way analysis of variance analyzed the independent variables of climate conditions and the dependent variables of student achievement and student behavior. The authors, to test data for normal distribution, used the Shapiro-Wilkes test and Wilcoxon test.

The results of the study, through the observational checklist, showed that students tended to look around the classroom room with p< .10, talk more with their neighbors in class with p< .03, and support their heads with their hands with p< .05 when the ventilation rate in the classrooms was increased compared to the normal ventilation rates that were established independently of the classroom temperature. The alpha results were at 0.10 for the Wilcoxon tests, which were significant.
Student academic performance was also negatively impacted by adverse temperature and ventilation rates in the classroom. Increased ventilation rates increased achievement rates of students by fourteen to fifteen percent, when accounting for the number of units on the test attempted at a constant error rate. The statistical significance for addition was 0.016, for multiplication was 0.009, for number comparison was 0.05 and for subtraction was 0.06. These results were established by using a 2x2 ANOVA, with p<0.05 for statistical significance.

Reducing temperature in the classrooms produced better performance on subtraction, acoustic proof reading, and reading and comprehension that showed the number of units in math subtraction. Reduced classroom temperature tended to decrease committed errors by about ten percent in acoustic proof reading. Reduced temperature increased the pace at which text was read at a constant error rate by about twenty-four percent. The authors summarized that reduced temperatures in the summer and increased outdoor supply rates have a positive effect on the performance of children in the classroom.

It should be recognized that all variables were not controlled for in this study. The sample population for the research was also very low. This study provides more feedback from a spectrum outside the United States that substantiated the effects of classroom climate conditions and temperature and the relationship to student performance.

Acoustics

Acoustical control in the classroom is a very important variable associated with student learning and achievement. Students that can hear properly in class can typically
stay focused and hear the instruction from the classroom teacher. An inadequate acoustical environment often leads to off task behavior and inattentiveness by students. Moreover, students often do not perform as well when they cannot adequately hear in the classroom. The following studies investigate varied acoustical environments that include internal classroom distractions, as well as external distractions such as airplane noise, exposure to noise levels at home and noise as it relates to automotive traffic around a school.

**Rosenberg**

The next study focused around improving classroom acoustics (ICA) through an FM sound based field project involving amplification over a three-year period. Rosenberg et al (1999) conducted a research project in Florida. The purpose of the project was to examine the listening and learning behaviors of students. The researchers also looked to identify study skills that students use and to see if those skills would increase or improve as a result of an improved acoustic environment. The project focused around experimental and controlled groups. The project used FM sound field classroom amplification devices in the experimental elementary group and non-amplified classrooms as the control group.

The three-year project included a sample population of over 2000 students in 94 general education classrooms in kindergarten, first grade and second grade. Approximately thirty-three elementary schools across Florida were used as the study. The population appeared to be adequate for the research being conducted and could be generalized to other elementary schools.
The study was conducted in two phases. In phase one, using an experimental group and a control group for collected data, elementary students were exposed to a classroom that either had or did not have sound amplification. Fourteen schools were used. Classes were paired by grade level within each school site. The sample used in phase one was 663 students in the experimental group and 804 students in the control group. Thirty weeks of data examined student behavior and performance. SES accounted for about 40% of the variance when associated with student attention to listening and learning behaviors.

Phase two of the study involved 735 students in 34 classrooms. There were a total of nineteen classrooms used in this portion of the study. Pre and post student treatment data from twenty of the thirty-four classrooms were gathered. In this phase of the study SES accounted for 57% and 61% of the variance when associated with listening and learning behaviors in the classroom.

An ANOVA was used as the methodology for phase one data. The results of the data showed no significant differences between the experimental and the control groups. Phase two only noted one significant finding and that included the results of the ANOVA in regards to student special service effects and for student gender. The authors used the Stat View statistical package for data analysis and maintained an alpha at .05 for all statistical analyses. The analysis of data from the project showed that students in amplified classrooms did demonstrate significant improvements in listening and learning behavioral skills compared to students in classrooms that did not have sound amplification. The results also showed that students progressed at a faster rate in
amplified rooms compared to non-amplified classrooms. It was conclude by the authors that the better the students could hear, the better they could learn.

There were several identified limitations of the study and the first being that all classrooms could not be arranged to have the same effects across the study. It was also noted by the authors that reverberation measurements along with noise, need more consideration since these are the two majors factors that influence poor classroom acoustics.

Haines et al

Haines et al (2001) conducted an investigation that analyzed the effects of chronic aircraft noise exposure on children’s health. The study took place in the areas and schools around Heathrow airport in West London, England. Several student factors in the study involving noise included noise annoyance, indicators of stress from noise, effects of blood pressure, attention, and other stressors related to exposure to noise. The effects on student reading performance were also analyzed in the study.

The population for the study included twenty schools around the Heathrow airport. The schools were then divided into two categories. The first ten schools were those identified in high noise areas and the second set of ten schools was identified in low noise areas. The total number of students in the sample population for high noise schools was 236 students and the sample population for low noise schools was 215 students. The study included data that was retrieved from a survey instrument, questionnaires, and analyzing of student academic data through reading scores on the Suffolk Reading Scale. The Suffolk Reading scale assessed the reading comprehension of students. This scale
was completed by each of the students. They took a multiple-choice test, which incorporated the possibility of four answers per question.

Parents of the students provided data by completing a children’s psychological morbidity survey instrument, which was a strengths and weaknesses questionnaire. The survey instrument included questions on stressors, emotional stability, and student conduct.

Data for confounding variables were also used and controlled in the study. The variables of student age, sex, existing noise protection, and socio-economic factors were carefully examined and controlled for in the study. These variables are important based on the effects of how they influence noise exposure and the difference between the effects of noise exposure and noise groups. Data were collected from questioning students about their environment. To measure annoyance, the students were asked several questions in their classes. The questions focused on how each child felt in regards to annoyance when aircraft noise was present. A five point Likert scale was incorporated for the questions. The questions on noise annoyance ranged from noise exposure at school, at home, and over the duration of time. The time frame for the study was one year. The Lewis Child Stress Scale was also used to assess the stress level of students when associated with hypothetical life events and how often children had stressful events in their lives.

The author used a cross sectional format as the methodology. The advantage of this methodology was that the authors were able to analyze numerous variables and the
effect of noise related exposure on these variables. All stakeholders were able to provide data. Students, parents, and teachers provided questionnaire or survey data for the study.

The results showed that children that were susceptible to high levels of noise in or around school had significantly higher annoyance levels than children in quiet schools. This result was noted with the control of several confounding variables that included the age of the student, their main language spoken, social deprivation, and multi-level modeling in relationship to school level differences. The relationship of annoyance as a direct result of noise was $p < .0001$, which was statistically significant. Children exposed to noise were also found to be more likely to suffer from hyperactivity than children who were not exposed to such noise. The relationship between hyperactivity and noise exposure was also significant at the $p < .001$ level. There was no statistical significance between reading scale scores between groups of children who were and were not exposed to noise. The authors, however, noted that when the fifteen most difficult test questions were eliminated from the 70-question test and analyzed separately, a significant difference was found between the two noise exposure groups of children, while several variables such as SES, student age, and student gender were controlled for. The difference between the two groups of children as measured by the fifteen questions and the exposure of noise was statistically significant at the $p < .032$ level.

The study indicated that there was a significant relationship between exposure to noise and academic performance and student behavior. The authors noted that increasing the duration of time of the study could enhance the study. It is the belief that long-term exposure would also have a significant negative impact on student behavior and
achievement when exposed to adversarial noise conditions. The methodology for the study was deemed appropriate.

**Moses**

Moses (2001) conducted a doctoral research project for improving classroom acoustics; in support of Iowa’s comprehensive school improvement initiative. The purpose of the study was to review literature and then make connections between acoustic environments and their relationships to speech perception and student achievement. Moses wanted to create a multi-media presentation tool that audiologists could use statewide to advocate for good hearing and quality listening. Although not formally stated in this research project, the research question could be summarized as what the relationship was between speech perception and academic performance within a highly functional acoustic environment.

There was no formal methodology for the study. There was no statistical evidence presented through the research project. Moses evaluated the current literature on the topic of noise and the relationship to speech perception and student achievement. She made several conclusions based upon the literature.

The findings of the study noted numerous recommendations to improve acoustics in the classroom. She recommended pads on the legs of desks or chairs in the classrooms and using more soft sided bulletin boards. She also recommended the arrangement of furniture in the classroom to be constructed in a horseshoe formation to keep a close distance for the children. She also noted several other classroom adjustments to improve acoustics, but they had cost factors involved. These improvements included lowered
ceilings, carpeting, heavy window treatment, and the use of technology that incorporated amplification systems in the classrooms.

Moses also found, through the review of literature, that speech discrimination ability and speech perception were critical components of early literacy and overall academic achievement. Adequate amplification in classrooms provided many benefits to students such as increased time on task, word and sentence recognition achievement scores, improved spelling scores, and standardized tests score.

**Vilatarsana**

Noise exposure of schools around Heathrow was the acoustic focus of the last study. This study was unique because of its affiliation outside of the United States, specifically focusing around noise exposure in England. Vilatarsana (2004) investigated ways in which children were or were not affected by chronic noise exposure. The study looked to identify the academic performance levels of students and the relationship noise may have on the quality and standards of education a student in Heathrow. The final component of the study analyzed the amount of noise levels that children were exposed to and if the noise exposure over time had a direct impact on learning.

Thirty-five schools in Hounslow were the sample population for the study. The students in the study were primary or elementary school aged children. The schools were identified as schools that were in the surrounding area of the Heathrow Airport. The age of the students focused on in the study were mainly seven years of age, which would be equivalent to second or third grade students in the United States. Approximately 1,539 students were accounted for in the student sample.
The data used for the study consisted of three main components. The first component was academic data. These data focused on Standardized Assessment Tests (SAT’s) for the content areas of math and writing of seven-year old students. A second component was subjective assessments of noise climate at each of the schools. This was evaluated through personal visits to the schools. The major contributors of noise from this assessment were aircraft noise and road traffic noise. The last piece of data collected was formalized noise surveys at each school. A five-minute sample of the noise environment in each classroom was also measured and recorded at each school.

Using the three data components, the author conducted partial correlations and descriptive statistics to analyze the independent variable of noise and the relationship to the exposure of noise on the students. The dependent variable in the study was student achievement. Socio-economic status was also identified as a covariate for the study, as well as other descriptors for each of the schools.

The results of the study showed that the subjective and objective data measures in schools around Heathrow airport of students that were exposed to noise levels were deemed chronic and excessive when analyzing environmental noise exposure. Vilatarsana also noted that it would be extremely difficult for any classes to be taught outside of the school building due to the exposure of outdoor noise from road traffic and airplane noise. Playground noise was also identified as being at an extreme level. The noise level exceeded the recommended noise decibel level of 55db. Seventy-four percent of the schools around the Heathrow airport in the Hounslow areas were exposed to noise levels that exceeded 80db, which is considered a high amount of noise exposure.
A decibel meter was used to measure internal noise levels. The instrument used the BB93 criterion to evaluate adverse amounts of noise exposure. Internal noise levels were identified in ten schools out of the 35. The measurement in these schools exceeded a safe decibel level in the classroom by 10db and fifty-seven percent exceeded 20db in the classroom. It was shown that teachers in these schools often compromised ventilation in their classrooms due to the distractions that noise exposed by opening up windows to the outside of the classrooms would create. Teachers also had to change voice patterns in the classrooms to adjust for the change of sound that occurred during each class. Teachers were identified as having voice levels that ranged from loud to almost shouting due to the external noise exposure.

There was a low correlation between the noise levels from road traffic and student standardized test performance on math, reading and writing performance. Environmental noise, such as car, train, or plane noise, was shown to have a relationship to lower cognitive performance. Student reading performance was found to be much lower with students subjected to aircraft noise as an environment exposure to noise. Reading and comprehension was the most important factor affected by adverse noise conditions, compared to math and writing performance. When analyzing noise and student results, on standardized assessment tests, while controlling for socio-economic status, aircraft noise had the strong correlation with poor academic performance.

The study was limited to the lack of control in each of the classrooms when looking at classroom design or layout. The building construction and age of the schools
were not considered as a confounding variable in the study and may have provided a unique insight on the design on newer schools, compared to older schools and the relationship to the impact of noise exposure. There was only one identified standard test used for the study although math, reading, and writing tests seem to be a commonly used test in many other studies. The last limitation of the study would be the exposure of noise to children in their homes and the effects not accounted for in considering lack of sleep that may have affected academic performance based on this indicator.

Age

The age of a school building has served as a surrogate for building condition in many research studies. Age in and itself is not a disadvantage, it is simply that older buildings do not have the components newer buildings do. These studies have compared the academic scores of students in old buildings to the scores of students in new buildings to ascertain if the age of a building has an influence upon student productivity. Building age and its relationship to student achievement, behavior, and attitude is very important in regards to comparing the fore-mentioned dependent variables when assessing advantages of newer and more modern schools with outdated non-functional older buildings. Newer school buildings provide many necessities than older less modern schools do not have. The effects of enhanced lighting systems, more control of temperature regulation in classrooms, more open spaces and the opportunity for natural light in schools have been shown to improve achievement and morale in schools, compared to less modern schools with outdated design features.
The first study examined the perceptions of students, staff, and parents in regards to leaving an older school and transitioning into a newer school. Stapleton (2001) conducted his investigation by surveying students, staff, and parents from a baseline group to a post move group. The purpose of the study was to identify perceptions of the changes that may occur between students, staff, and parents as they move or transition from an older school to a newer school. There were five research questions identified. The first three questions were related to the extent, if any, that students, staff, and parents perceive differences, such as morale, educational suitability, and productivity, between an older building and a new building. The fourth and fifth questions were related to students, staff, and parental perceptions, such as a newer school producing a better school environment in a newer building compared to an older building.

The students, staff, and parents completed section A of the Charles F. Kettering School Climate Profile Survey instrument. Parents and students were randomly selected for the study. The sample population for the study included two hundred and seventy-six students, which participated in the baseline move, and two hundred and twenty-three students, which participated in the post, move survey.

The independent variable for the study was identified as building age, and the dependent variable as the perceptions of the school environment. The statistical analysis and methodology for the study was an ANOVA. The survey instrument administered to the students, staff, and parents produced quantitative data to be used in the analysis.
The results were that students had lower responses in the newer school compared to those students in the older school. The survey instrument was divided into sections and categorized into several areas. The sections involved were: respect, trust, high morale, and opportunity for input, continuous academic and social growth, cohesiveness, school renewal, and caring.

The findings for the student data analysis indicated there was no significant difference in any of the sections except respect. The staff and parent responses identified similar results. The parent results show no significance in any of the eight survey areas.

It was noted in this study that a change from an older facility to a newer facility did have an impact on the perceptions the students, staff, and parents had, but the change was a negative one. Student perceptions were that they lacked an identity with the new school because they were not in the new building long enough to work out all of the problems. Staff members indicated that the new building was not kept as clean as the old building. This was disappointing to the staff. The configuration of the new building resulted in the staff being isolated into different wings. This caused separation and lack of communication with staff. Parent perceptions were the lowest of the three test pools that also included students and staff. Building age alone does not improve climate in the study.

Limitations of the study included the sample population only being tested in one school. This may not allow the findings of this study to be generalized. There are many factors that affect school climate. Although age was the primary indicator in this study, other factors such as socio-economic status may have influenced the results. Parental
participation was lower than staff or students. Parental perceptions were less represented which may have influenced the results in this area. The methodology used in the study was limited to responses that were subjective in nature based upon the survey responses on the Charles F. Kettering survey instrument.

**Hickman**

The next study examined new schools in Ohio and their relationships between school facilities and student and staff behavior and attitudes. Hickman (2002) investigated the transition from an older school to a brand new school. The premise of the study relied on the relationship of student and staff behavioral characteristics in older school buildings compared to identifying what changes occurred once the students and staff moved to the new facility.

Hickman chose 12 school districts out of a total of 612 for the study. These were the only districts that had new schools built between 1997 and 1999. The time frame was essential in the study because the researcher wanted a two-year time period before the new school was built, compared to a two-year window after the construction was complete and the faculty, staff, and students were in the new building. Once the school districts were selected there were initially 66 participants. Each participant completed a survey on school pride, morale, and attendance rates of students and staff. Participants included seven superintendents, ten high school principals, 12 high school assistant principals, and 22 high school guidance counselors. Fifty-one surveys were completed and returned from the sample of 66.
The data utilized in the study included four sets of information. The first set was the responses from a survey instrument that solicited demographic information on each of the school districts and high school buildings. The survey instrument allowed the researcher to classify the type and size of each school. The second and third sets of data incorporated were retrieved from the Ohio Department of Education, which provided data on school vandalism and graduation rates. The last set of data consisted of individual responses from the 51 participants in the study.

The methodology for the study included a quantitative research design, which provided descriptive and statistical analysis through the statistical package of social sciences (SPSS). A mixed methods methodology was employed to obtain data from open-ended interview responses from those participants who did not return the completed survey instrument to Hickman. Five null hypotheses were established. The researcher concluded that moving to new high school facilities was not related to a change in students discipline, graduation rates, student and staff attendance rates, and student and staff perceptions.

The results of the study indicated that there was a significant reduction in the number of student suspensions and expulsions in newer schools compared to student suspensions in older school buildings. The mean average number of suspensions and expulsions of students before the move from the older school building to the new one was 6.41 number of suspensions. That decreased to 5.74 number of suspensions once students were in the new school, with p< .003. Suspension means data at the older school facility were 18.49 and once the students were at the new facility the mean average for
suspending decreased to 16.96. The statistical significance of the expulsion change was at p< .004. There were no significant increases or decreases in student attendance rates or graduation rates when comparing students in older school buildings compared to newer school buildings. The statistical significance for graduation rates was p< .135, which was not significant. The means did change from 21.91, while in the older school building, to a mean of 29.36 when in the new school building, with an increase in graduation rates in newer schools. Student attendance rates reflected the same lack of statistical significance at p< .978 when analyzing attendance rates in the older school building compared to the newer school building.

Significant positive changes were also found in staff attendance rates when moving to the new school. Hickman accessed attendance data from the Ohio DOE and the rank order compressed data results from the staff perceptions surveys responses. A significant positive change in overall staff perceptions of student pride and morale and staff pride and morale were found with a statistical significance of .001 for staff and student morale and .005 for staff attendance. A significant positive change in overall staff perceptions of student behavior also had a statistical significance of p< .001 when the students were in the new schools.

Limitations of the study included the use of only a specialized group of school districts in Ohio that had new schools built between 1997 and 1999. Hickman also noted the per pupil expenditures for educational costs and socio economic status were not considered essential variables for this study, although he did note that they varied between schools districts. Certain parts of the methodology were limited to the bias of
school personnel answering the survey questionnaire. The use of superintendents completing the survey questionnaire was limited based upon their minimal interaction with other staff members in those schools and the inability to provide subjective responses about other school personnel. Student behavioral data was also limited in the study based upon the time that was needed to retrieve that data.

**Kilpatrick**

Kilpatrick (2003) investigated school facility condition as an influence on school climate. A study was conducted with two separate secondary settings. The purpose of the study was to determine whether school facility condition influenced the perception of all stakeholders of a school, which included students, parents, teachers, and administrators in regards to school climate.

The researcher asked what features of school facilities would be positively or negatively identified as factors that may influence school climate. The research questions were focused around the students, parents, teachers, and administrators at each of the two Alabama schools. There were also two null hypothesis identified. The first hypothesis stated that there would be no significant differences among students, parents, teachers, and administrators regarding their perception of school climate. The second hypothesis stated that there would be no significant differences in the perception of students associated with each of the two high schools regarding the influence of the facility on school climate.

The sample population of the study included students in Lincoln and Washington High Schools. Over 1,000 school climate surveys were issued to students, parents,
teachers, and administrators. There were 484 surveys that were completed and returned for a 48% participation rate. Focus groups were also conducted with five or more people from each school. The researcher and two research assistants conducted a facility assessment at each school.

Data were gathered in three ways. First, a school climate survey instrument, developed by the National Association of Secondary Schools (NASSP), was administered to 50% of each grade level, 9th-12th grade. Random sampling and selection was done for this process. Kilpatrick then organized two focus groups, one from each school. The focus groups were made up of at least five people. Each group had a minimum number of teachers, students, and one administrator.

The last component of data gathered was though a facility assessment instrument, which assessed building conditions at each of the schools. The author used a facility assessment from the Council of Educational Facility Planners, Inc. (CEFPI) guide. The researcher, and two other researchers, that assisted in the process, visited each building. The site was surveyed from a facilities perspective. The CEFPI standards were documented and recorded and then each researcher rated each school building. The results of the facility assessment and the school climate survey were used in the statistical analysis.

The methodology of study included a mixed methods study. Qualitative data was gathered from the focus group interviews at each school and quantitative data were gathered via the school climate survey and the facilities assessment. Frequencies and percentages, chi-square, and a 3x2 ANOVA were used to analyze the data.
Findings from the ANOVA showed statistical significance from the security and maintenance subscale results. Simple effects analyzed by the researcher showed that students had lower perceptions of safety and good maintenance at Lincoln high school, which was the older of the two high schools. Students at Lincoln high school had significantly lower perceptions of their school, which meant that students had lower morale about their school, with a mean of 23.26, while students at the newer Washington high school had a mean of 28.85 when considering the effects of security and maintenance in older and newer schools.

A significant main effect was found for the role of many variables in the study. The statistical significance for the main effects was at p< .0001. Main effects were found for the subscale group and were noted for the variables, which included student-teacher relationship, the role of the administration, academic orientation, behavioral values, community-school relationships and student activities. Those variables were significant with p< .0001.

An ANOVA was conducted with the findings related to the facility assessment and appraisal at each school. The older high school, Lincoln High School, had smaller work areas, lack of extra space, lack of a teacher workroom, and overcrowded classrooms. Students in the newer high school, Washington High School, had a higher satisfaction rate at their school. The newer high school had larger classrooms, nicer facilities, the auditoriums were more spacious, and there was a work area specifically for the teachers.
Limitations of the study included the use of only two high schools in the sample. The mixed methods research model used three points of data collection through a survey instrument, facility assessment, and focus group interviews. Kilpatrick also noted that her presence during the focus group interviews might have influenced the findings and conclusions of each group. The study was primarily limited to the responses of the students, parents, teachers, and administrators that participated and responded to the survey or focus group interviews, while assuming they were honest and not biased with their answers. Having administrators in the sample groups may have limited the other groups from being fully honest with their responses, especially in the focus group interviews.

**Wicks**

Wicks (2005) investigated the relationship between new school buildings and student academic performance and school climate in Mississippi. The author identified five research questions for the study. The first research question asked if the grade point average of students showed a significant increase when moving from an older school building to a newer constructed school building. The second research question asked if secondary variables of gender, age, ethnicity, grade level, urban and rural status, and family income status revealed a statistical significance when analyzed with the sample of student grade point averages.

Research questions three and four involved principal perceptions and responses of moving from an older building to a newer building. The third research question specifically asked how the principal rated components of their new facility in regards to
providing a quality education for students. The fourth research question asked what problems did principals perceive that existed, relative to school building structure and amenities, which may impact a student’s academic performance. The last research question revolved around student and staff perception and responses of moving from an older school building to a newer one. This research question also incorporated how students and faculty compare, contrast, and evaluate school climate issues as covered in the researcher’s CFK Ltd. School Climate Profile Instrument.

The sample size of the study included ten schools. There were five high schools that housed students from ninth through twelfth grade. There was one ninth grade school, one middle school, and three elementary schools. Approximately 123 faculty members were surveyed, and ten principals were surveyed using a survey instrument that incorporated 27 questions involving cosmetic and structural building conditions.

Data for the study included a survey instrument that was issued to principals, students, and faculty. Student grade point averages for 72 randomly selected students were used as a variable in the study. The dependent variables were the academic achievement of students, the perception of school climate of staff and students, and the perceptions of the principal on whether new amenities are conducive for providing a quality education. The independent variable was the school building age.

The methodology for the study incorporated an ANOVA that analyzed school climate from the older school building compared to the newer school building. An ANOVA was also used to obtain statistical significance of student grade point averages. Surveys from ten principals were also tabulated and analyzed.
The findings of the study revealed that research questions one and two, which involved student GPA and student variables, showed that GPA’s were slightly higher in their first year in the newer school compared to their last year in the old school. The average sample of GPA in the older school building was 87.51 on a scale of zero to 100, while the GPA in the newer school building was 88.27. The difference between the mean GPA’s was not deemed significant in transitioning from an older school to a newer school. Research questions three and four revolved around principal perceptions and responses of climate and educational adequacy. The principal survey results concluded that their schools had adequate structural design, and amenities. Principals reported that school maintenance and cleaning tasks were adequate and that the staff took pride in the new school building. The final research question focused on student and staff perceptions of climate in the new building. The faculty survey revealed a negative mean difference in which they perceived climate conditions to be better in the older schools compared to the new ones. On the other hand, student indicators in all eight areas of the survey showed a positive mean difference in climate being better in the newer schools.

There were several limitations for the study. The first was the restriction of the population Wicks relied on the survey respondents to be honest and objective when completing the survey. The researcher did not rely on standardized grades, but rather the in-school grades by grade point average, which could be subjective in manner based upon curriculum, grading scale inconsistencies and considering teacher’s grading systems. Secondary researchers in eight of the schools, which assisted with the research, may have generated a bias based on their personal relationship in each school. The last limitation
was this being a one time study and only looking at variables from the transition from an older school building to a newer school building.

Design Features That May Influence Student Health, Behavior, and Performance

Design Features were investigated in this section of the study. There were five studies that were categorized in this area. Design features included any physical or functional aspect of educational or school building design. There were several identified design features targeted in each of the studies. Those design features included classroom design, functional patterns and display, social areas, safety design, transitional spaces in schools, and architectural design.

**Anderson**

The relationship between school design variables and scores on the Iowa Test of Basic Skills (ITBS) were investigated by Andersen (1999). The study focused on elements of school design that may affect reading comprehension and vocabulary, mathematics, social studies, language arts, and composite percentile ITBS scores of eight grade students. This study was designed to provide the answer of the affect of design features and how they may predict the proficiency of academic performance on the ITBS test.

The sample building population initially focused around 50 middle schools from fourteen counties in Georgia. The sample was narrowed to total of twenty-two schools in the study based on schools being identified as adequate or inadequate. The top eleven schools had adequate facilities and the bottom eleven schools were deemed as inadequate. Approximately 46,000 eighth grade students participated in the study and
their academic data were taken from the Georgia public report card that was published in 1997-1998, by the Georgia Department of Education.

Data were drawn from several sources. The Georgia Department of Education provided student academic data for the ITBS and school related information for all 22 schools in the study. The Georgia Public Education Report Card also was a source to obtain student and school data. The Design Appraisal Scale for the Middle (DASM) consisted of thirty-eight independent variables that were descriptors of design features. To measure the adequacy of the design features in each building, the researcher administered the DASM, which resulted in a total score for each school building. These scores were used to develop a mean score for the two groups of school buildings. The mean of the DASM for the top eleven schools was 488 and the bottom eleven schools had a mean of 355. All twenty-two schools had a combined mean average of 422, with the possibility of 820 points on the appraisal scale.

The statistical analysis used for the study was a multiple regression that was used to determine the predictability of eight grade ITBS scores when regressed with 38 independent variables of the DASM. Anderson incorporated a three-phase approach to the study. He first analyzed the student academic data. Site visits were conducted and the DASM was administered at all twenty-two schools. He then performed an analysis from the academic data and the results of the DASM by a two-tailed bivariate correlation.

The findings of the study revealed that a positive significant relationship existed between selected school design features and student achievement as related to ITBS
scores of eighth grade students. There were twenty-five design features from the DASM that showed a positive correlation to ITBS components. Several variables of interest included the r values for a safe place being .439, classroom walls at .439, natural lighting at .592, windows at .613 and climate control at .723. The statistical significance levels were set at p< .05 and the range for r squared was 1.00. Anderson noted that schools that fully utilized the learning environment had high performance on their ITBS scores. Private spaces and quiet areas outside of the school give students access to privacy. A varied learning environment and the diversity of design features enhance learning.

This study was limited geographically as Andersen only used twenty-two schools from the central Georgia area. It was also noted that the subjectivity of the DASM might be a limitation of the study based upon the inability to design an instrument that would objectively measure the independent variables defined in the study. Academic data were accessed for only one year for eight grade performance scores on the ITBS. This study provides significance to the body of research involving student achievement, design features, and middle school students based on the limited research conducted on these variables at the middle school level.

**Ayers**

Ayers (1999) investigated the relationship between high school facilities and achievement of high school students in Georgia. She explored the possible relationships between school facilities, as measured by the Design Appraisal Scale for High Schools (DASH-1), and student achievement in Georgia high schools as measured by the Georgia
High School Graduation Tests (GHSGT) for eleventh grade students. Design variable and correlative variables were analyzed for their affect on student achievement.

The population of the study was twenty-four high schools that were located in two Regional Service Area (RESA) districts, during the 1998-1999 school year in Georgia. Data collection was done using two methods. The first method was through the Internet. The Internet allowed Ayers to gather data on student achievement scores from the Georgia High School Graduation Test. The Georgia Department of Education provided data on correlative variables such as student socio-economic status, educational background of teachers, average years of teaching experience, and student population data. Site visits were also conducted at all twenty-four schools that participated in the study.

The methodology for the study included a non-experimental design. Multiple regressions were conducted using information from site visits, student academic data. Data from the Design Appraisal Scale were used for each high school to determine a total sum score for the educational facility variable. Descriptive statistics were used for all DASH-1 items such as hallway width, classroom furniture, patterns and display, acoustics, classroom and hallway color, windows, and natural lighting.

The results of the study showed all regression models of the F value were significant at p< .05. The full regression for math scores in relationship to demographic and correlative variables showed that correlative variables accounted for 68% of the variance on the GHSGT. Demographic variables accounted for 52% of the variance in
regards to English performance on the GHSGT. The DASH-1 facility scored results accounted for 6% of the variance as related to English performance on the GHSGT.

Other student academic achievement data were also analyzed in the multiple regressions. Math scores were influenced by the demographic variables of population, years of teaching experience, educational background of teachers, and SES. In the study 2% of the variance for math performance was directly related to design features related to the variables contained in the DASH-1. Science scores were also influenced by the design features contained in the DASH-1 and accounted for 3% of the variance of science scores. The variance of reading scores was also affected by the expanded DASH-1 and accounted for 2% of the variance.

It was also noted by Ayers that the variance in writing scores were explained by student socio-economic status, average years of teaching experience, average educational background of teachers, student population, which accounted for 82% of the variance when considering school size and DASH-1 results. Approximately 60% of the variance for scores in math, English, social studies and science was explained by correlative variables, which were variables such as SES that may have influenced variance. The number of years of teaching experience and the educational background of teacher presented the least amount of variance for the correlative variables, but on the other hand it was well noted that socio-economic status, DASH-1 results, and population of students in each school accounted for the most amount of variance.

Limitations of the study included only twenty-four schools in the sample population, and the DASH-1 design feature inventory was the only data collection
instrument for facility conditions. The GHSGT was the only measure for student achievement, and the study only examined student achievement as it related to the physical architectural setting and did not address the other variables of teaching methodology and instructional programs.

Yarborough

Yarborough (2001) investigated the relationship of school design features to academic achievement of elementary school children. The purpose of the study was to determine if student achievement, as measured by third and fifth grade performance scores on the Iowa Test of Basic Skills (ITBS), was affected by design factors of the school facility as measured by the Design Appraisal Scale for Elementary (DASE) students. The research question for the study focused around the effect of school design and its influence on student achievement of elementary school students. Yarborough hypothesized that there would be a positive correlation between third and fifth grade academic achievement scores of students and the eleven design patterns focused on in the study. The second hypothesis was that there would be no significant relationship between the eleven-design patterns in the assessment instrument and student achievement.

The sample for the study included the third and fifth grade students in twenty-four elementary schools, in the west central Georgia area. Data for the study included academic achievement data attained from the Iowa Test of Basic Skills (ITBS). These data were obtained for each school through the Georgia Report Card for parents. This is a state generated report that gave parents academic achievement data for the school their children attend. The Design Appraisal Scale for Elementary (DASE) schools was used to
describe over 86 design variables and design patterns. Each of the principals in twenty-four schools completed the assessment. School and demographic information were also considered for the study and socio-economic status was determined by student free and reduced lunch program.

There were eleven design variables that were explored in the study. Each of the design variables was analyzed for statistical significance and for their level of variance in considering their impact on student learning. The various design variables included movement patterns, large group meeting spaces, architectural layout, day lighting and views, color, building scale, location of school, instruction neighborhoods, outdoor learning environment, instructional laboratories and environmental conditions.

The methodology in the study manipulated the data through a non-experimental design. The academic data from the ITBS scores were used as a measure of student academic achievement. The building design and condition data from the DASE were used for the building conditions. Covariate information on socio-economic status and school and student demographic information were also used. Several multiple regression and step-wise regression procedures were used in the analysis.

The results of the study showed that design variables did influence student learning. In third grade, circulation and movement patterns accounted for 3.5% of the variance on the effect of student learning. Architectural layout accounted for 2.6% of the variance, location of school accounted for 3.3% of the variance, outdoor learning
environment accounted for 3.2% of the variance and color accounted for .4 % of the variance. A total of 14.2% of the variance was accounted for by building design for third grade student achievement. In fifth grade, large group meeting space accounted the highest amount of variance of building design affect at 3.1%. Architectural layout accounted for 1% of the variance, day lighting and views accounted for 1.8% of the variance, color accounted for .2% of the variance and instructional laboratories accounted for 2.4% of the variance. A total of 9.7% of variance for building design affected student achievement for fifth grade students.

The Iowa test of Basic Skills (ITBS) was the only measure of academic performance data. The Design Appraisal Scale for Elementary (DASE) school buildings was subjective in nature and may have led to bias or personal interpretation of the person participating. The sample population was small in nature and results may have varied with a larger sample size.

**Broome**

Broome (2003) conducted a study that examined the relationship between design of the school facilities and student behavior and academic achievement. The purpose of the study was to take several independent variables dealing with building and school design and conduct a bivariate correlation with student behavior and student achievement. Socio-economic status was used as a control variable. The null hypotheses for the study stated that there would be no significant relationship that would exist between school facility design and student achievement outcomes or student behavioral outcomes.
The study had five independent variables involving the facility. They included the learning environment functionality, adequacy of social areas, quality of transitional spaces, visual appearance, and emphasis on safety and control. Student achievement and student behavior were the dependent variables and socio-economic status was the control variable. The population of the study included middle school students that were in the eighth grade. Twenty-nine schools in Tennessee and Mississippi participated in the study. Twenty-eight schools participated in the study. The total number of students in the population for the study was not identified.

Data for student behavior was generated by the amount of incidents of out of school suspensions in each school. Academic data from reading and math performance scores, measured by the Norm Curve Equivalent scores (NCE) provided information on student achievement. The NCE scores provided test score results in reading and math between the two states of Tennessee and Mississippi. This becomes important because each state uses different accountability measures to gauge academic performance. Tennessee uses both the Iowa Test of Basic Skills (ITBS) and the Tennessee Comprehensive Assessment Program (TCAP). The majority of this information, as well as control variable information, were attained through the Tennessee and Mississippi Departments of Education.

Descriptive statistics and the assessment of means were also used statistically in the study. Pearson correlations of norm tests scores were also identified. Several pieces of data involving the independent variables, dependent variables and control variables were
manipulated and statistical significance was determined at the p< .05 level of coincidence.

The results of the study and the bivariate correlations between the five independent variables involving school design, two dependent variables of student behavior and student achievement, and the SES being used as a control variable. This information showed that student achievement and school design were very low in value and not statistically significant at .722, .689, .807, .639, and .587 for the learning environment functionality, adequacy of the social areas, quality of transitional spaces, visual appearances, and emphasis on safety and security, respectively.

The results of the bivariate correlation between the five independent variables, the dependent variable of student behavior, and the control variable of SES and school design were also very low in value and statistical significance at .270, .951, .923, .093, and .561 for the learning environment functionality, adequacy of the social areas, quality of transitional spaces, visual appearances, and emphasis on safety and security, respectively. The statistical significance level for the study was p< .05.

The author failed to reject the null hypotheses that no significant relationship exists between school facilities design and student achievement and behavior. In this study school design variables were not significant in relationship to student achievement or student behavior. The study was limited in the nature that all of the possible variables that could have been added in the study were not controlled for.

Hughes
Hughes (2005) investigated the relationship between building design variables and student achievement in a large urban Texas school district. The purpose of this study was to analyze the relationship between building design characteristics and math, science, and reading performance scores through the Texas Assessment of Knowledge and Skills (TAKS) from elementary school students located in urban schools district in Texas. The school districts had designated schools as being exemplary, recognized, or academically acceptable by the Texas Education Agency (TEA). The study also explored the relationship between the total score on the Design Assessment Scale Evaluation (DASE) and the state recognized rating for each of the elementary schools in that urban district located in Texas.

Only fifth grade students were in the sample population for elementary schools in this study. Data for approximately 1,000 students were analyzed by their academic achievement for fifth grade in math, science, and reading.

The DASE measured the degree in which the variables were present in the learning environment. There were eleven variables associated with the scale and they included design, movement patterns, large group meeting areas, architectural design, daylight and views, psychological impact of color schemes, building scale, location of school, outside location, and laboratories. Academic data were only used for elementary school students in the fifth grade. The Texas Assessment of Knowledge and Skills (TAKS) was used to assess academic achievement in math, science, and reading.
This was a descriptive study and the methodology included an analysis of the dependent variable of student achievement and numerous independent variables that included building condition. Correlation, two-tailed t-tests, and a one-way ANOVA were used to manipulate the data. Alpha was established at p< .05 to determine the statistical significance of the data. Student reading and math achievement scores were noted to be influenced more by building condition than were science achievement scores. Building design variables of interior paint color and outside learning areas had a statistically significant relationship with student achievement in subscale categories. Reading achievement was significantly influenced by the design variable of color. The r-squared value was 50.41 and this variable was established as the most important in relationship to reading performance.

Color and the outside learning areas also showed a positive correlation with math student achievement. Although the relationship was deemed minimal with color showing a significance of .132, and the outside learning areas having a significance of .065, which is weak; both still had some relationship with student achievement in math. Outside learning areas showed positive correlations with math, science and reading performance. There was also a moderately positive correlation between the DASE and TAKS math scores when associating the variables of color at .502, which was very weak and not significant in respect to the impact on student achievement. This study was limited to only elementary school students in fifth grade.

Building Conditions That May Influence Student Attitudes
The following section of the synthesis includes studies that investigate the relationship between school building conditions and the impact on student attitude, mood, and morale. There will be five studies presented in this study. Four of the studies have previously been presented earlier in the synthesis. Earthman’s study is the only study that identifies student attitude as the only dependent variable. The four other studies combine variables such as school building age and the relationship to student attitude. This dependent variable of student attitude is of much interest as this variable may lead to new research phenomenon in the future, as there is limited research in the area of school building condition and student attitude.

**Samuels**

Samuels (1999) investigated the effects of light, mood, and performance at school. This study was also reported in another section of the synthesis. The variable of mood is being further investigated in this study. It is important to distinguish the relationship that mood and attitude may have in regards to students being in adequate and inadequate school buildings.

The study also included the independent variable of lighting and the author concluded that students have better attentiveness, mood, and satisfaction when in adequate school buildings that have proper lighting, compared to inadequate school buildings that have inadequate lighting. A strong connection and relationship was established between student mood and human functioning when independent variables involving building conditions in schools are adequate.
The results of the study further support the importance of an adequate school building environment and the relationship to student mood and academic performance. It was also noted by Samuels that adverse building conditions, such as improper ventilation, had been associated with depression of the nervous system, emotional depression, lethargy, headache, and more susceptibility to distractions in the classroom.

Stapleton

Stapleton (2001) investigated the differences in school climate between older school buildings compared to newer school buildings. The purpose of the study was to reveal if there were student, staff and parent climate changes when student, staff and parents transitioned from an older school building to a brand new school building. The independent variable for the study was school building age and the dependent variable for the study was the perceptions of the school environment when students, staff, and parents transitioned to the new high school, as measured by the Charles F. Kettering II school climate survey instrument.

The sample for the study included one high school in Georgia. The students at the sample high school were moving to a newly constructed school. The total sample of students, staff, and parents included slightly over 200 participants for the study. The methodology included a quantitative analysis that included a pre-move and post-move survey instrument. The Charles F. Kettering II School Climate Survey was used as an instrument that analyzed school climate. Statistical significance was determined through the use of an ANOVA.
The findings of the study indicated that most of the survey responses were statistically significant when analyzing the effects of student perceptions and attitudes when moving from an older school building to a newer school building. Student survey responses involving respect and trust showed p<.01, morale p<.01, and the indicators of cohesiveness, school renewal, and a caring environment with p<.05. The parent and staff findings indicated a lack of significance of school perception and attitude when transferring from an older school building to a newer school building. Teachers lost a sense of school identity and felt isolated in the new building and the newer school was not as well maintained.

**Hickman**

Hickman (2002) investigated the affects between older school buildings compared to newer school buildings had upon the student and staff behavior and attitudes. This study was presented in another section earlier in the synthesis. The purpose of the study was to analyze student and staff behavior and attitudes when transitioning from older school buildings to newer school buildings.

There were eleven school districts in Ohio that participated in the study. The sample of schools included twelve high schools. The high schools were located in diverse areas in Ohio, which included rural, suburban, small city schools. Independent variables for the study included student and staff attendance, suspension rates, student expulsions, graduation rates, and staff and student pride and morale. The independent variables for the study included student and staff behavior and attitude.
The methodology included quantitative analysis, which resulted in descriptive statistics, as well as qualitative analysis through an interview survey instrument. The mixed method approach allowed the researcher to use data in a statistical means, as well as to interact with the high school teachers and students by conducting interviews through a survey instrument.

The results of the study, in regards to student and staff attitude, pride, and morale, showed that there was a significant positive change in overall staff perceptions, and student pride and morale when transitioning from an older high school building to a newer high school building. Moving to a new high school was related to an increase in student and staff attitude, pride, and morale. The statistical significance for the student and staff morale and attitude was p<. 001. The finding of the study supports the relationship between newer and more modern school buildings and their affects student and staff attitudes.

**Kilpatrick**

Kilpatrick (2003) investigated whether school building condition influenced perceptions of administrators, parents, teachers, and students in regards to school climate as it relates to morale, perceptions and feeling about one’s school. The purpose of the study was to analyze two secondary schools in Alabama and their perceptions of school climate and morale, and how the faculty, staff, and students communicate and interact. Positive and negative influences on school climate were examined and identified by teachers, students, and administrators.
The study incorporated a mixed method model that used school data, results of survey instruments, and researcher interpretation. The sample included two high schools that had grades nine through twelve accounted for at each school. Both Lincoln and Washington High Schools were located in rural North Alabama and had similar school demographics. A survey instrument was the first tool used to collect data on perceptions. The instrument was called the School Climate Survey and was developed by the NASSP. The survey instrument identified ten subscales that ranged from issues regarding student behavioral value, parent and school-community relationships, student-peer relationships and student activities. The researcher participated with the second part of the data retrieval process in regards to the focus groups and the qualitative data gathering. The final instrument incorporated was a facility assessment, using the CEFPI guide. The researcher, with two other researchers, conducted on-site visits and completed rating of each school building based upon school building adequacy or inadequacy.

The findings of the study, in regards to school climate, indicated that students had a much lower perception of school safety and maintenance compared to teachers and parents of that high school. Parents, teachers, and students at Washington High School expressed a value in the adequacy of the school building condition in relationship to a positive climate found in the school. The students at Lincoln High School had different views and they expressed that they did not feel that the school facility had a positive influence on school climate. The findings for this portion of the study were revealed from qualitative data retrieved from focus groups.

**Earthman**
Earthman (2008) investigated the relationship between the attitudes students have about their school building and their achievement. The purpose of this study was to investigate student attitudes in regards to satisfactory and unsatisfactory school building conditions and then see what impact the school building condition may have on student achievement. Earthman wanted to see if there was a significant difference in the attitude students have about their school buildings as measured by the Student School Building Appraisal Scale (SSBAS). The final phase of the study presented data regarding the possible difference between the academic performances of students who have good attitudes, as measured by the SSBAS and academic performance of students, compared to student having poor attitudes.

The population of the study included the students in twenty-two high school buildings in Virginia. Of the twenty-two schools, eleven of them were rated as being in unsatisfactory condition and the other eleven were categorized as being in satisfactory condition. The student population consisted of two groups of high school students. One group consisted of 154 students in four buildings assessed as being in satisfactory condition. The other group contained 114 students housed in six buildings assessed as being in unsatisfactory condition. Principals of each the schools rated their own school’s building condition and had overall scores range from a low score of 54 to a high score of 71. The mean average for the unsatisfactory schools was 56.8, while the mean average of the satisfactory schools was 67.2.
Each student completed the SSBAS. This survey was the first data component that assessed the attitudes of students regarding the condition of the school building. This information was done in the form of a Likert scale, which ranged from one to four on each question. There were a total of thirty-six questions on the survey instrument. The last survey question asked the students to rate their school as good, satisfactory or unsatisfactory. Data also collected on subtests and mean scaled scores of Virginia Standard of Learning tests for English.

The student responses in the SSBAS were calculated for their mean score standard and were then analyzed by the use of a t-test to determine if a significant difference existed between the two student mean scores. The comparisons of mean scores of the students in schools that were deemed satisfactory or unsatisfactory were then analyzed with English achievement data scaled scores of all students in the school division. A one-way ANOVA was then conducted.

Student performance scores on subtests for English SOL performance were then calculated. Earthman used p< .05 for this calculation and the results yielded as significance level of .057, which fell slightly short of statistical significance. It was noted that a trend level significance was acknowledged for student achievement in satisfactory schools on all subtests, but limited variance was noted.

It was concluded from the results that were based on the student survey answers on the SSBAS and academic performance on English Standard of Learning subtests that school-building conditions had an affect on how students felt about their school building. Students in schools that were unsatisfactory responded on the SSBAS in a negative
manner, while it was opposite for students in satisfactory schools. They responded in more of a positive manner.

Out of the thirty-six survey questions, the student responses for only eight questions failed to have significance. Those questions were associated with light and sunlight, color of walls, and thermal control and acoustics. It was noted that the majority of the questions were statistically significant between groups. Several questions focused around classroom structure such as classroom temperature with $p < .000$, variations of temperature in the classroom in the fall and spring and $p < .000$, the heat in the classroom and its effect on student attentiveness and dozing off with $p < .000$, effect of improperly sealed classroom windows with $p < .000$, noise in the classroom with $p < .001$, and the condition of desks and furniture in the classroom with $p < .000$. The statistical significance level of $p < .05$ was incorporated.

The final conclusion of the study focused on gender differences. There were differences between male and female responses. Earthman concluded that male students had less favorable feelings about their school’s building conditions compared to their female counterparts. This study is noteworthy for future study as it includes the unique dependent variable of student attitude, which still is somewhat unchartered. The failure to control for teacher experience and quality was a limitation of the study.

**Studies That Use Attendance As A Measurement of Student Performance**

Students need to have regular attendance at school in order to benefit from the systematic instruction needed to learn properly. On the contrary, repeated absence from
school of a student inhibits the learning process. Some of the researchers have used attendance as an intermediary for student academic success. Having adequate seat time in their classes is essential for student success in school.

This section of the chapter analyzes two studies that include the variable of student attendance. It is important in considering this variable and determining, from research, if adverse building conditions have an influence on attendance rates of school children. The following two studies explore for the relationship between student attendance at school and building condition.

**Shendell et al**

Shendell et al (2004) investigated the association between classroom carbon dioxide concentrations and student attendance in the states of Washington and Idaho. The hypothesis of the study looked to predict if higher indoor minus outdoor carbon dioxide concentrations were associated with increased student absenteeism. The purpose of the study was to conduct an indoor environment quality assessment, analyze carbon dioxide levels in classrooms, and account for these variables when determining average daily attendance of students in schools.

The population for the study included twenty-two school buildings that contained a total of 409 traditional classrooms including, twenty-five portable classrooms. The sample of classrooms used traditional ventilation systems through centralized heating and cooling systems, as well as the use of mechanical ventilation, which was accounted for by the use of wall unit ventilation systems in the portable classrooms.
The study included four sets of data. The first set included an indoor environment quality assessment. Technicians conducted this assessment and school faculty and staff accompanied them. The technicians implemented a walk-through survey instrument to measure carbon dioxide levels during the school day. Only two short-term measurements were conducted for the study with each measurement lasting about five minutes.

Carbon dioxide data were measured by using a device called the Q-Trak model 8551 instrument. The first measurement of carbon dioxide was taken in the center of the classroom. The second measure was taken by circumventing the airflow directly from each ventilation unit in the classroom. This measurement was conducted by placing the measurement instrument directly into the HVAC supply capture hood.

Attendance data of students in each school was collected through school attendance records. The majority of the schools used the concept of accounting for total student enrollment, the number of total students absent, and the number of absences each day, by each classroom. Average daily attendance data were also accounted for. Other confounding variables were considered in the manipulation of the data and they included student socio-economic status, classroom size, classroom structure, locality of the schools, and ethnicity.

The methodology of the study included a multivariate analysis. Descriptive statistics accounted for and compared the independent variable of carbon dioxide and ventilation with the dependent variable of student attendance. Student attendance, student ethnicity, gender, socio-economic status and classroom demographics were also accounted for. Descriptive and inferential statistics were calculated by using many
statistical evaluation means including linear regressions and analysis of variance.

The findings of the study demonstrated that when improving classroom ventilation, there also was a positive correlation with the reduction of student absenteeism. There was also a correlation found between student and teacher attendance rates having a direct impact on student achievement. About forty-five percent of the classrooms in the study had inadequate ventilation standards. The majority of the classrooms that had inadequate ventilation were found in classrooms in schools in Idaho.

The majority of the forty-five percent of classrooms in the study demonstrated a short-term level of carbon dioxide that was above 1000 parts per minute, which would be considered excessive. The authors noted that the increase in CO2 was associated with a statistical significance level of $p < .05$. The amount of carbon dioxide in the classrooms accounted for a 0.5 to 0.9 decrease in annual average daily attendance. This had a correspondence of up to a twenty percent increase in student absenteeism. Annual average daily attendance was found to be about two percent higher in traditional classrooms compared to portable classrooms and this finding was statistically significant with $p < .01$.

The study was limited because not all classroom factors that also may have influenced student absenteeism were controlled. The methodology seemed appropriate and confounding variables were accounted for.

**Duran-Narucki**

The relationship between school building condition, school attendance, and academic achievement, using a mediation model that interacts dependent variables, was
completed by Duran-Nurucki (2008). The purpose of the study was to analyze the affect of adverse school conditions on student educational outcomes while accounting for student attendance. Student attendance was used as a mediator to establish the effect if any on student achievement, when they are in school buildings that are either in satisfactory or unsatisfactory condition.

The population of the study included elementary schools from Manhattan, New York. Ninety-five elementary schools were selected from a total of 119 schools available from that area. The schools selected for the study faced strict criteria that established student addresses and the accessibility of data in certain public databases in the school District of New York City. Schools that had the accessible data available in the public databases were chosen for the study.

Data for the study included a twenty-item building condition survey instrument that was conducted by architects and engineers who were not employed by the school district. The instrument used to gather building data for the elementary schools used a Likert scale that ranged from one to five, with a score of one being poor and a score of five being good. Student academic data were the English Language Arts (ELA) and math standardized test scores for students in elementary schools. Student attendance data were measured by the average percentage of days attending school during the school year. Other variables accounted for were student ethnicity, socio-economic status, teacher quality, and school size.

The methodology for the study used a multiple regression analysis. Student achievement was delineated as the dependent variable and standardized test scores for
language arts and math were used. Student attendance was the mediator variable and was the variable that interacted with both the dependent variable of student achievement and the independent variable of building conditions. The independent variable that was regressed from the study included school size and density, windows, interior walls and color, roofing, boiler systems, and floor structure and finish.

The results of the study showed that there was a relationship between school building condition and student achievement. The multiple regression showed that school building condition was significantly related to test performance in math and language arts with $p < .000$. It should be noted that socio-economic status, school size, teacher certification, and teacher turnover rates were all used as covariates for this portion of the study. Alpha for the study was set at $p < .01$ or $p < .05$ for two tailed tests.

The affects of school building condition on student attendance were significant as school building condition was a predictor of student attendance. Covariates for this portion of the study included socio-economic status, ethnicity, school size, and teacher quality. School building condition impacted student attendance and was statistically significant with $p < .000$ for this portion of the study. In inadequate school buildings, it was shown that students attended school less often and their academic performance was not as strong in math and language arts as compared to students in adequate buildings. When school attendance was used as a mediator with poor academic achievement in the study, the results showed that school building conditions were no longer an indicator of the contribution of poor student academic achievement in language arts. The author also noted that the mean of environmental levels in schools such as
interior school walls and color, floor condition, and inadequate toilet and bathroom conditions often created an atmosphere in those schools that may have had an indirect affect on a student’s attitude, motivation, and performance.

The study was limited to the use of data that was available through the New York City Board of Education website. Demographic data may be limited as it pertains to the school environment and the surrounding community. Strengths of the study included the adequate control of variables.

Density

Density defines the amount of space students occupy in a school building. The following studies reflect the density and size of school buildings in relationship to student behavior, student achievement and student attitude. There were four studies identified that identify density and the relationship this independent variable have on student achievement.

Williamson

In (1998) Williamson completed research designed to investigate the relationship of school size to self-esteem and academic achievement, as reported by students in Missouri public high schools. The study investigated if there were statistically significant relationships between the independent variables of school size and socio-economic status and the dependent variables of self-esteem and student achievement. The study was separated into two stages. Stage one identified a null hypothesis that there were no statistically significant relationships between the variables of school size and self-esteem.
Stage two identified a null hypothesis that there were no statistically significant relationships between school size and student achievement.

The population of the study in stage one included 485 school districts. From that group, 63 high were included in stage one. All high school students in the population participated in a questionnaire that was in the Missouri School Improvement Plan (MSIP), which each school was required to take. Chronbach alpha was established at .79. A five point Likert scale was used for the survey.

School size was broken into two categories. The categories included schools with survey results of low self-esteem and high self-esteem. There were twenty-six small high schools and three large high schools that identified low self esteem through survey results from the results of the Missouri School Improvement Plan questionnaire. There were 20 small high schools and 14 large high schools that identified high self esteem from the results of the MSIP questionnaire.

The population of the study in stage two included 480 school districts. From this group 53 high schools were included in stage two. All student data were obtained from the Missouri Department of Education. Mean scores represented academic data and student achievement data were reported in mean scores for each school and included the performance scores for math, science, language and social sciences.

School academic achievement was then broken into two categories. The categories included schools with results of low academic achievement and high academic achievement. There were eight small high schools and twenty-two large high schools with identified low academic achievement. There were seventeen small high schools and
six large high schools that identified high academic achievement. Socio-economic status for both stages was measured by percent of student participation in the free and reduced lunch program.

Williamson also identified sixteen characteristics that were used as indicators for the study. They included student-teacher ratio, staff experience, average teacher salary, per-pupil expenditure, dropout rates, medium district income, accreditation, district location, poverty rate, school organization, adult educational attainment, single parent families, assessed evaluations, voted district levy, adjusted district levy, and identification with the community. The characteristics previously mentioned were used to assess large and small high schools and the effects of these characteristics in relationship to student achievement and self esteem.

The methodology for the study incorporated the social package of statistical sciences (SPSS). A regression analysis was used for stage one and stage two. Stage one used data from a questionnaire issued to all students from the Missouri School Improvement Plan Initiative. The survey was done on a five point Likert scale. Self-esteem data were used as the dependent variable and were regressed with data from the independent variables of school size, which identified 63 high schools in stage one. Socio-economic status was also identified by a student’s free and reduced lunch status and was included as an independent variable.

A regression analysis of the dependent variable of student academic achievement was done by using student mean scores of Missouri assessment tests of math, science,
language, and social studies in stage two of the study. The independent variable of school size and socio-economic status were also identified in this stage.

The results of the regression coefficient of the independent variables showed the percent of students receiving free and reduced lunch had a slightly higher influence on student self esteem than grade level enrollment. The standard coefficient of free and reduced lunch was 0.31 and the standard coefficient of grade level enrollment was 0.27. Williamson noted there appeared to be a statistical significance and positive correlation between the variable of self-esteem and high school size. There was a higher instance of self-esteem noted as the size of the high schools increased. The F statistic was 85.64 with an alpha of .0001 and the variance of 0.12. The r-value was .26.

The results of the regression analysis in stage two showed the percentage of student receiving free and reduced lunch status had twice the effect on student academic achievement that grade level enrollment did. The coefficient was -0.53 for free and reduced lunch students and grade level enrollment was -0.24. Williamson summarized this as a negative correlation between student academic achievement and school size. Student academic achievement tended to decrease as high school size increased. Small schools with low student achievement tended to have district medium incomes of less than $20,000 and lower per pupil expenditures compared with other state averages.

Pearson r was used to compare student achievement and self esteem. There was a noted correlation of -0.095 with a significance level of 0.038. A small negative correlation was noticed but not of particular significance. Only five schools were
identified as having high self-esteem and high academic achievement. Of the five schools three were small in size and two were large in size.

The study had two noted limitations and the first identified was the acknowledgement that self-esteem was a complex variable. The measurement of one’s self esteem is highly reliant on a student’s reliability that they were not biased in their answers and was the measurement a true indication of a student’s self-esteem.

Gentry

Gentry (2000) investigated the possible relationship between school size, academic achievement, and scholastic aptitude in Georgia’s public high schools. She used the Georgia high school graduation test and the scholastic assessment test known as the SAT to measure academic achievement.

This was a quantitative study that used ANOVA and a linear regression with an F ratio as the statistical methodology. The variance was tested at an alpha of \( p < .05 \). There were three control variables noted and they included socio-economic status, ethnicity and advanced certification of teachers. Once the dependent variables and independent variables were identified the linear regression was conducted to look at the differences in variance. The dependent variables in the study were identified as the 1998-1998 Georgia high school graduation test, the 1998 scholastic assessment test scores, and the percent of students eligible for Georgia’s HOPE scholarship. The independent variable was the size of the school.
Gentry grouped the schools from largest to smallest categories. There were four categories of schools used in the sample. Group one of the schools ranged from 1575-2826 students, group two of the schools ranged from 1200-1574 students, group three ranged from 850-1199 students, and group four had less than 849 students. Each group had 29 schools for a total of 116 schools.

The findings of the study showed significant differences between larger schools and smaller schools, specifically from group one to four and from group one to three. The Scheffe’ multiple range test were conducted with $p < .05$. Students attending larger schools outperformed students in smaller schools on the cognitive measures on which the students were assessed. The degree status of teachers and their years of experience did not significantly correlate with student achievement. This study did not include affective or behavioral components in this study.

Gentry noted several limitations with the first including that the schools used in the study were only traditional Georgia schools from ninth through twelfth grade. The achievement data were limited to one academic year, 1998 through 1999, of data from Georgia’s graduation tests. This investigation only looked at cognitive measures through student achievement. The scholastic assessment test did not measure student achievement but rather the aptitude of the student.

Swift (2000) investigated the effects of student population density on academic achievement in Georgia elementary schools. A null hypothesis was used instead of
specific research questions, but the research in this study focused on what the relationship was between school density and the academic achievement of students based upon the Iowa Tests of Basic Skills (ITBS). The research hypothesis stated that there was no statistical difference between school density and the academic achievement of elementary students as measured by the ITBS.

The methodology of the study included the use of the statistical package of social sciences (SPSS). Swift used a multiple regression analysis, including an analysis of covariance (ANOVA) to eliminate bias of the ITBS scores, accounting for minority rates, socio-economic status, and teacher experience and teacher education. Academic data were collected from third grade students. The measures of student achievement were obtained from the Georgia Public Education Report Cards in 1997-1998. Swift used a survey wheel, which was a circular measuring instrument that was used to determine linear square footage. The square footage was then converted to an architectural area. The measurement along with total student enrollment was used to gain the density of each school. Schools were then labeled as low, medium or high density.

An ANOVA was run for each set of achievement test scores. This was done to test the null hypothesis that a school’s density would not have an influence on student achievement. Alpha was set at $p < .05$.

The sample size of the study included 48 elementary schools, which were located in seven counties in Georgia. Only the elementary schools that served K-5 children were used in this study. Thirty schools were included in the population. Schools were grouped
into two groups. Those schools with high ITBS scores were in one group and the other fifteen schools with low ITBS scores were in another group.

The findings of this study were that elementary schools built with an architectural square footage of less than 100 square feet per student tend to have lower science, social studies, and composite test scores than students in facilities built with square footage in excess of 100 architectural square feet per student. There were three sets of test scores that showed significance with an alpha of p< .05 or less and they were in science with p< .001, composite test scores with p< .019, and in social studies with p< .003. Third grade schools with an architectural square footage rate per student of 100.27 to 134.1 had significantly higher ITBS scores in science, social studies and composite scores than schools with less square footage. The null hypothesis was rejected as Swift acknowledged a relationship between school density and student achievement in elementary school students.

There were several limitation identified in the study. The first was that the implementation of the curriculum across the schools was not consistent, although the Quality Core Curriculum (QCC) was implemented. It was noted that the quality of the teaching staff was not held constant. Only architectural area of the schools was focused on for Swift’s study. Interior spaces were not examined. The transfer rate of students was not accounted for in this study. District wealth, age of the school building, and the amount of parental involvement was not considered in this study.

Maniloff
Maniloff (2004) investigated high school size and the effects on teachers’ perceptions of working conditions. He used high school size as the independent variable and teacher perceptions of time, facilities and resources, leadership, empowerment, and professional development.

The methodology of the study incorporated a 39-item survey instrument. The survey instrument had a six-point Likert scale that ranged from strongly disagree to strongly agree. The teacher working conditions variables were categorized into five areas which were time, facilities and resources, leadership, empowerment, and professional development. The reliability of the survey instrument was established through a Chronbach reliability test. Chronbach’s alpha was established at .8162, which met Chronbach’s reliability test. Schools with 300 or fewer students were considered small, schools with 310-800 students were considered as medium populated schools, and schools with 801-2,700 students was considered large.

Descriptive statistics were used. Five linear regressions were used to determine the effect of school size on teachers’ ratings of the five dependent survey variables of time, facilities and resources, leadership, empowerment, and professional development. An Analysis of Variance (ANOVA) was also conducted to see whether teacher working condition ratings differed by categories of school size.

An ANOVA was used to test the means of the three groupings of schools, as well as to determine the statistical significance among the three categories of school size. The sample population for the study included 7,601 North Carolina high school teachers in 216 North Carolina high schools.
The findings of the study identified that of the five independent linear regression results of school size and teachers’ perceptions of work conditions, there was a statistical significance of \( p< .0001 \) for all five regressions in regards to the relationship of school size and teacher perceptions. Alpha was set at \( p< .05 \) for this study and regression.

As each dependent variable was analyzed closer, the first dependent variable of teachers’ perception of time had a variance of .01 and this indicated that only one percent of the teachers’ perception of time was affected by school size. The next variable included the teachers’ perception of facilities and resources. The variance for this dependent variable was .004, which indicated only .4 of one percent of teachers’ perceptions of facilities and resources was affected by school size. The variance of .01 indicated that only one percent of teachers’ perceptions of both leadership and empowerment issues were affected by school size. The variance for the last dependent variable of teachers’ perceptions of professional development had a variance of .003, which indicated that .3 of one percent of the teachers’ perceptions of professional development was affected by school size.

Maniloff concluded that school size had a negative effect on teachers’ perceptions of their working conditions although the variance was very low. The ratings for working conditions decreased as the size of the school increased. The author could not support the idea that decreased high school size produced a more meaningful work environment based on the results of the survey analysis. It was also noted through the results of the ANOVA that teachers’ time to work on curriculum, classroom management, and individual instruction decreased as school size increased.
Although the regression analysis results showed significance, the amount of variance in each regression continued to be very small. Limitations of the study included the validity of the survey instrument as it had only been used once and was not documented. This was the only source of data used for the study. Perceptions at each individual high school were based on teacher opinions and may have been biased. The data gathered were also localized to the state of North Carolina. Not all variables were accounted for in the study such as student socio-economic status.

**Miscellaneous**

The following four studies could not be categorized into a specific category of research of this study. Nevertheless, the studies deal with variables that are associated with the main body of research concerning the relationship between building condition and student health and productivity. Theses studies are of interest and involve several unique topics. The following studies included an investigation into a deeper understanding of research and evaluating the physical and outcome variables. The studies that were investigated included the topics of: financial responsibility of maintaining a school facility, school renovation and maintenance of a school building, and the affect of school building condition on a sub group of students, specifically students recognized as socio-economically disadvantaged and of a racial minority.

**Maxwell**

A case study of schools within the Syracuse City School District of New York was completed by Maxwell (1999). The case study examined school renovation and
maintenance and their relationship to student performance. The case study posed several research questions, which included whether the learning and academic performance of students were affected by the condition of school facilities. The case study also examined the questions of why the quality of facilities might affect math performance more than reading, and if there might be a difference in the way students attain math skills compared to reading skills, and why the relationship may be stronger in older students such as sixth grade students compared to third grade students.

A multiple regression analysis was conducted in the study. There were four student performance measures used. The performance measure examined third and sixth grade math and reading scores from the pupil evaluation program test also identified as the PEP.

School renovations and maintenance in the study included refinishing of floors, painting of walls, the complete renovation of school kitchens, the overhaul of lighting systems in schools, moving to fluorescent lighting. It was also noted that new blackboards were also installed in classrooms. There were several schools in the district that also had building additions to the school, which accounted for growing populations of students.

The findings of the case study revealed that the physical attributes of school facilities play an important role in a student’s academic performance, attitude and behavior. Students that were subjected to the noise associated with the renovations, while school was in session, may have resulted in decreased student performance. The study
revealed a positive relationship between upgraded and maintained school facilities with math achievement.

There were several noted limitations of the study. The first included needing a larger sample size and methodology. There was also a need for more reinforced and identified correlation between improved student academic performances and newer, renovated, and better maintained school buildings, which was not clearly identified.

**Brannon**

Brannon (2002) investigated the relationship between school building conditions and the leadership and financial ability of a school division by using measures of the perceptions of school board members, a superintendent, central office staff, board of supervisors and principals in regards to the condition of the school building. The examination of the relationship of the financial support provided by leadership and the on school building conditions were examined. The last factor identified was the relationship between the behavioral effort of leadership team and the condition of school buildings.

The methodology incorporated an assessment of each of the school buildings in one Virginia county. This assessment was conducted by having principals assess their buildings using the Commonwealth Assessment of Physical Environment. In addition, an independent contractor assessed the same buildings using the CAPE. This provided a comparison of building condition by more than one individual.

The researcher surveyed the respondents to determine their perceptions of the condition of their buildings. Brannon then compared the results of the building assessment with the perceptions the respondent groups had of the condition of the
buildings. This was done by comparing the building assessment scores from superintendents, a private contractor, central administration, and from principals. There was also a comparison made between the maintenance requests from the principals and the requests those were completed over the past five years.

The statistical analysis incorporated in this study was a descriptive research methodology. This type of methodology describes and interprets and in this study the perception surveys were interpreted as well as data from the funding allocations from the school division in regards to building maintenance and improvement requests. Variables for the study revolved primarily around the perceptions school division personnel had about the adequacy of their buildings. The financial impact of the division was an important variable. It was important to identify how those funding factors influenced adequate or inadequate school building conditions.

The findings showed that there was a positive correlation between school leadership and building conditions but was modified according to how close the individual was to the building being assessed. Brannon stated that the school board members and board of supervisors did not consistently agree with the survey results of the CAPE, as measured by the principals, the independent contractor, and the perceptions and budgetary requests of the building principals. The principals had less confidence in the adequacy of funding for the upkeep of their school buildings than the other three groups. Perceptions of school board members, the superintendent, and central staff were generally positive in regards to overall conditions of schools. Brannon stated over twenty-five percent of the total responses, from the three groups, reported school
facilities were adequate or adequate with implementation of improvements. Scaled score results from the perception survey instrument revealed that school board member’s perception of the condition of school buildings appears to be at a very high level, while the scaled score of principal results revealed that the school building standards were below standard when analyzing technology adequacy.

One noted concern was the age of the school buildings in this district. No school had been built in the past ten years and only seventeen and a half percent of the schools were under twenty years old. The contractor’s analysis noted that there were many unfavorable conditions in the building inventory of the school division.

Findings from the budget requests showed that financial allocations to the local high schools over the five-year period indicated that money was given based on the needs of the physical environment, as perceived by the superintendent and school board members rather than the principals. Brannon noted that requests by principals for monies over the five-year period had never been fully funded. He noted the meaningfulness of this due to the financial constraints, which may have caused building maintenance and school improvements to not be fully funded.

The research component of the study included limited descriptors and a very small sample size. The researcher was somewhat vague on the key findings especially in the findings for the budget request section.

The descriptive research methodology was appropriate. Limitations of the research included that the study group included the home school division of the researcher, which may have given an interpretation of bias. The use of an independent
contractor possibly may have eliminated some bias but it was also not designated if the contractor was based in the locality where the assessments of the schools were made.

Brannon concluded that the findings in this study indicate that there is a positive relationship between building conditions, leadership and financial support. The perceptions of the educational leadership also indicated that the overall maintenance and condition of school buildings were standard or above standard.

**Bosch**

Bosch (2003) endeavored to identify relevant variables that might explain how school facilities affect student educational outcomes. The Delphi Technique was incorporated in this study. The use of this technique was primarily done to establish a set of priorities for architects. The author stated that there were two main reasons for using this technique and they included the geographical distances between participants involved in the study and because this type of method usually requires the least time for participant involvement. The major strengths of the Delphi Technique include a high level of isolated thinking, it is problem centered, independent judgments are acknowledged, and participants can usually complete the tasks in a timely manner and ideas are generated in a short period of time.

The population for the study included seventeen educators that were deemed experts in the field. The sample population participated in the Delphi technique by completing prioritization of four iterations of the original list of variables. The initial variables for the study were obtained through a review. The review resulted in the identification of the variables of: school size, building maintenance, visual, thermal and
acoustical comfort, and indoor air quality. Numerous educators identified measures of success and school facility effects. Researchers identified the physical variables related to measure of success. The author identified gaps and developed research priorities based upon the data analyzed.

The methodology of the study included several ways to gather pertinent information on physical variables and educational outcomes from educators and perceived experts in the field. Several survey instruments were used to include interview surveys and the process of concept mapping. Concept mapping is a reflective tool that allows a researcher to prepare a project, generate ideas about the project, structure the main ideas and main points and then interpret them and use them for the project. The questionnaire was issued to a group of experts. The goal of this method was to gain information and knowledge from these experts, as well as gather their opinions and perceptions of the topics of physical variables and educational outcomes.

The topics of the questionnaires included identifying physical factors and establishing a relationship between educational outcomes. The questionnaire also identified ratings for physical factors, developed hypotheses that linked the physical environment to measures of success, and identified the highest priorities and finalized a framework for future consideration.

The conclusion of the study identified research priorities that were aimed to help future researches gain knowledge of the effect of physical variables on educational outcomes. This study incorporated a multi-method research design. The use of educators
and experts provided insight on the future needs within this field. The results of their impact provided the following set of research priorities that identified several physical variables that warranted consideration for future research. The physical variables included team work stations, faculty collaborative spaces, well designed circulation spaces, spaces for quiet reflection, adaptable seating, daylight in classrooms, school maintenance and overall building quality. Future investigation of the dependent variables of student achievement, student behavior, satisfaction, and affective performance were also identified.

The Delphi Technique may be limited in nature based upon the large amount of time that is needed by the researcher to use this type of method in research. The Delphi Technique can be very subjective in nature, which may have led the author to personal bias or manipulation of the survey results. This type of method is also limited to the ability of the researcher to have face-to-face interaction with the survey participants and the group members in the participant pools.

**Thornton**

The relationship between school building conditions and the achievement of students identified in the subgroups of economically disadvantaged and minority students in high schools in the Commonwealth of Virginia were investigated by Thornton (2006). The purpose of the study was to determine if there was a significant difference between the academic achievement scores of economically disadvantaged students and minority students housed in school buildings designated as substandard, compared to the scores of students housed in school buildings rated as standard.
The sample population for the study included 72 high schools from across the Commonwealth of Virginia. The sample of 72 schools was divided in half and categorized as standard or substandard. The thirty-six schools that were categorized as standard included student achievement data from 734 students. The other thirty-six schools that were categorized as substandard included student achievement data from 523 students.

Data used for the study included student achievement data from Virginia Standard of Learning (SOL) tests in Algebra and Geometry, Earth Science, Biology, Chemistry, Reading, World History parts 1 and 2, and United States History. The Commonwealth Assessment of Physical Environment (CAPE) was used by principals to assess building conditions in their high schools. Data involving economically disadvantaged or minority status students for each school was attained through information provided by school on the Virginia Department of Education (VDOE) website.

The results of the study revealed that the condition of the building did not influence achievement among economically disadvantaged students that were housed in substandard school buildings. In this study economically disadvantaged students housed in substandard schools outperformed economically disadvantaged students in standard schools.

There was a positive relationship established between building condition and student achievement among minority students. The conclusion could be made that school building conditions do have an impact on the student achievement of minority students
and did effect student performance on Standard of Learning performance, with p< .05 for seven data sets including Algebra 1 and II, Geometry with p< .000, Earth Science and Biology with p< .000, Chemistry with p< .003, and World History 1 with p< .000 when analyzing economically disadvantaged student performance in inadequate school buildings compared to student performance in adequate school buildings.

Limitations of the study included the personal bias that may come with a principal or staff of a school completing the Commonwealth Assessment of Physical Environment (CAPE) and the effect of the objectivity of the survey. There were several other variables that may have accounted for the affect of student achievement of economically disadvantaged students and minority students in this study and may have affected the outcomes of the study. The methodology incorporated in the study relied heavily on the proper identification of minority student and economically disadvantaged students in the sample population. This may be a limitation if those students were not properly identified.

Building Conditions and Teachers

There were several studies relating to teachers and school buildings. The following studies were directly related to teacher satisfaction, stress, perceptions, productivity, and well-being. These studies shed light on the importance of school buildings and how they influence teachers. These four studies add to the body of knowledge when considering the effects school buildings and their conditions has upon teacher performance and morale.
Ott (2001) investigated the influence of school renovation and school building addition construction on teacher stress. There were several research questions used for this study. The examination of several factors that were related to school renovation and or additional construction and how they caused stress for teachers were also investigated. Were there perceived levels of stress during renovation and or additional construction factors that affected teachers? How were teacher coping mechanisms related to school renovation and or additional construction and do these mechanisms reduced stress for teachers? These were the key research questions involved in the study. The final question asked if there was a correlation between teacher stress levels that involved construction factors and what were the applications of coping mechanisms used when this was identified.

The research methodology incorporated descriptive and inferential statistics through SPSS. A t-test was used to determine significant differences between sub groups of teachers, which were male and female teachers, as well older teachers compared to younger teachers. Teachers completed a survey instrument that incorporated renovation and construction related questions, which allowed them to express concerns during this process.

The teachers were randomly selected from schools that were involved in the process of a renovation or a construction project. Twenty-eight public schools were randomly selected for the study, which spanned across nineteen Pennsylvania counties.
The population included 136 teachers from public elementary schools, 223 teachers from nine middle schools, and 270 teachers from high schools participated. The total population included 632 certified teachers.

The findings of the study showed that the highest mean score of the construction stressors, which included things that caused stress in teachers during the time of renovation or construction, were 3.90 and this accounted for relocation of classrooms. The highest mean rating score from the total data for coping mechanisms was 3.36, which accounted for faculty and staff assistance when moving belongings to another area. The top five construction indicators, which were present during school renovation or construction, were the presence of dust in the building, the presence of dirt in the building, the increased noise from construction, the presence of fumes and odors, and the changing of room temperatures. Ott noted, through her quantitative tests, that teachers were stressed during the renovation process. It was also noted that good communication was essential in creating positive attitudes among the teachers and the staff.

The study was limited to a culmination of all grade levels that included elementary, middle and high schools used through the state of Pennsylvania. The principals at each of their schools administered the teacher survey, not the researcher. Time constraints, which included the amount of return time, were also a possible factor that may have affected the questionnaire results. The final limitation included the lack of personal contact the researcher had with the questionnaire.
Lang (2002) investigated how teachers alter their space and routines in their classrooms and what influence this has on the physical environment. There were several research questions for the study. The first question asked in what ways do teachers change or rearrange their physical environment so they have a sense of well-being. There was also an investigation on ways teachers adapt their behavior with individualized designed physical environments so that they may have a sense of well-being. The last research question asked what the teacher perceptions were of the overall social or cultural value of the designed physical environments, with respect to accomplishing their teaching goals. There was also an identification of what features or characteristics of the designed physical environment teachers perceive and identify with the most.

The methodology of the study involved a case study that explored the perceptions of a small group of teachers within a school building on a temporary site, while their main school was under a two-year renovation. The methodology was completed in three phases. The first phase included an initial questionnaire to teachers that volunteered to take the survey. The second phase consisted of observations that took place within the classroom. The final component included a clinical interview that was done after each classroom observation.

The population of the study included thirty-one teachers. This was approximately sixty percent of the staff. All thirty-one teachers were observed and interviewed. The majority of the teachers participating in the case study were thirty years or older. Sixteen
of the participants were female and the other fifteen participants were male. Fifty percent of the sample had an advanced degree and the majority of the teachers were white. There were three types of classrooms identified for the study. The three were regular classrooms, portable classrooms, and laboratory classrooms.

There were six variables measured in the case study. They included the size or layout of the classroom, the lighting in the classroom including glare from the lighting, the noise or acoustics in the classroom, the temperature and ventilation in the classroom, the finishes and furnishings in the classroom, and the teaching tools or communication devices in the classroom.

The findings of the case study indicated that most teachers felt that the size and the layout of the classroom were more critical to their teaching experience than the five other variables explored. The teachers expressed a strong desire to be able to freely arrange and design their classroom space. There was a negative response for sharing teaching space with other teachers, especially those that did not share the same or similar teaching styles. Teachers ranked teaching tools, specifically technology capability, very high in regards to importance, but also recognized that to have these features classroom space and the movement of furniture had to be restructured in the classroom.

Limitations of the study included the situation of an exploratory case study and the uniqueness of this type of study and that it could not be generalized. Each of the variables was difficult to control and define. The final limitation involved the answers on the surveys and how participation and teacher answers in the survey were limited to the perceptions of only those teachers interviewed.
Ruszala (2008) investigated the relationship between the condition of high school facilities in the school divisions of Virginia and teacher satisfaction. The purpose of the study was to analyze teacher satisfaction based upon school building conditions in high schools in metropolitan school divisions in Virginia, by allowing principals of school buildings to assess the physical condition of their building by completing the Commonwealth Assessment of Physical Environment (CAPE). Once the principals completed the CAPE, there was an investigation to see if there was a relationship between the CAPE results and teacher satisfaction as measured by the results of the 60 Teacher Opinionnaire of Physical Environment (TOPE) that was completed by the teachers.

The population of the study was high schools in Virginia. Twenty-three principals completed CAPE survey instrument. High school teachers completed the Teacher Opinionnaire of Physical Environment (TOPE) that assessed the physical school condition of a school building from the teacher perspective. Teacher demographic data were also collected through the surveys.

The methodology for the study was a correlation study using descriptive statistics. Pearson correlation coefficients were calculated and several exploratory multiple regressions were used for statistical analysis. The dependent variable for the study was teacher attitude and satisfaction. The numerous building condition variables included school age, lighting, climate conditions, and wall color and were regressed to analyze what impact those independent variables had on teacher satisfaction and attitude, based on the physical condition of their school.
The results of the Pearson correlation coefficients indicated that a moderate positive correlation was found between the overall building conditions reported by the Commonwealth Assessment of Physical Environment (CAPE) and the overall teacher satisfaction as reported by the Teacher Opinionaire of Physical Environment (TOPE). The correlation coefficient was .615, which was significant with \( p < .01 \). Wall paint emerged as the most significant factor of teacher satisfaction out of all of the variables. Paint and teacher satisfaction had a statistical significance of .011, with \( p < .05 \).

It should be noted that paint schedules needed to be considered when analyzing teacher satisfaction and overall upkeep and maintenance of a school building. Paint color should have been considered when applying paint to wall surfaces in the school. Fifty-three percent of the variance of the Commonwealth Assessment of Physical Environment was related to the paint variable and this variable impacted the overall teacher satisfaction the most. The results of the CAPE and TOPE instrument were quite subjective and dependent on the exact precision and accuracy used by the sample population to provide accurate and non-biased information on the surveys. The final limitation of the study was that not all of the variables could be controlled for or were considered for in this study. This study was unique due to the reflection of teacher satisfaction and attitude based upon the relationship to the physical condition of schools.
CHAPTER 3
CRITICAL REVIEWS PERTAINING TO BUILDING CONDITIONS

This chapter centers on the eighth and final strain of studies that deal with building conditions and their influence on student achievement, behavior, and attitude. The studies in this analysis allow researchers, architects, and builders to gain a better understanding of the influence of standard school building conditions and to non-standard school building conditions on student achievement, attitudes, and behavior.

The independent variables of school building conditions and the dependent variables of student achievement, behavior, and attitude will be noted in a meta-matrix, as was previously done in Chapter 2. The dependent and independent variables are clearly identified in the meta-matrix. Statistical significance or the lack of significance will also be carefully analyzed in each of the studies.

Building Conditions

This section of the study is dedicated to studies identifying school building condition as the independent variable. There are eighteen studies in this section. The studies were analyzed for the relationship between school building conditions and the possible relationship to student achievement, behavior, and attitude.

Cervantes

Cervantes (1999) investigated the condition of school facilities as related to student achievement and behavior. There were two research questions addressed in the study. The first question asked if there was a relationship between the building condition
of selected Alabama schools and the academic achievement of students enrolled in fourth, seventh and eleventh grade. The second question asked if there was a relationship between the building condition of selected Alabama schools and the number of suspensions of students who were in fourth, seventh and eleventh grade.

The sample population of the study included nineteen Alabama public school facilities that contained students in the fourth, seventh and eleventh grade. Of the nineteen schools, there were four elementary schools, two middle schools, five high schools, and eight unit schools, which were a combination of grade levels. The dependent variable in the study was student achievement as measured by reading and math composite scores through the Stanford achievement tests and student behavior through suspension rates. The independent variable was the school condition.

The methodology incorporated in the study was descriptive, using a quantitative analysis. The School Facility Appraisal Instrument developed by Hawkins and Lilly was used to assess the condition of the school facility. Fifteen doctoral students completed the facility appraisal assessment. This provided the information for the facility conditions of the selected Alabama schools. Reading and math composite scores were used for the academic data for student achievement. The Alabama Department of Education records of test scores were attained for the students. Stanford Achievement Tests, 9th edition scores, were used for the reading and math performance scores. Suspension rates were also obtained from the Alabama Department of Education. Incidences were documented though discipline data software. Alpha was set at p< .05.
The findings of the study concluded that the relationship between the overall building condition and reading and math achievement was not significant. There was a relationship found between the educational environment and reading achievement. The combination of the building category variables of the school site, plant maintainability, and math achievement showed a relationship between the three areas. There were also identified positive relationships between the student socio-economic status and the building category variable of school site.

In seventh grade, all schools in the study identified a significant relationship between the four building categories of total building condition, structural and mechanical, educational adequacy and the environment for education. In eleventh grade, a significant relationship between reading and math achievement and the variable of school site were identified. Students performed better in reading and writing in standard school sites compared to substandard school sites. In regards to suspensions, there was a significant relationship between the overall condition of the school building and the number of suspensions. The sub standard building condition of structural and mechanical, and educational adequacy, as well as the sub-standard building condition of safety and security were correlated variables to larger suspension rates in seventh and eleventh grade schools. Cervantes also noted that the school building areas of classroom space, equipment, aesthetics, common areas for socialization and parking were influential in the academic achievement of students.

Cervantes listed two main limitations of the study. The first being that the study was limited to nineteen selected Alabama public school facilities and only those students
in those facilities were used for the study. The second limitation was the inability of the researcher to identify all of the variables for the study such as parental influence and attendance.

**Lanham**

Lanham (1999) investigated the relationship between student achievement and the physical condition of school buildings, specifically elementary classrooms in Virginia. This study incorporated some of the same basic methodology Cash employed in a previous study in 1993. The population of the study included 299 randomly selected schools. Each elementary school was initially numbered and every third school was selected. Of the 299 schools selected, the principals of 197 schools responded to the survey. This represented a 60% participation rate for the school building population.

The Commonwealth Assessment of Physical Environment (CAPE) was modified and used in Lanham’s study. The modifications reflected the character of the elementary schools compared to secondary schools plus added items related to technology availability. Lanham selected 20 principals to assist in the validation of the modified CAPE. The principals of these schools were not included in the study population.

Standards of Learning scaled scores in math, English and technology were obtained for third and fifth grade students through data from the Virginia Department of Education. Data analysis of the building conditions and student achievement was done through the Statistical Package for the Social Sciences (SPSS). The statistical methodology was a stepwise regression and a multiple regression, which were the primary focus areas within SPSS. The regression was done analyzing the testing scores of
the third and fifth grade Standard of Learning scores in math, English, and technology. The scaled scores were compared to two or more predictor variables that included school site size, cleanliness and maintenance, air conditioning, ceiling type, and frequency of sweeping. The intent of this shift was to analyze the effects of technology in school buildings and the subsequent influence on learning.

The findings of the study, when analyzing the five step-wise regressions, showed that free and reduced price lunch participation entered as the first significant variable in each study. Other noted variables of significance included ceiling type, site size, connection to a wide area network, room structure, overall maintenance, floor type, and sweeping and mopping frequency. In analyzing English assessment scores, free and reduced lunch percentages accounted for 48% of the variance in third grade and 52% of the variance in fifth grade. Lanham also noted a similar finding in technology assessment with free and reduced lunch percentages accounting for 41% of the variance. The math findings were vastly different. Free and reduced-price percentages in third grade math accounted for only 26% of the variance and only 16% for the fifth grade. Lanham concluded that student achievement in math appears to be less affected by socio-economic factors than student achievement in English and technology.

The findings of air conditioning use were also entered as a variable showing significance in three of the five step-wise regressions. In third grade English, air conditioning accounted for over one and a half percent of the variance in scores. Lanham noted that improving just by one rating in air conditioning quality, third grade English scores would increase by over four and a half percent. In fifth grade math, air
conditioning accounted for almost three percent of the variance. Improving the quality of air conditioning by one rating would increase fifth grade math assessment scores by almost nine points. In fifth grade technology, air conditioning accounted for almost five percent of the variance. Improving the air quality by one rating would improve fifth grade technology scores by three percent. Lanham noted that the physical climate of classrooms reflected by low systems ratings is a significant factor in student achievement.

The findings from each test showed other predictor variables of significance. In the third grade English assessment, it was noted that improving the rate of sweeping frequency by one rating point would increase the average third grade English assessment scores by almost 27 points. In the third grade math assessment, improving room structure by one rating point would increase the average third grade math assessment scores by almost 29 points.

The conclusion of the study found that improving certain building conditions, specifically air conditioning, noise control, building cleanliness, and internet access can improve student achievement. It should be noted that free and reduced lunch status accounted for the highest variance in all five regressions, with air conditioning second in three of the five studies. Lanham also noted that Virginia elementary schools appear to be in better condition than their counterparts nationwide but cautioned correlating performance with lower socio-economic status. Lanham was specifically concerned with free and reduced lunch student performance data on Standard of Learning tests.

Lanham modified his study to explore the building conditions at the elementary school level. This was non chartered water as well, but due to the time frame, this
study could be replicated for further study to enhance the body of knowledge in elementary schools. Strengths of the study included a large sample size in his study and data analyzed through a statistical program that would identify a dependent variable and regress predictor variables to check for variance and significance. Lanham’s survey provided a tool with measurable data that the author later used in a quantitative manner.

One noted limitation was that the author compiled the data of all elementary schools without the consideration of school setting. There is a possibly outcome change in the findings if the researcher had chosen urban or rural elementary schools, or even separated the two areas and then compared the findings. Another limitation of the study was the early development of Standards of Learning tests. The tests were fairly new to schools and may not have had the curriculum framework alignment necessary for complete confidence in the results of the tests. Lanham’s main inference in his Assessment of Physical Environment survey specifically focused on technology initiatives and the adequacy of technology services and computer networking in schools. These variables could have been expanded more in the research study.

O’Neill

O’Neill (2000) investigated school facilities and their relationship to student achievement, behavior, attendance, and teacher turnover rate at selected Texas middle schools, in Region 13. His research identified possible environmental aspects of the school facility, which may have influenced or enhanced learning in these middle schools. Four research questions were developed for the study. Those questions included to what extent school facilities affect student achievement, student behavior, student
Seventy-six middle schools were included in the sample from 48 school districts. Principals from each school district in Region 13 completed a mailed survey questionnaire to assess their school buildings. The survey instrument was named the Total Learning Environment Assessment and was designed by O’Neill. The TLEA contained 82 questions concerning the condition of the buildings. Principals were asked to respond to the items of the survey with a response of strongly agree or strongly disagree. The principals also completed four short-answer questions. The two main components of the survey were architectural and cosmetic features. This information was used to assess building conditions that would then be compared to student achievement, student behavior, student attendance, and teacher turnover rate, which was reported by the Public Education Management System (PEIM). The independent variables used in the comparison were the interior environment and external environment.

The dependent variables were analyzed in four separate t-tests, through the Statistical Package for Social Sciences (SPSS). The four dependent variables were student achievement, student behavior, student attendance, and teacher turnover rate. The independent variables included school facilities as measured by the Total Learning Environment Assessment (TLEA).

O’Neill incorporated quantitative data from the surveys completed by the middle school principals. He disaggregated the data components for all of the schools by each question and then summarized each question in the survey along with the short
answer questions. Each t-test was employed to test the relationship between the independent variable and the dependent variable. O’Neill used an alpha or significance level that was set at $p< .05$. Accounts for variance and r-values were also analyzed in the t-tests. The t-tests provided evidence that each of the dependent variables across the independent variable categories showed a significant difference, with $p< .05$ between the top 25 and the bottom 25 of the surveyed schools.

The findings of the t-test that analyzed student achievement as the dependent variable and school facilities as the independent variable showed building age as a significant factor when determining student achievement. Academic learning space, in the building assessment, was positively related to the percentage of eighth grade students passing math and reading. The exterior environment also showed significant impact of eighth grade students passing the Texas Assessment of Academic Skills.

The t-test for student behavior and school facilities found a positive relationship between two measures of student behavior, in school and out of school suspensions. The first facility variable that demonstrated an influence was the exterior environment of a school. There was a significant difference in the number of in school and out of school suspensions when the two groups of students in the two categories of schools measuring the exterior environment was compared. External aesthetic appeal was related to both out of school suspensions and in school suspensions. The last finding showed significance for interior color schemes, interior comfort, and humidity comfort.

Findings for the t-test that analyzed student attendance and school facilities showed that the student attendance rate was not found to be significant in correlation to
school facilities. O’Neill noted two independent variables that were correlated to large r values, which were the academic learning space and the building age. The t-tests that analyzed teacher turnover rate and school facilities also showed that teacher turnover rate was not found to be significant when correlating school facilities. The two independent variables, as measured by the Total Learning Environment Assessment (TLEA), showed that the largest “r” value related to teacher turnover rate was the environment for education and the interior environment of the school. The conclusion of the four t-tests indicated that student achievement and student behavior were significant with school facilities while student attendance and teacher turnover rate were not significant in relation to school facilities.

The statistical methodology involved several t-tests that analyzed different independent variables of school facilities, compared to four established dependent variables. The t-test were deemed an appropriate tool for the measurement of the variables. The Total Learning Environment Assessment survey used some questions from Cash’ previous survey from the CAPE. O’Neill’s survey instrument was precise and comprehensive, which allowed principals to assess the architectural and cosmetic features of their building.

Limitations of the study included the use of only 76 Texas middle schools and the findings from the study could not be generalized to any other group other than this sample size. O’Neill also noted the objectivity of the responses to the survey instrument may be affected due to the use of a self-survey that was used. The last limitation was all of the variables could not be identified which may have resulted in
error, variance, and less significant correlation in which O’Neill employed and deemed important.

Strengths of the study included the exploration of student behavior and teacher turnover rates in relation to school facilities. Although these two variables were not found to be significant in this study, it was important to look at these factors when assessing buildings and exploring possible further studies within these two areas.

**Guy**

The following study examined the relationship among school condition and student achievement in West Virginia high schools. Guy (2001) investigated the relationship between student achievement, as measured by the Total Basic Skills Test results, and the age, density, and size of the building in which the students attended.

The population of the study included every high school in West Virginia that contained an eleventh grade and had a building principal. One hundred and twenty-six schools were in operation during the time of the study. It was noted that four schools did not receive an evaluation, which decreased the sample to 122. Three additional schools were then eliminated from this pool due to the class size average requirement of 20 students per class. The final sample of the study was 119 schools.

Data included student achievement test results that were attained through Stanford Nine tests that included reading, math, language arts and science scores. The total basic skills score means were attained by calculating the mean of the four tests identified through Stanford Nine testing. Student enrollment data, grade levels served, and socio-
economic status were obtained through the West Virginia Education Information Center (WVEIS).

The methodology for the study identified student achievement as the dependent variable and the independent variables of building age, student density, and school size. Guy identified building conditions by ranking schools as below average, average, or above average.

Data were analyzed through the statistical package of social sciences (SPSS). An analysis of variance and covariance was performed, using socio-economic status, and student achievement data, and then compared with building condition.

Guy identified a wide range of mean scores across the building condition categories. The building condition categories included a site evaluation component that assessed site condition, drainage, parking, bus loading areas, access roads, playing fields, and site utilities. A building component evaluation was also conducted that included numerous areas for assessment, such as building structure, roof and floor structure, ceiling fans, interior and exterior doors, operating and fixed windows, boilers, furnaces, air ventilation, electrical, and technology infrastructure were examined.

Reading scores and the comparison of the means of reading scores and building conditions and site evaluation were evaluated. Students in schools rated as above average performed better than their peers in facilities that were rated average or below average. The significance level was p< .033 for reading and p< .030 for language arts scores, which indicated a strong relationship and correlation of both, but neither was statistically significant. The Total Basic Skills Test scores of students, when compared by total
building conditions, showed a difference of .452 higher among schools that were above average, average or below average, which was not considered significant.

The results of the analysis concluded that higher student achievement scores were not found in newer schools. Guy noted that students attending the oldest high schools scored better on Total Basic Skills Tests than students in newer schools, but not significantly higher. Square footage per student, when correlated with student achievement, did not show statistical significance. Students in schools with density areas between 133-155 square feet per student showed test scores somewhat higher than their counterparts in buildings that had up to 200 square feet. The correlation between school size and student achievement was also not significant, but it was identified that schools with 900 or more students had a higher percentage of socio-economic status compared to schools smaller than 600 students.

As noted in many other studies, it was also impossible for the author to identify all of the variables that influence student achievement. Guy also stated that eliminating four schools with very poor facility evaluations led to less significant results.

**Lewis**

Lewis (2001) investigated the relationship of facility conditions and student test performance in the Milwaukee public school system. The hypothesis of the study was that as facility assessment scores increase, academic test scores of students also increase. Building conditions were used as the independent variable, while socio-economic status, race and ethnicity, attendance, and discipline were student indicators. Student achievement was the dependent variable for the study.
The sample population of the study included 139 K-12 public schools in Milwaukee, Wisconsin. The Milwaukee School District assisted in providing student test score information and information on the characteristics of the students such as attendance rates, discipline infractions, socio-economic status, and mobility rates.

Data for the study included three components. Student academic information was attained from the Wisconsin Student Assessment System (WSAS). Student academic data were gathered from math, science, language arts, and social studies scores of students in fourth, eighth, and tenth grade. Academic data were gathered from 1996 to 1998.

The second portion of the data in the study was student characteristic data, and became the control variable of the study. This information was furnished by the Milwaukee school division and included student characteristic data on socio-economic status, attendance, discipline, and mobility. The last piece of data included was a school facility inventory conducted by the Construction Control Corporation. This was an independent agency that assessed each school on total facility condition. The Construction Control Corporation analyzed the results in four categories, which included existing building condition total, existing condition adjusted, educational adequacy total, and educational adequacy adjusted. Each school was assigned a point value based on its age. Schools that had an age ranging from zero to 40 years were not deducted any points from their total score. School that were 40 plus, 50, or 60 years old could have points deducted from their facility evaluation up to 1,000 points.

The instrument employed to assess the buildings used a Likert score with a score that ranged from one and five, to calculate existing conditional totals and educational
adequacy totals. Adjusted scores based on a building’s age were also calculated. The facility assessment scores ranged from 1000 points and were considered poor and up to 5,000 points which were considered excellent.

The Statistical Package of Social Sciences (SPSS) was the main methodology used to conduct several multiple regression analyses. The multiple regression tests analyzed the relationship between school building conditions and student achievement scores. Other student characteristic variables were also controlled in the regressions.

The results of the data analyses showed that reading had a large influence and was highly significant with a change of 1.00 point in its standardized score, associated with a change of .54 to .90 regressed as an independent variable with the other dependent variables of academic performance. Most of the student characteristics such as attendance, discipline, and mobility had little relationship with the student academic performance. Socio-economic status was shown to have an influence. Student achievement was significantly related to building conditions in 11 of the 36 estimates on student academic data collected from 1996 through 1998, with a probability level established of p< .05. The School condition explained up to 16% of math performance scores of all students in the sample population in 1996. There was also a strong connection identified between student achievement and building condition according to the building condition survey scores. As the building survey scores went up by 10 points, student achievement in math scores increased by 1.6 point per each increase of ten points.

American Indians and other minority students were not included in the study. The gap of time between the assessment of facility conditions and the retrieval of student
academic data may be considered a limitation. It is not known how the differences occurred between elementary, middle, and high school students based upon the inability to categorize into these different levels. This study incorporated reading as an independent variable, where academic performance is usually used as the dependent variable. This evokes the question of its use in other regressions and how reading performance accompanied with adverse building conditions may affect student performance.

**Stevenson**

The next research project involved the relationship of school facilities conditions to selected student academic achievement outcomes, which was conducted by Stevenson (2001). This was a comprehensive study of South Carolina schools and was presented to an education oversight committee. The effects of school age, size, and attendance were the main independent variables used in the study, while student achievement was the dependent variable.

The total sample population for the study included 988 school buildings, of which approximately 534 were elementary schools. The levels targeted were third, fourth and fifth grade students. The average school age for the elementary school buildings was 36 years old. There were approximately 227 to 286 buildings with 59% of the population accounted for in the middle schools used for the project. The average age of middle schools was approximately 37 years. There were approximately 168 high schools included in the study. The average age for high schools was 34 years. High school students averaged 933 on the SAT.
There were four areas of data for the project. The first piece of data was responses from the principal questionnaires. The questionnaires assessed each of the school’s physical environments.

Principal focus group data were also attained, which provided information on the impact of student learning along with building conditions involving the school facility. Scholastic Aptitude Tests were used at the high school level to measure student achievement. The Palmetto Achievement Challenge Tests (PACT) scores assessed elementary and middle school students in grades third through eighth. South Carolina state data were also used by the means of teacher and student attendance, school size, and socio-economic status.

An ANOVA was the methodology for the study. The author identified the r-value, the r squared value, and the adjusted r for each analysis. The ANOVA was also used to obtain the significance of the variance when analyzing student achievement by SAT scores in high school and PACT scores in elementary and middle school with the independent variables of student and teacher attendance, school size, and student attendance.

Socio-economic status accounted for a large amount of variance in all of the analyses. For example, in elementary school SES ranged from 53% variance in third grade to 58% of the variance in fifth grade. The other independent variable had much lower variances in elementary school, but not as significant as SES. Regarding third grade math performance, student attendance accounted for 2% of the variance. In fourth grade math performance, 1.3% of the variance was accounted for by student attendance.
In fifth grade math performance, 1.9% of the variance was accounted for by student attendance.

Middle schools also accounted for a large amount of variance when associated with SES. Middle school math and language scores from the PACT showed that the variance ranged from 38% and 39% percent in math, while language scores had 86% of variance involving SES. Student achievement scores in middle school math also showed that student attendance accounted for three to five percent of the variance, which is significant but not with a large effect. When analyzing language arts student achievement the variance was a bit larger accounting for five to seven percent variance when accounting for student attendance and performance.

High school student achievement was based solely on SAT performance. A large amount of variance was also correlated at this level of school when analyzing SES and performance. SES accounted for 59% of the variance when analyzing the highest prediction of SAT performance in South Carolina high schools. Student attendance also had a small amount variance of 3%. School age, student attendance, teacher attendance, and school size had an effect on student performance involving PACT and SAT scores of students in South Carolina. It was noted by the author that overcrowding, poor physical condition of the school plant, portable classrooms, lack of storage, and inadequate laboratory space were all variables that adversely impacted the educational process.
The study was limited to not all of the possible variables that influence student learning being accounted for in the study. High school data for the SAT performance scores for achievement were incorporated and is limited to no curriculum for this standardized tests, which is based on a verbal, writing, and math assessment.

**Al-Enezi**

Al-Enezi (2002) investigated the possible relationship between the conditions of high school buildings and student achievement in Kuwait. This study was a replication of the study by Cash, which was completed at Virginia Tech. Al-Enezi, completed his study in 2002, and was the first noted study, using the Commonwealth Assessment of Physical Environment (CAPE), conducted outside of the United States.

There were three research questions used for the study. The first question explored the relationship between the overall building condition, the cosmetic, and the structural condition of the school building and student achievement. The second question explored the relationship between building condition and student achievement while comparing similarities and differences between genders. The final research question asked what aspects of the physical building conditions were related to student achievement. Al-Enezi used 56 high schools for his study population. The high schools were gender-based schools. There were twenty-eight schools in which only boys were enrolled and twenty-eight schools in which girls were enrolled in his population.

Twelfth grade student test performance data were used in this study. Mean scores on high school examinations were used to determine if building condition had any influence upon student achievement scores. This information was collected from the
Information Center at the Kuwaiti Ministry of Education. High School examination data were analyzed for Science and the Arts.

Al-Enezi assessed each school building using the Commonwealth Assessment of Physical Environment. This was modified to fit the gender-based schools in Kuwait. The data collection instrument had to be re-written in Arabic. The principal of each high school in the study provided the assessment of the building condition by using the (CAPE) assessment developed by Cash. Five randomly selected principals who were not participating in the study were asked to validate the CAPE by administering the instrument on an initial sample of schools. By this means they were able to make recommendations for changes and modifications.

There were several variables used in the study. In research question number one the two sets of student achievement scores were compared through a Pearson r analysis. The independent variable was the building conditions as measured by the CAPE. The building condition was grouped first by the overall assessed condition of the school building. The buildings were then grouped by using cosmetic condition of the school building and the structural condition of the school building, again as measured by the results of the CAPE. The dependent variable was student achievement.

In the second research question a one way and a two-way factorial design were used. In research question two, the factorial design entered building condition and student gender as the independent variable and student achievement as the dependent variable. The third research question used two statistical analyses to answer this question. The first was a multiple regression and the second was step-wise multiple regression. Al-Enezi
noted that socio-economic status was not statistically controlled in this study because the Kuwaiti schools do not collect any data on SES of students.

The statistical method of data analysis focused around descriptive statistics. Several methods were used to analyze data through the statistical package of social sciences (SPSS). He used an alpha of $p < .05$ to determine level of significance. An ANOVA, Pearson r, t-test, and a multiple regression were the main tools for the data analysis. The results of the two-way ANOVA found that building conditions have a significant effect of test scores in science. A multiple regression indicated that building conditions account for seventy-seven percent of the variance of science achievement, but not in the Arts’ achievement. A stepwise regression indicated that graffiti and roof leaks were the two main predictors for student achievement.

The findings from the data analysis were that there was a statistically significant relationship between building conditions and student achievement on all sub-tests. The researcher did note though that the results varied by gender and by academic study. Al-Enezi stated that building conditions have a lesser impact on academic achievement in the boys schools and in the Arts. He also noted that building conditions did not seem to effect academic achievement among the girls. Graffiti and roof leaks were the main predictors of physical aspects of the condition of the schools that account for student achievement. All schools had similar physical structures such as windows, concrete ceilings and fluorescent lighting. The majority of the school buildings were under thirty years old. Only ten percent of the school buildings in Kuwait were over thirty years old. Almost half of the principals, however, reported some type of roof leaks. Most schools
had adequate science equipment and functional laboratories. The principals also noted that the classroom walls were either painted white or in some type of pastel color.

Cosmetic conditions were also analyzed from the principal survey. Most schools had recently painted classroom walls and for the most part were painted within ten years. Graffiti in the schools was found in more than four sections of fifty percent of the schools while over thirty percent of principals reported that graffiti was in at least two places of the school. The majority of the principals stated their classroom furniture was in satisfactory condition and looked attractive.

Al-Enezi concluded that there was a significant and positive relationship between structural and cosmetic building condition and student achievement in Science majors and Art majors when all 56 school buildings were analyzed. The achievement test scores in the boy’s schools in the Science majors showed a significant relationship, ranging from $p < .001$ to $p < .004$ in math, physics, biology and chemistry with $p < .05$, between building condition and student achievement. Scores in the boy’s school in the Arts major showed a lesser impact. The relationship between building condition and student achievement of girls in the Science and Arts’ major showed there was no effect on their performance.

This work by Al-Enezi was unique because it was the first major study conducted outside of the United States that used the modified CAPE survey. Although Kuwaiti schools were gender-based; there was statistical significance within building condition and student performance. A large sample-size of schools was used. They were gender specific and equal by total number of schools.
Limitations of the study may include that each school was only gender based. The researcher does not give descriptions to show how the instruction, preparation, learning environment, or testing environment may have been similar or different between genders. Another limitation could be the culture of the study. Building materials may not be consistent with other foreign countries and how would one compare the physical structure of a school abroad with one in the United States.

Lair

The next study investigated the effect of school facility conditions in Texas and the effects they may have on student achievement. Lair (2003) examined which factors might directly affect the decisions to include school facilities as a component of educational adequacy. She also researched how funding impacted priorities of school maintenance, renovation, and construction. She also sought to identify the relationship among the variables of socio-economic status, building age, cleanliness and maintenance, and the conditions of the school’s structure and their influence on student achievement.

The sample population for the study included 29 schools in the Ysleta school division in Texas. Fifty-two schools were initially randomly selected for the study, 33 were contacted to participate, and 29 schools agreed, which provided a total of 56% participation of the Ysleta school division in Texas. Twenty-nine principals participated in the study by completing a facility assessment on their schools.

The study was organized into four phases. The first phase included author visitations to the 29 selected schools. The second phase of the study included gathering over eight years of data through the Ysleta Independent School District Public Education
Information Management System (PEIMS) and through the Academic Excellence Indicator System (AEIS).

The third phase of the study included an interview with the former superintendent of the Yselta school division. The final phase of the study included an interview with the current superintendent of the Yselta school division, as well as the collection of documents regarding school renovation and the Texas Assessment of Academic Skills (TAAS) test scores.

The data collected in the study were used in six linear multiple regressions. The regressions of six independent variables of school size, building age, overall cleanliness, overall maintenance, overall structure, overall cosmetics, and a control for disadvantaged students were accounted for.

The results of the first regression noted that building age accounted for 42.5% of the variance of all student achievement on the TAAS, which represented the percentage of passing students. The second regression analyzed the percent of disadvantaged students based upon free and reduced lunch status and performance on the TAAS. The results of that regression showed that building age and maintenance accounted for 63% of the variance of socio-economic status and student performance.

The third multiple regression analyzed the percent of Hispanic students passing all of the sections of the TAAS while accounting for all of the independent variables regressed. The results showed that building age accounted for 46% of the variance when accounting for Hispanic performance on the TAAS, while no other independent variables entered the equation. The fourth multiple regression analyzed the percent of white
students passing all sections of the TAAS, for whom all other independent variables were accounted. The results of the regression showed that cleaning explained 49.8% of the variance when accounting for white student performance on the TAAS. The fifth regression analyzed the percentage of black students passing all sections of the TAAS while accounting for all independent variables. The results showed no independent variables were significant in this regression.

The final regression analyzed the percentage of all ethnic groups passing all sections of the TAAS from the 29 schools in the sample population. Lair used all eight years of academic data collected for this regression. School size and building age were used as the independent variables. In this regression, building age and school size accounted for four percent of the variance of the eight years of academic data on TAAS scores.

The study was limited to a smaller sample size of schools participating in the study. Although 29 schools and 24,000 students were represented in the sample population for the study, slightly over 50% of the Yselta school district schools were involved in the study. Principals conducting self-assessments on their facilities may have led to personal bias and may not have been as forthcoming about the building conditions of their schools. The study was also limited by the lack of access by the researcher to information concerning school building renovation, repairs, and construction projects for the school division.

Leung and Fung
Leung and Fung (2005) conducted a study in Hong Kong investigating the enhancement of classroom facilities of primary schools and the effects on learning behaviors of students. The purpose of the study was to analyze the relationships between facility management and the effects that facility management had on learning behaviors. This study focused on primary school children and their transition from older schoolhouses to newer millennium schoolhouses in Hong Kong.

The population for the study included 750 primary school children in Hong Kong, China. The schools for primary school children focused around older school buildings and the transition to millennium school buildings. The Chinese government initiated a standard public school design for public primary schools, named millennium schoolhouses. The population of 750 primary school children was included in the transitional moving from the older school to the millennium school. The sample population for the study and for the schoolhouses included three older schoolhouses and the three new millennium schoolhouses into which the primary school children transitioned.

The data for the study included a questionnaire completed by the primary school children. The questionnaire had three sections that included background information of the students and their school, the level of satisfaction of facilities management performance in their classrooms, and learning behaviors in their classrooms. The facilities management components were broken down into five categories that included space management, teaching tools, light and ventilation, comfortable atmosphere, and supplementary facilities. The learning behavior components included six categories that
included coordination, academic performance, attention, classroom preference, discipline, and goal achievement. Chronbach alpha for the facilities management and learning behaviors were found to be reliable at 0.862 and 0.948.

The methodology for the study included the use of a questionnaire instrument for 750 primary school students. The questionnaire had a scale that ranged from one through five. If a score of one was given, the response was in total disagreement or total dissatisfaction. If a score of five was given, the response was in total agreement or total satisfaction. A pre-survey and post-survey instrument was conducted. The findings from the pre-survey and post-survey results were then analyzed by correlation coefficients and by an independent sample t-test.

The results and findings of the study indicated, in the sample independent t-test that compared facilities management and learning behaviors, that four of the five facilities management components were significant in the new millennium schools. Space management with \( p < .262 \), lighting and ventilation with \( p < .211 \), comfortable atmosphere with \( p < .195 \) and supplementary facilities had significant mean differences. There was only one type of learning behavior that was identified as being improved attention. Attention had a mean difference from the older schoolhouse to the newer millennium school with \( p < .059 \). Statistical significance level was \( p < .01 \) or .10.

There was also a strong correlation noted between facilities management and changes in learning behavior. The light and ventilation significance levels ranged from \( p < .105 \) through \( p < .235 \), and comfortable atmosphere ranged from \( p < .092 \) through \( p < .190 \). Both of these facility management components correlated with all of the
improvements in learning behaviors at the new millennium schools. Improvement in coordination with $p<.128$ through $p<.235$, attention with $p<.115$ through $p<.190$, and goal achievement with $p<.082$ through $p<.152$ were the learning behavior components that correlated significantly with all five facility management components. Statistical significance was $p<.01$, .05, or .10 for these components.

This study was limited to only three or four months of separation between the primary students transitioning from the older schoolhouse to the newer millennium schoolhouse. The authors recommended a longitudinal study that would span over a longer time period. The sample was also limited to three primary schools that transitioned to the newer millennium school. This study provided a unique analysis of primary schools outside of the United States.

**Picus et al**

Picus et al (2005) investigated the relationship between student achievement and the quality of education facilities in the state of Wyoming. The purpose of the study was to investigate how school facilities relate to student achievement.

The sample population of the study included 60,000 students from across the state. Students in fourth, eighth, and eleventh grades from the public schools, accredited institutions, and accredited private schools were included in the study. Data in the study included a building condition score that was composed of 22 building subsystems such as foundations, flooring, and ceilings. An individual rating tool was also included in the study. A school representative and a sub-contractor from the consulting firm, MGT Incorporated, completed a mutually agreed upon survey of 20 questions. This tool was
used further in the study to assist with future needs of facility planning. The overall condition of the school building was then calculated by the average of the weighed value of the applied subsystems. Student achievement data were assessed from fourth, eighth, and eleventh grade students based upon their performance in reading, math, and writing scores on the Wyoming Comprehensive Assessment System (WyCAS).

The methodology for the study included the combination of the building quality scores produced by MGT and the student achievement scores in reading, math, and writing, as indicated through the WyCAS over a three-year time frame starting in 1999. Bivariate correlations were the most widely used statistical method incorporated in the study. Socio-economic status was also accounted for, but only among elementary school students in the sample population. The effect of SES was measured through multiple regression.

The results of the findings for the study revealed that there was no relationship between building condition and suitability of school facilities in relationship to student achievement among students in Wyoming. Each analysis of data yielded very similar results indicating no significance between the school facility suitability and academic outcomes. Statistical reliability was set with \( p < .01 \) and \( p < .05 \). Reading scaled scores were \( p < .40 \) for eleventh grade students. Writing scale scores were \( p < .35 \) for eleventh grade students and \( p < .21 \) for all three grade levels. Math scaled scores were \( p < .32 \) for eleventh grade students and \( p < .12 \) for all three grade levels. The authors noted a small positive relationship between suitability and WyCAS performance but this finding was deemed as one found by chance or anomaly.
Although the researchers determined the WyCAS assessment tool was deemed a high quality tool to measure student academic data, the valued assessment may have been limited to the precise delivery of instruction and the curriculum framework from the teachers instructing the WyCAS. Student free and reduced lunch status analyses were limited to students in elementary schools only. While SES data were considered for eighth and eleventh grades, SES data were not calculated for this portion of the sample population. The authors also noted the importance of several other resources and factors in the study such as the quality of teachers, educational leadership, curriculum, and parental involvement, but these confounding variables were not accounted for in regards to the value in the study. The ability of a division superintendent to conduct a formal facility analysis of their particular schools in their school division would also be considered a limitation based upon their limited interaction in the day to day operation in local school buildings.

The building assessment instrument used in the study is worth more consideration of the reliability of the evaluation and the responses of MGT Incorporated and the school personnel that conducted the evaluations, which may have been biased with their assessments. Lack of control of SES of middle and high school students is a very limiting factor.

**Syverson**

Syverson (2005) investigated the relationship between Indiana high school building conditions and the Indiana Statewide Test for Educational Progress (ISTEP) for math and English scores. The main research question for the study asked if there was a
relationship between the level of school building conditions and the total battery scores on the qualifying exam in Indiana high schools. The premise of the research was to analyze the effects of adverse building conditions on student achievement in Indiana.

The methodology included data from the Commonwealth Assessment of Physical Environment developed by Cash. The CAPE had been used to evaluate the condition of school buildings in several other studies. There were 25 building condition factors surveyed. They included age, structural, cosmetic, thermal conditions, and many other independent variables. The results of the CAPE produced an overall building condition score.

The sample population began with 50 schools that were asked to complete the survey. Ten percent of the available schools were included with every tenth school selected from an alpha list of qualified schools in an interval sampling process. Once this process was complete the finalized sample was 28 schools, and each principal or designee completed the CAPE.

The Indiana Department of Education was used to access data for graduation rates. The dependent variable for the study was student achievement, based on the Indiana Statewide Test for Educational Progress. The independent variables included the school facility conditions of the school buildings evaluation of being substandard, standard, or below standard, as measured by the CAPE.

The findings of the study revealed a relationship between student achievement and building condition. Scaled scores on the Indiana statewide test for educational
progress in English and math were correlated to building standards from the CAPE, which attempted to distinguish a relationship between school building conditions and student performance. The CAPE findings of the 25 building conditions showed that 75% of the schools in the study were perceived as above standard on the overall condition. Seventy-nine percent of the school buildings were considered to be in the upper building level condition when measuring the cosmetic item. Structurally, 57% of the buildings were ranked in the upper building level condition.

Limitations of the study included asking local school personnel to complete the CAPE survey. As principals completed the surveys on their own schools, answers on the CAPE may have reflected personal bias. All of the variables were not identified in the study and may have produced or resulted in statistical error. This study could not be generalized to other high schools because only Indiana high school academic data were used. The data gathered were generated in an Excel document and not SPSS; no significance level was generated. The last limitation was presented in the small sample size of Indiana high schools.

**Edwards**

Edwards (2006) conducted an investigation analyzing school facilities and student achievement where student perspectives were given on their connection between urban learning environments and student motivation and performance. The purpose of the study was to evaluate how students perceive their own motivation, academic achievement, and personal conduct as being positive or negative based on the educational facility in which children learn. The condition of the educational facility was also examined and how it has
an affect on student perception of the overall staff of teachers and administrators within the school building. The last important component evaluated was the student’s perception of the degree to which their school district values a student’s education and personal safety, based upon the condition of the educational facility.

Fourteen middle schools and twenty-five high schools were used as the sample population. The sample was selected from an enrichment program and summer school program that was held from four to six weeks in the geographic area of Columbus, Ohio. The sample was randomly selected and students provided information that was used in a qualitative nature for the study.

A survey instrument composed of fourteen questions was administered to the students in the summer programs. This was the first piece of data collected. The survey instrument was constructed in a Likert scale form and had questions that asked about student perceptions, beliefs, and the physical learning environment at their school. Interview data were also used for the study. Open and direct discussions were initiated by the author to gain face-to-face perspectives on attitudes about learning, perceptions of the learning environment and how students learned in class. The last piece of data used was student observations in their learning environment. Observations were documented and recorded regarding student behaviors in their physical environment. Data coding was used and the methodology for the study involved a qualitative analysis based upon a student survey, interviews and student observations.

Once all of the data were collected, analyzed and conclusions were developed that student safety and building conditions were concerns of the students in the sample
population. It was apparent through the student data collected that the condition of school buildings also influenced the motivation of students. Students showed consensus that they could learn better and achieve more in schools that were in good condition. Students also felt that teachers would be better instructionally when they had an effective physical environment in which to teach.

Edwards also made mention to numerous observations of students engaging in certain behaviors individually and with other students that may have contributed to the affect of the school condition and environment. Approximately fifty-one percent of the middle and high school students in the sample population felt that having a poor physical environment had a negative impact on their motivation to succeed. Space considerations were also deemed significant in relationship to where students interact and where students learn in their classrooms. Students noted that sometimes the effects of a poor teacher sometimes outweighed the effects of a sustaining and comfortable environment. Students felt they could learn and achieve better in a school that was neat, clean, and in good physical condition.

The study was very interesting from the standpoint of the student feedback that was acquired through the interview process and observations. The sample population was very small and only included summer school or remediation students. Both of these considerations were limitations of the study.

O’Sullivan

The following study investigated the possible relationship between schools building conditions and student achievement in the high schools of Pennsylvania by
O’Sullivan (2006). The study was a replication of the Cash study in Virginia. He used the same basic methodology as previous studies, he compared the student achievement scores of students in previously assessed buildings rated as being either in poor or good condition.

Three research questions guided this study. The main question asked whether a relationship between the academic scores of students existed when the overall building condition of the school was used to separate two groups of schools. The second question asked if there was a difference between the achievement scores of students when the cosmetic building condition was used to divide the two school populations. The third question asked if there was a difference between the student achievement scores in buildings where the structural feature of the building was used to separate the two groups of buildings.

Two hundred and five randomly selected high schools were used for the study. The schools were identified through the Pennsylvania Department of Education. Each school was selected using a table of random numbers.

Data collection for the statistical methodology included an assessment of each school building by the principal to determine the condition of the building. The result of the assessment was a total score for each building. The schools were then placed in an ordinal list of schools from the highest score to the lowest score. The top and the bottom quartile of the list became the study population of the buildings. The assessment instrument was tested for reliability by using the Chronbach alpha reliability test. Scores on this test range from zero to 1.0. The reliability coefficient was at .70, and this figure at
or above this range is acceptable in most research settings. The result of the Chronbach alpha coefficient were .7671 for the overall building conditions category, .6473 for the cosmetic building conditions category and .6439 for the structural building conditions category. This reliability test was used on the modified Commonwealth Assessment of Physical Environment survey. Student academic performance data were attained through the Pennsylvania Department of Education website. Student scale scores on the Pennsylvania System of School Assessment exams in mathematics, reading, and writing were used to examine academic performance. The socio-economic status was controlled by using the percent of students participating in the free and reduced program.

O’Sullivan used the statistical package for social sciences (SPSS) to conduct the data analysis. A step-wise multiple regression was the main tool used for the data analysis. Student achievement was used as the dependent variable and building condition as the independent variable.

Findings of the principal survey of buildings indicated that the majority of school buildings surveyed were 49 years old or older. Fifty-three percent of principals stated that the last renovation of their school was after the year 2000. Eighty-nine percent of the principals stated that portable classrooms were not used. Over 82% of the classrooms had windows. Ninety-eight percent of the classrooms were self-contained and had locking doors. Over 80% of principals stated their school buildings were in satisfactory or outstanding condition.

The findings of the study showed that at least one variable from the cosmetic and structural building area had a correlation with student academic achievement.
O’Sullivan also reported that facilities adjacent to each school and graffiti locations were the two most significant predictors of student achievement. The majority of high school principals stated that the interior of the classrooms and the exterior of the school painted were painted within ten years. Eighty-six percent of principals stated their schools were swept on a consistent basis. There were about thirty-two percent of principals that found graffiti in schools. Once the graffiti was found, 91% of principals stated that it was removed within a week. Eighty-nine percent of the principals found their schools were maintained in a satisfactory or outstanding manner.

O’Sullivan concluded that there was an identified significant predictor between student academic achievement and school building conditions with adjacent structures to school buildings, which in this study were swimming pools. The adjacent building structure accounted for 2.8% variance in reading performance and 4.7% of the variance when accounting for math performance. There was also a significant positive relationship between school buildings with graffiti on exterior walls, painting on interior walls of classrooms and academic achievement. The increase in overall test performance was noted to be 55 points higher in schools without graffiti. The final conclusion was a positive relationship between schools that had renovations or additions and student academic achievement.

One limitation of the study included limited depth of investigation of other variables, other than building conditions and student achievement. The CAPE survey only had a 48% return rate leaving 52% of the principals as non-participants.
Bullock

The next study involved the relationship between school building condition and student achievement at the middle school level in the Commonwealth of Virginia and was investigated by Bullock (2007). This study investigated the relationship between school building conditions and student achievement as measured by student performance on Standard Of Learning tests, which targeted over three hundred middle schools in Virginia. The researcher looked specifically at the structural, cosmetic, and the overall building condition as it related to student achievement.

The target population of the study was initially all three hundred and four middle schools in Virginia. All schools were contacted and one hundred and eleven schools participated in the study. This gave the author approximately a 58% return of the targeted population.

An ANCOVA was used for the statistical analysis of the data through SPSS. The data used in the study included the structural and cosmetic results from the Commonwealth Assessment of the Physical Environment (CAPE) at each school. Academic data for students were attained through the Virginia Department of Education including Student Standards of Learning (SOL) results and students passing of English, Math and Science middle school SOL tests. Student socio-economic status data were also factored in the study based upon student participation in the free and reduced lunch program.
The results of the study, involving student achievement in relationship to overall building condition, showed that the percentage of students passing the English SOL was 3.89 percent higher, the Math SOL was 2.22 percent higher, and the Science SOL was 3.86 percent higher for students in buildings classified as standard compared to student in substandard schools. There was evidence of a positive relationship acknowledged between school building condition and student achievement in the middle schools of Virginia. Students performed better in new or recently renovated schools.

The passing percentage of SOL’s were also greater for females than for their male counterparts in all subjects. In overall building condition, the greatest difference occurred in English SOL performance with females in standard school buildings scoring 4.59 points above students from schools in substandard condition. The results were similar when the structural and cosmetic items of the CAPE were used as the independent variable. Females in standard schools scored 7.35 points higher passing percentage with structural conditions and an 8.04 higher passing percentage in cosmetic conditions compared to females in substandard schools.

The results of the study might be limited because of personal bias by the principals who were asked to rate the condition of their school by using the CAPE instrument. The limited response rate of the participation of the principals was also a limitation since only one hundred and eleven schools participated out of over three hundred middle schools in Virginia. It should also be acknowledging that all students did not take the middle school SOL test and that all students were not identified for the free and reduced lunch status.
Crook (2007) researched the relationship between the percentage of students passing the Standard of Learning (SOL) examinations and the condition of the educational facilities in high schools in the Commonwealth of Virginia. The purpose of the study was to examine the relationship between the percentage of students passing the Virginia Standards of Learning (SOL) tests and school buildings that are assessed as standard schools or substandard schools as well as the differences of performance in structurally and cosmetically standard and substandard schools.

The population for the study included 142 high schools that had eleventh grade students. As a result of the building assessment, the schools were broken down into a standard school category and a substandard school category. This determination was done through the principals assessing their own school. The sample of students in the substandard buildings was 729 eleventh grade students, with approximately thirty-four percent participating in the free and reduced lunch program. The sample of students in the standard buildings was 1,106 students and only twenty-two percent of this population participated in the free and reduced lunch program.

Data used for the study included the results of the CAPE assessment of the building by the principal. The second portion of data used in the study was student academic achievement data from the Virginia Standard of Learning (SOL) tests. This battery of tests examines core proficiency in math, reading and writing, social studies and science. This information for each school was attained from the Virginia Department of
Education (VDOE). The socio-economic status of the sample population was also used in the study and was determined by the percent of students at each high school on free and reduced lunch status. Socio-economic status of students was used to control for the differences in the two student groups.

The methodology for the study included descriptive statistics, pair wise comparisons, correlations, and an analysis of covariance (ANCOVA) by assessing the designation of each school as standard or substandard and the percent of students passing their Virginia Standard of Learning (SOL) test. There were also several variables that were analyzed in the study and then assessed by student performance on Virginia Standard of Learning (SOL) tests. The dependent variable for the study was student achievement and the independent variables were the condition of the school building. Those variables included wall color, noise, acoustics, lighting, classroom structure, school building age, windows, flooring, heat, and floor maintenance.

The results of the study showed that building condition does have a relationship with student achievement. There were significant differences between student scores on SOL assessment in buildings assessed as being in either satisfactory or unsatisfactory condition. Students in satisfactory schools scored higher in reading than students in substandard schools. The scores for students in standard buildings was 87.7% passing, compared to 81.1% passing for students in substandard buildings. The difference in performance showed a variance of 6.6%, with p< .001 meaning that building condition had a significant effect on student reading and writing scores. Alpha for the study was set
at p< .05. Student Writing scores in substandard schools had an average of 83.3% pass rate, while student writing scores in standard schools had a pass rate of 88.9%, showing a difference of 5.5%. In regards to statistical significance, p<. 019, with alpha set at .05.

Crook noted that there were differences in SOL performance of students in buildings rated as substandard and standard schools, when analyzing performance in math, but none of the differences were significant. When assessing the structural building condition which includes building size and density and major systems in a school such as lighting and heating and ventilation, the results were very similar to the cosmetic conditions, which could include cleanliness, paint, and maintenance factors when analyzing reading and writing scores. Student Writing performance scores in schools assessed as standard showed an 87.9 % pass rate, while students in schools assessed as substandard were only 80.9%, which accounted for a 7% difference, while p< .001, with an alpha at p< .05. Student Reading performance scores in standard schools showed an 89.5% pass rate while students in substandard schools reading performance showed an 82.8% pass rate, which accounted for a 6.7% difference with p< .008, with alpha set at p< .05.

The limitations of the study included that a high school sample of algebra tests scores may have included some middle schools students who may have taken algebra in middle school, thus limiting performance percentages for that area. The CAPE is an assessment completed by the principals of each of the high schools. This may have been a limitation if they did not fully complete all of the categories of the CAPE assessment or their judgment was influenced by familiarity of surroundings.
Geier

Geier (2007) investigated the facility quality of elementary schools in Michigan and their influence on student achievement. The research questions in the study focused on the quality of building conditions of urban, suburban, or rural locations.

The sample population of the study initially involved 90 elementary schools. Thirty schools from a rural area were incorporated, as well as 30 schools from an urban area, and 30 schools from a suburban area. The researcher randomly selected a sample of 70 schools from the strand of 90 schools with an anticipation of a fifty percent return rate.

The dependent variable was student achievement. Student achievement was measured by third, fourth, and fifth grade scores on the Michigan Educational Assessment Program. The primary independent variable in the study was building conditions of the elementary schools. Other independent variables included in the study were socio-economic status and median household income.

The methodology for the study involved a survey instrument that identified the building conditions in Michigan elementary schools. Building conditions were separated into two categories, namely standard and substandard. Survey responses were used to rate the school buildings from a survey instrument. Descriptive statistics were utilized and a multiple regression and an ANOVA were conducted through the Statistical Package of Social Sciences (SPSS).

The findings of the study showed that urban schools had more inadequate building conditions than suburban or rural schools. When looking at density means, urban schools had the highest square footage per student. In addition, the urban schools were
not renovated as frequently as suburban or rural schools. The survey responses from principals noted that interior finishes and HVAC were areas of concern. All schools, rural, urban, and suburban, reported a need for HVAC. Principals also noted that most of the needed repair in their schools was structural condition, not cosmetic.

Variance of academic performance ranged from one percent to over four percent in four of the six multiple regression tests when linking building condition to student achievement. The variance showed that student achievement was affected, but not to a large effect based upon the low account of variance. Socio-economic status was also significant in all six multiple regression tests. The variance of SES accounted for was about 50%.

There were several limitations noted by the author. The first limitation was that not all of the variables were accounted for in the study. A larger sample size would have been more beneficial. It was also noted the instructional assessment and curriculum alignment may have affected the outcome of the multiple regression tests. The final limitation was that the entire four-core subject areas were not analyzed, only math and reading were analyzed.

**Osborne**

Osborne (2007) explored the relationship of teachers’ perceptions of the educational suitability of elementary school facilities with student achievement. There were two research questions identified in the study. The first question asked if the suitability of the learning environment, as perceived by fifth grade teachers, had a relationship to student achievement of fifth grade students in reading, as measured by the
Pennsylvania System of School Assessment (PSSA). The second research question asked if the suitability of the learning environment, as perceived by fifth grader teachers, had a relationship with student achievement of fifth grade students in math, as measured by the Pennsylvania System of School Assessment (PSSA).

The methodology used in the study incorporated a survey instrument called the School Environment Suitability Assessment (SESA), which measured school facility conditions. The survey instrument was issued to fifth grade teachers. The survey instrument used a Likert scale for responses. The survey instrument was broken down into twelve categories that included school facility conditions. The categories included lighting, thermal, heating, and ventilation.

A descriptive analysis was used to analyze the school facilities and an alpha level of p< .05 was used. The statistical package of social sciences (SPSS) was used for the data analysis. A t-test, ANOVA, and a multiple regression were used to analyze the data from the Pennsylvania System of School Assessment (PSSA) scores in math and reading for fifth grade students. Those scores were compared and analyzed to the average School Environment Suitability Assessment (SESA) scores that were responses of the fifth grade teachers.

The population of the study included forty elementary schools in Pennsylvania. At least two or more teachers from each school responded to the survey. A total of 121 fifth grade teachers completed the SESA survey.

The dependent variable was student achievement of math and reading scores of the students in fifth grade. The independent variables included school facilities, as
measured by the SESA survey. A moderator variable was also identified and used in this study. That variable was the socio-economic status of fifth grade students.

Math and reading scores were correlated among participating schools. The multiple regression co-efficient for the student socio-economic status variable were identified as significant with p< .05. Student achievement on the standardized tests and teacher perceptions of schools were related, but were not statistically significant. A significant relationship was identified between the education level of the teachers taking the survey and their thermal comfort in their school. A significant relationship was shown between the educational level of the teachers taking the SESA survey and their privacy in their school. The last finding was identified by a multiple regression used in the study. The multiple regression identified thermal comfort as a significant predictor variable in determining fifth grade math achievement on the PSSA.

Limitations of the study included the possibility of personal bias of the survey based on the survey being a self-survey instrument. The SESA survey was completed online and may have been considered a limitation based on the technology ability of the teachers taking the survey. Three Pennsylvania schools were from a wealthy area and mostly from the suburbs in Philadelphia. The author also stated it was impossible to identify all of the independent variables that may effect student achievement. The study also only involved student achievement and not the methodology or instructional programs used at the elementary schools.
A study of the relationship between the selected school building facility components and student achievement in Pennsylvania middle schools was investigated by Fuselier (2008). The purpose of her study was to examine the relationship between the dependent variable of student achievement when compared with the three independent variables of lighting, thermal comfort, and acoustics. This study is of importance due to their being limited research on student achievement and the affects of building conditions in middle schools.

The sample population for this study included approximately 75,000 eighth grade male students and approximately 70,000 female students from Pennsylvania middle schools. Academic data used for this study was attained from the Pennsylvania System of School Assessment (PSSA). Middle school scores in Math and English were used for eighth grade students. The building condition data were used from 104 principal surveys that were used and derived from the School’s Physical Environment Variables Assessment (SPEVA). This assessment instrument was a combination of the Cash (1993) Commonwealth Assessment of Physical Environment (CAPE), and McGuffey’s (1982) work involving physical environment variables. The SPEVA measured lighting, thermal factors and acoustics in a twenty-one-question survey developed by Fuselier.

The SPEVA was scored on a numerical value based on the evaluation each principal gave on the condition of lighting, thermal factors, and acoustics in their middle school. The numerical value was then calculated to arrive as a score indicating the
building is in poor condition, average condition, or excellent condition. The numerical value ranged from one, which was poor condition, to a three, which was excellent condition. The levels of the independent variables were determined by the sum of each item on the SPEVA component. Middle schools that average a score from six to eight were considered at the bottom range of condition. Middle schools with a sum of nine to fifteen were considered in the average range of building condition and schools with a sum of sixteen through eighteen were considered at the top range of building condition.

The methodology used for the study included a quantitative study that was non-experimental. The author used descriptive statistics, independent t-tests, linear regression and an analysis of variance (ANOVA).

The findings of the study showed that the SPEVA revealed that 89.9% of principals in their Pennsylvania middle schools felt that their school’s building conditions were in adequate to excellent condition. Fuslier’s study revealed minimal correlation or significance of student achievement of eighth grade Math or Reading scores with the variables of school lighting, thermal conditions or acoustics being accounted for.

Lighting and acoustics in the classroom was not shown to significantly effect academic achievement for male or female test scores in Math or English. Statistical data results showed an f (2,96), which equaled 3.653 and an alpha of p<.030. The thermal sum explained about four percent of the variance of male students and three and a half percent of the variance for passing the math portion of the PSSA. Four percent of the variance was deemed significant for the study but was concluded by the author that the variance could be deemed a weak predictor of male students passing the math portion of
the PSSA. Acoustics and lighting provided no influence on student achievement in Math or English, while thermal factors did, but only with a minimal effect of four percent of the variance.

Limitations of the study included not accounting for all variables that affected student achievement in the study. Those variables included teaching methods, curriculum, and family support and environment. Personal bias may have been evident with principals evaluating their own school.

Influence of Dependent and Independent Variables

A meta-matrix was developed by Lemasters in her 1997 review of research. A similar table is included here to illustrate the independent and dependent variables used in studies analyzed in the review. Significant differences in student measures of achievement, behavior, and attitude were found in some research reports. For the most part, the differences in academic scores were found in some subject areas and were not found in others. For instance, reading and math subject areas were most frequently reported as having significant differences in scores. If significant differences were found in any subject area the study was judged to have significant difference between the two groups of students.

The table is arranged in alphabetical order by the author’s last name. There are three dependent variables arranged to the left of the table. They include student achievement, student behavior, and student attitude. There were several independent variables acknowledged. The volume of independent variables precluded the table from identifying every variable. It should be noted that the variable “other” includes the
independent variables of temperature, attendance, attitudes and miscellaneous building components as an independent variable.

The table contains numerous symbols that are placed into cells. The first is identified as R, which represents that a relationship between the independent and dependent variables were found. The symbol S indicates significant findings, at least at p<.01 or p< .05 level of significance. The symbol NS signifies that there was no relationship was found between the dependent and the independent variable.

The tables consists of 54 studies and each study was systematically analyzed and then designated a symbol. In some cases, multiple symbols were given based upon the total number of independent variables identified in a study.
### Table 1
Matrix of Dependent and Independent Variables by Study

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</table>
Table 2 provides data relative to the independent variables where a significant difference was found between scores of students when measuring achievement, behavior, and attitude. This table allows the reader to gauge the significance or relationship involving the most current research from 1998 though 2008.

Table 2

The Number of Studies Indicating Significant and Non-Significant Relationships with the Independent and Dependent Variables

<table>
<thead>
<tr>
<th>Independent and Dependent Variables</th>
<th>Significant Relationships</th>
<th>Non Significant</th>
<th>Relationship Found</th>
<th>No Relationship</th>
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Table 2 summarizes all of the 54 studies and elaborates on the findings, or the lack of the findings for each of the studies. The majority of the studies using these independent variables reported statistical significance or a relationship between school building condition and student achievement and behavior.

The studies on attitude clearly identified a trend line relationship between school building condition and student attitudes, but the data did not support a statistical significance difference between student scores. It should be also noted that studies where
significance was not reported were clearly identified. The last column at the bottom and on the left of the table included studies with the overall building condition.

The studies that used a building assessment tool concluded that student achievement, student behavior, and student attitude were influenced by schools that were identified as substandard or standard through a facility assessment tool.

Table 3

Major Building Components That May Influence Student Health, Behavior, and Performance

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<tr>
<th>Independent Variable</th>
<th>Author</th>
<th>No Significance</th>
<th>Significance</th>
<th>Relationship</th>
<th>Norm Mean Scaled Scores</th>
<th>Pass Percentage Assessed</th>
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Table 3 descriptively identifies all of the independent variables that were identified in the 54 studies of the synthesis. The last two columns on the right of the table identify the kind of data used in the analysis to measure student performance. There were several instances where the researchers were able to use mean scaled scores whereas other researchers were forced to use percent of students passing an examination as there data. If a study did not clearly identify how academic data were analyzed the NA was inserted into the field.

The majority of the studies clearly identified mean scaled scores on tests for student academic achievement. The test data, along with the identification of the studies that were not significant did show some relationship of the variables variables. The majority of studies that incorporated means scaled scored academic data showed higher instances of significance or relationship in regards to student academic achievement compared to studies that used percentage of students passing an examination as a way to identify academic achievement.

Table 4 identifies how being conditions were assessed and measured in studies that used a survey instrument to identify schools as standard or substandard. This table becomes meaningful based on the fact that eleven of the studies use the CAPE and the majority of those studies used mean scaled scores to identify data for student

| Renovation | Maxwell (1999) | | X | X |
| Leadership and Finance | Brannon (2002) | | X | NA | NA |
academic achievement.

Table 4

<table>
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<tr>
<th>Researcher</th>
<th>Tool or instrument for school building evaluation</th>
<th>Person(s) that conducted the assessment of the school building conditions</th>
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<td>Brannon</td>
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<td>14 Question Survey</td>
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<td>Survey Instrument</td>
<td>Principal</td>
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<td>Lair</td>
<td>Attaining of Renovation Documents</td>
<td>Interview with former and current Superintendent</td>
</tr>
<tr>
<td>Lanham</td>
<td>Commonwealth Assessment of Physical Environment-CAPE (by Cash)</td>
<td>Principal</td>
</tr>
<tr>
<td>Leung/Fung</td>
<td>Survey Instrument</td>
<td>Students</td>
</tr>
<tr>
<td>Lewis</td>
<td>School Facility Inventory</td>
<td>Construction Corporation: Individual Agency Control</td>
</tr>
<tr>
<td>Picus et al</td>
<td>Survey Instrument</td>
<td>A school representative or division superintendent and a subcontractor, MGT</td>
</tr>
</tbody>
</table>
The principal was identified as the person that completed the assessment of the building. The CAPE was used in 10 out of the 21 studies, from 1998 through 2008, which used an instrument to measure building conditions. Studies that used the CAPE or modified CAPE along with the use of mean scaled scores to identify data for academic data had higher instances of significance and identified relationships in the findings of the studies compared to studies that used an alternative assessment of the building, along with pass percentages of assessments, which were used for academic data. The table clearly demonstrates the significance of the principal as the person that should be involved with measuring a school building’s condition and preferably through the CAPE.

Those studies that used other measurements to identify school building condition and personnel other than a building principal in building assessment identification would clearly be looked at in a detrimental effect of the measurement of the school building.
condition. This fact alone supports the idea that the inadequate diagnosis of the school building tremendously weakens any findings when trying to correlate student achievement of students. This becomes a detrimental weakness in methodology and the results of the studies using anything other than the CAPE, as a measure of overall building condition, may not present complete accuracy through the findings presented in those studies.
CHAPTER 4
FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The present synthesis of studies include ten years of research from 1998 through 2008. In completing the review, over 130 research studies were analyzed to determine their relevance to the subject of the relationship between student achievement, student behavior, student attitudes, and student attendance with school building condition. Of that number, 54 studies were selected as appropriate sources of data relative to the main research question.

There were three prior syntheses of research that had spanned the years from 1979 though 1997. Weinstein (1979), McGuffey (1982), and Lemasters (1997) analyzed almost 300 studies in this time frame. The purpose of the current synthesis is to build upon the knowledge base of the previous three syntheses, as well as add any new ideas that have surfaced in regards to research surrounding student health and performance, while considering school building condition.

During the time period of the three previous reviews of Weinstein (1979), McGuffey (1982), and Lemasters (1997), research topics tended to be focused upon using various building components or features as the independent variable when comparing the performance of students. Recently the trend in research has been broadened to include the investigations of how other building features and components influence student health and performance. Such variables as design features, density, renovations, and even the impact of the building on ethnic and poverty students have been used successfully in
studies. This is encouraging to find out that the field of inquiry is interesting enough to broaden the research investigations.

Over the past ten years, the way that school buildings were evaluated and measured for overall school building condition provided several trends. The principal for the most part was the primary person that evaluated the overall condition of the school building in the majority of studies. This occurred in 10 out of the 20 studies. The efficacy of the principal evaluation was collaborated by several researchers who individually evaluated a select number of buildings and compared their results. With a high inter-rater reliability, the researchers felt the principal was the best individual to properly evaluate the school building condition.

Many of the 54 studies used mean scaled scores or percentage of students passing an assessment instrument to measure academic performance of students. The possible difference in these two measures of student performance can be important when considering the actual measurement of student achievement. The percent of students passing an examination is only a number of students achieving a selected goal or score on a test and does not measure individual student performance. Studies completed with the percent of students passing an examination did not have as robust findings as those studies with mean scaled scores of students.

Studies that used student academic performance data that were presented through mean scaled scores presented stronger support of findings of significant relationships between student academic achievement, student health, and building condition than other studies.
The considerations of confounding and demographic variables were accounted for in some studies, but not in others. This may or may not have had an influence on the results and findings of each of the studies.

Organization of Research Findings

Earthman (2004) established a prioritization of 31 criteria for school building adequacy, which he presented and reviewed for the American Civil Liberties Union Foundation of Maryland’s task force. There were seven identifiable criteria that demonstrated an effect on student achievement. Those criteria were listed in the order of the effect and included human comfort and classroom temperature as an overall concern when accounting for HVAC systems. Indoor air quality and adequate lighting were the next two criteria of importance. Classrooms should have proper ventilation and lighting, which is attributed to enhanced academic performance. The other four criteria included acoustical control, secondary science laboratories, student capacity at elementary schools, and student capacity at secondary schools.

The fore mentioned criteria established by Earthman (2004) were used as the basis and the justification for the variables accounted for in this study. The variables that were identified in this study included the effects of temperature, lighting, acoustics, density on student achievement, and student health and productivity. The use of these variables in this synthesis were based upon four of the seven criteria Earthman (2004) established as having a direct correlation with their effects on student achievement.

This portion of the chapter is divided into seven sections and in each section the findings of research will be reported. The first section deals with those studies that used
a major building component, that is strongly linked to influencing student health and performance, as the independent variable. These variables are lighting, temperature, acoustics, and the age of the school building. These four variables have been the independent variables for a number of studies. In fact, age of building is in reality a surrogate for building condition, but will be treated as a separate variable.

The second section contains a discussion of those studies in which the design features of a building are used as an independent variable. In these studies, the researcher is trying to identify the relationship between a set of design features and student performance. Such studies are valuable in providing data on which design features might enhance student performance if designed initially into the building.

The third section of the chapter contains a discussion of studies that used the building condition as an independent variable, but tried to identify the influence the building may have on student attitude. The fourth section discusses the use of attendance rates as a surrogate for student performance. The reason the researchers used attendance rates is because of the inability of securing the actual student achievement data or the school system used a passing rate of students as a measure of student performance. The fifth section of the chapter contains a discussion about the density of school buildings. The sixth section discusses studies that use a variety of independent and dependent variables to ascertain the relationship between the two, and the final section discusses building conditions of a school, teachers and overall building conditions.

Summary of Findings

Major Building Components That May Influence Student Health, Behavior, and Performance
Lighting

There were four variables examined that involved major building components. The first variable included lighting in school buildings. The Heschong Mahone Group (1999) and (2003) conducted two separate studies in the western part of the country, specifically Colorado, Washington, and California dealing with the presence of daylighting in classrooms and its effect on student achievement. The two studies reported the importance of adequate daylight, larger windows, and natural daylight in classrooms, which accounted for higher student achievement compared to schools that had no windows, limited access to natural light, or a view.

Samuels (1999) examined the relationship between full fluorescent lighting in school classrooms compared to classrooms that were illuminated by cool white lighting. In this study classrooms with full fluorescent lighting had higher instances of student achievement compared to classrooms that had alternative forms of lighting. It was found that higher attention spans were accounted for and students were more focused in class with better illuminated classrooms, which in return improved student achievement of students.

Wei (2002) conducted a study in Hong Kong. It was found in this study that classrooms that had adequate access to lighting and that were well lit influenced student behavior. Lighting that deflected off of objects in the classroom and glare that distracted the learners were concerns of the students and often influenced student behavior.

Battles (2006) found that students in classrooms that had full fluorescent lighting had less incidences of off task behavior compared to students in classrooms that used
cool white lighting. The five studies demonstrated the effect of lighting in the classrooms.
Classrooms that had natural daylight, had views, and used fluorescent lighting to
illuminate classrooms had larger effects on student achievement and student behavior
compared to schools that had no windows in the classroom, limited access to natural light
and used alternative forms of lighting in classrooms rather than fluorescent lighting.

Temperature

Temperature in school buildings was the next variable examined. Smedje and
Norback (2000) investigated the adequacy or inadequacy of ventilation systems in school
buildings in Sweden. Adequate ventilation in classrooms proved to lower instances of
respiratory problems of students and teachers, which in return improved student and
teacher health and also reduced stress. This study supported the importance of adequate
ventilation systems in schools.

Perez, Montano, and Perez (2005) investigated the relationship between
temperature and climate in student classrooms and the effect on student achievement.
Students often performed better on basic tasks when classrooms were controlled at
comfortable temperatures, which were typically held constant in the low 70’s in
classrooms. The effects of student performance in classrooms that had control
temperatures between the upper 70’s and low 80’s were weaker compared to student
performance in classrooms that had control temperatures in the low 70’s.

Wargocki, Wyons, Matysiak, and Irgens (2005) investigated the relationship
between classroom temperature and outdoor air supply rates and student achievement in
Denmark school buildings. As concluded in the Smedje and Norback (2000) study, it was
also reported in this study that increased ventilation rates in classrooms, compared to classrooms that had substandard ventilation rates, had higher instances of better student achievement. Classrooms that had moderate temperature control and were comfortable to students produced positive effects on student performance, health and accounted for lower instances of poor behavior of students.

All of these studies showed a positive effect on the control of temperature and ventilation in classrooms. A classroom temperature that ranged in the low 70 degrees produced the best comfort environment for students. When ventilation rates were adequate in classrooms, there were less instances of off task behavior and student health was found to be better.

Acoustics

Acoustics was the third independent variable examined in this section. The majority of the studies reported on sound amplification in classrooms and the effects of adverse noise conditions on student achievement, behavior and health. Rosenberg et al (1999) conducted a field research project involving sound amplification in elementary school buildings in Florida. Amplified classrooms produced a better environment that allowed children to hear adequately and consequently learn better. Haines et al (2001) reported that there was a relationship to noise exposure and student performance in school buildings in England. Although it was concluded that noise exposure was not a statistically significant factor that improved reading performance, it did acknowledge the support of amplified classrooms to have an importance of influencing student behavioral skills.
Moses (2001) identified several attributes of adequate amplification in classrooms which in return contributed to higher instances of student time on task, word and sentence recognition, improvement in spelling performance, and better performance on standardized tests, compared to students in inadequately amplified classrooms. This is yet another study that supports the influence of sound amplification in classrooms.

Vilatarsana (2004) investigated that excessive noise in and around schools around Heathrow Airport in England, had a negative influence upon student learning. This study found different results compared to the Haines et al (2001) study. Although the Haines study did not fully correlate adverse noise and student achievement, the Vilatarsana study did.

The relationship between student performance and adverse noise exposure was inconclusive in the Haines et al (2001) study and adverse noise had a limited effect on students, whereas Vilatarsana (2004) did find a direct relationship between adverse and excessive noise in and around schools.

Age

The fourth and last variable considered to influence student achievement, health, and productivity was school building age. Hickman (2002) investigated how student behavior may be affected for students transitioning from an older school to a newer one. Suspension rates in this study were found to be lower in the newer school. The age of the school was not a major influence on student attendance or graduation rates in this study.

Kilpatrick (2003) investigated how school facility conditions influenced student climate and behavior in an older high school compared to a newer one. Student
perceptions and climate was influenced by the age of the school building in this study. Students perceived they were safer and felt maintenance was better in the new school. Wicks (2005) investigated the effects of adverse building conditions on student grade point averages, as an indicator of measuring student achievement. In this study grade point averages were found to be somewhat higher in newer schools compared to older schools, but not at a statistically significant level.

Design Features That May Influence Student Health, Behavior, and Performance

The design features that included private spaces and quiet areas in schools allow students to have privacy. Anderson (1999) substantiated that a varied learning environment, along with the diversity of design features, enhanced student learning. Design features in this study influenced student achievement. Significant relationships existed between selected design features and student achievement on eighth grade ITBS scores in Georgia. Ayers (1999) investigated the relationship between design features and high school student achievement in Georgia. Although the variance was considered low in reading, science, and math performance, a relationship was reported between design features and student achievement. Hughes (1999) investigated the relationship between design features and student achievement in elementary schools in Texas. The building design features of interior paint color and outside learning areas showed a significant relationship with student achievement, specifically in math performance.

Yarborough (2001) reported there were differences between student achievement on third and fifth grade ITBS scores when selected design features were present in school buildings. Broome (2003) conducted a study investigating the relationship between
design features of school buildings in Tennessee and Mississippi and their relationship to student achievement and behavior. There was no statistical significance reported between the effect of school design features on student behavior. Broome also showed the opposite effects of design features having an influence on student achievement. There was no significance found between the design features and student achievement in this study, compared to the four studies that correlate an influence on student behavior and student achievement when accounting for design features.

Building Conditions That May Influence Student Attitudes

Samuels (1999) found and did not dispute that adequate school buildings had a positive relationship to student mood and attitude. Stapleton (2001) found a lack of significance of student attitude when a student transitioned from an older school building to a newer one, while Hickman (2002) found that transitioning from an older school building to a newer one did produce a positive change in student morale and attitude.

Earthman (2008) investigated the relationship between attitudes students have towards their school building and their achievement. Earthman noted that there were gender differences in the attitudes of students. Male students had less favorable feelings about school building conditions when they were in schools assessed as being unsatisfactory compared to female students in the same schools. Student mean scores in language arts were analyzed by schools that were deemed unsatisfactory compared to those deemed satisfactory. Earthman noted that the results of the study just fell short of significance, but it was noted that trend level significance was acknowledged although
the variance was limited.

Studies That Use Attendance As A Measure of Student Performance

Shendell, Prill, Fisk, Apte, Blake, and Faulkner (2004) identified a relationship between adverse building conditions and student achievement. Ventilation rates had a relationship with absenteeism of teachers and students in schools in Washington and Idaho. A relationship with student achievement was found. When ventilation was improved, there was a higher instance of more teachers and students attending school. The increase in CO2 was associated with about a 20% increase in absenteeism and was statistically significant. This broaches the question of a new phenomenon of adverse building conditions affecting absenteeism. Teachers cannot teach and students cannot learn if they are not in school.

Duran-Narucki (2008) found that in inadequate school buildings students attended school less and as a result the student tests scores in math and language arts were lower compared to student achievement in adequate school buildings. Building condition was found to be statistically significant with student performance in math and language arts, while accounting for attendance.

School building conditions were statistically significant when accounting for school buildings and their direct effect on student attendance in schools. Students are absent from school more often when enrolled in inadequate school buildings compared to students in adequate school buildings.

Density

Williamson (1999) compared schools with low and high student academic
achievement based upon school size. Achievement tended to lower in schools when the school’s size were larger. Gentry (2000) found that students attending larger schools in the state of Georgia outperformed students in smaller schools in Georgia on assessment tests, while measuring student aptitude, not student achievement.

Swift (2000) reported that school building density had a relationship to student achievement. Composite test scores were higher in elementary schools in Georgia when the square footage of space per student was higher than scores in schools that had less square feet. The three studies varied in results, but it appears that schools that have more square footage in classrooms did produce higher student achievement compared to schools with classrooms with less square footage.

Miscellaneous Studies

There were several studies that could not be categorized into a building condition or a building component. School renovation was an uncommon variable that was identified in the following study. Maxwell (1999) conducted a case study that examined school renovation and maintenance processes and the effects on student academic achievement. The physical attributes of the school building were found to play an important role in student achievement. It was noted that students that were subjected to noise, associated with the school renovation, may have performed poorly. There was a positive relationship established between upgraded and well-maintained schools and achievement in math after the renovation was completed.

Thornton (2006) investigated the relationship between building condition and the relationship to student achievement of economically disadvantaged and minority
students. The condition of the building did not influence achievement among minority students. Economically disadvantaged students housed in substandard schools outperformed economically disadvantaged students in standard schools. All of these miscellaneous studies provided a unique insight on independent variables that were somewhat uncommon in research. The studies were of interest, but most provided little common ground for any new research in the future.

Building Conditions

There were 18 studies that investigated the relationship of overall building condition and student achievement. Thirteen out of the 18 studies showed a positive relationship to and or a statistical significance between student test scores when the overall building condition was used to define the school physical environment. There were four studies that did not have findings that connected overall school building conditions to achievement.

Cervantes (1999) found there was a relationship between the educational environment and reading achievement, but the relationship between the overall building condition and math and reading performance was not statistically significant in Alabama schools. Cervantes also concluded that there was a significant relationship between the overall building condition and the suspension rates of students. Those students in substandard schools had higher rates of suspension compared to students in standard schools. Lanham (1999) reported that air conditioning was significant when English and math performance was compared. Improving temperature in the classroom had a direct effect of academic improvement and performance in math and technology. The physical
environment was a significant factor of student achievement. Sweeping and classroom structure were predictor variables that were significant when accounting for student achievement.

O’Neill (2000) assessed student achievement of schools in Texas and the overall building condition of schools. Differences between student achievement scores were significant when comparing students in old and new buildings. The academic learning space of students was also a predictor of student achievement in math and reading. He noted that interior color schemes, interior comfort, and humidity comfort, when measuring the overall facility condition, were related to higher accounts of in-school and out of school suspensions in substandard schools when accounting for external aesthetic appeal.

Guy (2001) conducted an investigation in West Virginia Schools. When analyzing the effects of overall building condition, Guy found that higher student achievement scores were not necessarily found in newer school buildings. There was a strong relationship between school facilities and student achievement, but none were statistically significant. Lewis (2001) found that the student achievement and the overall building condition of schools was related to schools in Wisconsin. Almost 16% of the variance of math performance was accounted for when measuring the overall building condition.

Stevenson (2001) investigated several building conditions that adversely affect the educational process and are related to student achievement. They include overcrowding, poor physical condition, lack of storage, and inadequate laboratory space. Al-Enezi (2002) concluded that graffiti and roof leaks were two main predictors of the
environment that affected student achievement in schools in Kuwait. He also found a significant and positive relationship between structural and cosmetic building conditions with student achievement.

Lair (2003) found that building age and maintenance accounted for a large amount of student performance variance when accounting for student achievement in schools in Texas. She reported that there was a relationship between the overall building condition and student achievement.

Leung and Fung (2005) conducted a study in Hong Kong investigating the relationship of school facility condition with student achievement and student behaviors. They found a relationship between student achievement scores when the overall building condition was the independent variable, but none of the relationships were significant. Picus et al (2005) found that there was no relationship or significance between building conditions and suitability of school facilities in relationship to student achievement amongst students in Wyoming. Syverson (2005), however, reported a significant relationship between the overall building conditions of schools in Indiana with student achievement.

Edwards (2006) found that space considerations had a significant relationship in where students chose to interact in schools and where they learn, specifically classrooms. Students expressed that they could learn better in schools that were clean, neat, and in good physical condition.

O’Sullivan (2006) concluded that school facilities in Pennsylvania adjacent to the school, such as swimming pools in this study, and the location of graffiti, were the two
predictors of overall building condition that affected student achievement when considering math performance. Bullock (2007) reported a positive relationship between middle schools in Virginia and student achievement. Students performed better in newer or recently renovated schools.

Crook (2007) reported that building condition had a significant relationship with student achievement. Student achievement was higher in math and reading in Virginia high schools that were assessed as standard compared to schools that were assessed as substandard. Geier (2007) acknowledged that urban schools in Michigan had more inadequate school building conditions compared to schools in the suburbs or rural areas. Overall building condition did have an effect on student achievement, but the variance was low.

Osborne (2007) investigated the relationship of teacher perception of the educational suitability of elementary schools while accounting for student achievement. Thermal comfort was identified as a significant predictor in determining math performance on the Pennsylvania System of School Assessment. Student achievement on standardized tests and teacher perception were noted as having a relationship, but not a statistically significant one. Fuselier (2008) investigated the relationship between the overall building conditions of middle schools in Pennsylvania. She revealed that the building conditions of lighting, thermal conditions, and acoustics had a correlation with student achievement, although they were deemed minimal.

All of these studies included some type of building measurement to determine the condition of the structure. The CAPE was a prevalent tool used in over half of the studies.
The principal typically was the person that evaluated the school building. Other studies included a survey instrument or an alternative school facility appraisal instrument. Many of the studies used mean scaled scores or pass percentages when evaluating data. There were more instances of significance in studies that incorporated the CAPE while also using mean scaled scores to evaluate student achievement.

Conclusions

The basic tenet of the body of research studies reviewed in this study was that the school building did in fact have an influence upon the health and productivity of students and teachers. Both common belief and theory indicate there is such an influence. The question then becomes how does one determine if that phenomena exists and to what extent can it be measured. The studies in this review almost always used the condition of the building, selected building components, or building features as the independent variable to ascertain if that variable had an influence on measures of health and productivity of the users. When the researcher found a significant difference between whatever measures of health and productivity that were used, this was an indication that the building had an influence. There were some exceptions to this standard conceptual formula for ascertaining building influence, but for the most part researchers have been consistent in the use of this methodology.

Because of this underlying tenet, the review of research should at least address the main question of whether or not the research is clear as to building influence and if found the extent of that influence. In the main, the review of research was based upon the preponderance of evidence found in the studies. The discovery portion of this study
found research reports that indicated there was substantial evidence of the influence of the school building. Likewise, there were research studies that indicated no evidence was found to support the idea of building influence. In both cases the studies were well-crafted and executed, however, all studies suffered from some sort of methodological error or the effect of confounding variables not being entirely controlled. Nevertheless, all of these studies in this review are respectable studies and represent the best research to date.

There are several strains of research that have reported significant differences in achievement scores when students are in either satisfactory or unsatisfactory school buildings. Research studies in this group have reported these differences range between 3-5 percent of achievement scores. In one group of such studies, the school building was assessed by use of an instrument that was designed specifically for research purposes. In other words, the assessment instrument was designed to capture the most important components of a building that has been shown by previous research to be related to student achievement and not the entire gamut of building features, components, or utilities which may or my not have relevance to student performance.

Another strain of research that appears to be promising is those studies that have used student attendance rates as a surrogate for student achievement. Student attendance rates in these studies have been used when the state reports on mean scaled scores on nationally normed tests for students. The results of these studies have shown there is a relationship between the school building condition and student attendance and subsequent achievement.
Based upon the evidence presented in the studies reviewed here, the following conclusions are put forward:

1) In those studies that used a building assessment instrument based upon research findings, the building does have a significant influence upon the health and productivity of students and teachers.

2) In those studies that used a school building assessment instrument based upon the maintenance needs, the researchers could not always find significant differences in student measures of health and productivity.

3) In those studies that used student mean scaled scores of standardized achievement tests rather than the percent of students passing an assessment measure, significant differences in student scores were found indicating the building did have an influence upon students.

4) In those studies where student attitudes was the dependent variable, the researchers could not find a significant line of influence between school building condition and student attitudes. The analysis did, however, show a trend towards influence, but that influence was weak.

Discussion

There are many factors that influence the productivity and health of students in school buildings. They include items such as control of confounding and demographic variables, survey instruments used to assess building conditions, and the way in which academic achievement is reported.

The statistical analyses in most of the studies analyzed were appropriate.
Controlling for certain confounding and demographic variables add to the validity of the findings, especially when accounting for statistical analysis. Many of the 54 studies failed to control for teacher quality and curriculum issues. Curriculum accountability and benchmarks are issues that many researcher did not control for in the analysis and how they were accounted for during a school year. If major components of the curriculum are not properly presented and taught then a student’s exposure to certain content will limit their progress on examinations.

Socio-economic status is another confounding variable that often accounts for a large amount of variance when conducting a statistical analysis. SES was mostly accounted for by a student’s status of free and reduced lunch determination. There is concern noted about the percentage of students that may not complete paper work once identified for this service. If students are not properly identified and accounted for in the pool of the free and reduced lunch program the use of this statistic becomes less reliable as a control measure of the student population. Nevertheless, until a better statistic is identified, the student participation in the free and reduced lunch program is the only reliable measure available to the researcher to control for the socio-economic status of the student population.

The Commonwealth Assessment of Physical Environment was originally developed for research purposes. It was crafted to identify the physical condition of school buildings as it might relate to student performance on academic tests. The items that comprise the CAPE were designed based upon previous research that had indicated a certain building component or condition was related to student performance. In other
words, the items were developed based upon research that had found a significant relationship between some component and condition of the building and student performance. The most basic of these components were safety issues, thermal environment, light, acoustics, and roof integrity. Other components that previous research indicated had an influence on student performance were condition of the student furniture, science equipment, day lighting and presence of graffiti. All of these building components were included in the items of the CAPE.

A scoring system for the CAPE was developed to provide the researcher with a method of developing data to designate school buildings as being in either satisfactory or unsatisfactory condition based upon the responses to the instrument items. As a result, assessment of the school building using the CAPE provided the researcher with a building score for each school, which permitted division of the schools into groups for comparison purposes.

There have been research studies investigating the relationship between school building condition and student achievement, behavior, and attitudes where the researcher has employed various different instruments to ascertain the condition of the building. In most cases these instruments have been designed to identify maintenance needs that must be attended to in the capital budget of the school system. These instruments are used to identify all of the needs of the building in order to keep it in good working condition. The purpose of these instruments is to provide data to educators and school authorities to make decisions about how they would go about remedying the physical needs of the building. The purpose of these kinds of assessment instruments is very different from the
purpose of the CAPE.

The instruments that are used for technical assessment or maintenance needs identification is not adequate for measuring the influence the condition of the school building has upon student health and performance because their purpose is different from the CAPE. The technical assessment includes all items that might be in need of repair or replacement. Most of these components or maintenance needs are not related to student performance, or if they are related, the relationship is so tenuous that it is almost impossible to identify. Yet these same items may have the same weight in the final score of the building as does the more important components of the building that are related to student performance through previous research. This in essence skews the score away from the important building components and spreads the effect upon the broader scale of maintenance items. The effect is, in the use of these instruments, that the building condition is marginalized to include those items that have little or no influence upon student health and performance. Naturally, this gives a different picture of the school building condition than the more focused approach using the CAPE.

Within the ten year period of this study, there have been eleven studies where the researcher has used the original CAPE or some derivative thereof. The results of these studies have been rather consistent in what has been found. For the most part these studies have found a significant difference in student test scores when they are learning in unsatisfactory and satisfactory buildings. The differences in these test scores have ranged from two percentile points to upwards of 17 percentile points. Commonly, the researchers of these studies report that students in satisfactory school buildings score 5-
10% above students in unsatisfactory school building on standard measures of achievement. More recently within the time of this study, researchers Lanham (1999) and Crook (2007) has found the same degree of differences in student test scores.

There have been a similar number of studies in which the researcher used a technical assessment or maintenance needs assessment to determine the condition of the school building. The results of these studies have been similarly consistent. The findings of these studies indicate that they could find no relationship between building condition and student achievement. Within the ten-year period of this study, there have been four studies where the researcher has used a technical assessment or maintenance needs assessment to identify the condition of the school building. The researchers of these studies have not been able to find any difference in student scores and report there is no relationship between building condition and student performance. This is, of course, patently wrong because the data do not indicate there is no difference, only that they could not find one given the assessment of the school building.

Student performance measures have been a large variable in the majority of the syntheses. In many studies, the researchers used mean scores and overall passing scores of students compared to raw data. Unfortunately, the standards of quality in determining the average scores or calculating a certain percentage of students passing may be a concern based upon a state’s accountability measures. For example, in Virginia, students take Standard of Learning tests in elementary through high school. The minimum cut score for passing the assessment is a 400, with the scale reaching 600 for a perfect score. Students scoring anywhere between 400 and 600 are considered passing the
examination. With such a wide range of acceptable performance, it is impossible to gauge the efforts of students as a group for research purposes.

Raw scores allow researchers to distinguish between overall successes rates of student achievement usually through a norm referenced test, whereas, an average or percentage may present ambiguity of findings of the true relationship or significance of student academic performance.

As further discussion is needed in regards to pass percentages typically found on assessment tests, compared to norm referenced tests, Duran-Narucki (2008) conducted an excellent study using attendance rates of students in satisfactory and unsatisfactory school buildings as a measure of student performance, which could be compared to see if there is a difference between the two student bodies. Students attended school less regularly in substandard school buildings. This mounts the question of the further relationship between substandard school buildings with attendance rates and student performance.

Recommendations for Further Study

This study afforded a comprehensive review of studies from 1998 through 2008. The current synthesis has allowed the presentation of the most up to date research findings from 54 studies that were identified nationally and world-wide. The purpose of this study was to analyze those studies in which the researcher wished to ascertain the influence the school building condition had upon the health and productivity of students and teachers. Based upon the analysis of extant research in the field, several areas of new research were presented that might be beneficial in understanding the
relationship between the school building and student and teacher health and performance.

1) Further research using student attendance rates as a surrogate for student achievement is needed. The measuring of achievement in many states now takes the form of trying to have every student reach a certain level of performance. As such, students can re-test many times so as to achieve the level performance demanded by the state. This process is very good for the student in that the student is able to succeed. The down side is that for researchers, there is not an extant measurement of the efforts of the student. An initial study might be mounted to determine the degree of correspondence the rate of attendance has upon student performance when accounting for school buildings that are substandard or standard. The results of the study could be a guide to researchers in the effectiveness of the rate of attendance in substituting for academic test scores.

2) A review of research of studies devoted to the relationship between school buildings and student achievement should be considered for the next generation of studies. The exact time frame should be dependent upon the quantity of studies completed. A timely review of studies is always appropriate regardless of the time span. As many new accountability measures arise in the future, an update of current research and any new phenomenon involving school building conditions and student achievement, student behavior, and student attitude is a necessity for current educators, administrators, and school building architects and contractors. Meta-analytic studies of common based research efforts to refine the knowledge base upon which these studies are founded allow for fruitful avenues of further research.

3) New ideas about student attitude and perceptions of the school environment...
have surfaced in the current synthesis. The Earthman (2008) study on attitude could be replicated and or manipulated to gain a better understanding of a student’s attitude and perceptions of one’s school building and how that school building has a larger affect on student morale, perceptions, achievement, and student behavior.

4) Lemasters (1997) noted the importance of a national study on the relationship between school building condition and student performance that could encompass different parts of the country. This type of study has yet to be mounted and is being further recommended. Although each state has different means for measuring student performance, the United States Department of Education conducts a National Assessment of Education Program. The results of that program might be accessible to researchers to measure student performance. A few studies have been completed using data on the national level. Further exploration is needed using such data.

5) In the course of designing research studies some new instruments have been developed and used. These instruments measure a number of variables used in the studies involving building condition, student performance, and student and teacher attitudes. All of these instruments would be respectable subjects of validation studies to norm their effectiveness, validity, and reliability. A series of validation studies on the instruments that evaluates the overall condition of the school building such as the CAPE and any other instrument that measures building conditions would be appropriate.

6) With the advancement of technology and the use of technology in schools, more research should be conducted on the influence of the incorporated technology use and applications in schools, compared to schools that have limited technology. Schools
could be identified as buildings with adequate technology tools or resources, compared to schools with inadequate technology tools or resources. The examination of technology in school buildings and the relationship on student achievement, behavior, and attitude is needed.

7) The faculty and students at several major universities over the past 20 years have compiled a corpus of research studies dealing with the relationship between school building condition and student achievement, behavior, and attitudes. Many of the studies have emanated from the theoretical model developed from the Cash study in 1993. Over ten researchers have completed studies using the CAPE in this synthesis. It seems appropriate now to find out what researchers at these institutions, that has focused around this topic, have been able to report. A study that analyzes the findings of all of the studies completed at these universities from the period of 1993 to 2009 should be mounted to report the results.

In summary, the main research question for this study asked if there were any current relationships between school building conditions and student achievement, student behavior, and student attitude. There were numerous studies found within the time period of 1998 through 2008. There is still much interest in how a school building affects a student’s productivity and health.

School buildings that are well maintained and are modernized provide the optimal environment for children to learn. The environment in which children learn in and play in continues to be of the utmost importance.
RESOURCE DOCUMENTS


Polytechnic Institute and State University, Blacksburg, VA.


Lang, D. C. (2002). *Teacher interactions within the physical environment: How*
teachers alter their space and/or routines because of classroom character.
Doctoral Dissertation, University of Washington, Seattle, WA.
www.eric.ed.gov/ERICWebPortal/


O’Neill, D. J. (2000). The impact of school facilities on student achievement, behavior, attendance, and teacher turnover rate at selected Texas middle schools in region XIII ESC. Unpublished doctoral dissertation, Texas A&M University, College Station, TX.


children. Technical University of Denmark: International Centre for Indoor Environment and Energy. www.ie.dtu.dk


### APPENDIX A

#### Descriptors For Searches

- acoustics
- acoustics and student achievement
- acoustics and student behavior
- acoustics and student attitude
- acoustics and student achievement and student behavior and student attitude
- behavioral sciences in school buildings
- classroom and color and student achievement
- classroom and color and student behavior
- classroom and color and student attitude
- classroom design
- classroom design and student achievement
- classroom design and student behavior
- classroom design and student attitude
- classroom environment
- classroom environment and student achievement
- classroom environment and student behavior
- classroom environment and student attitude
- classroom size
- classroom size and student achievement
- classroom size and student behavior
- classroom size and student attitude
- classroom size and student achievement and behavior and attitude
- color
- color and student achievement
- color and student behavior
- color and student attitude
- color and student achievement and student behavior and student attitude
- crowding
- crowding and student achievement
- crowding and student behavior
- crowding and student attitude
- crowding and student achievement and student behavior and student attitude
- educational environment
- educational environment and student achievement
- educational environment and student behavior
- educational environment and student attitude
- educational environment and student achievement and behavior and attitude
- educational facilities
educational facilities and student achievement
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facilities and student achievement and behavior and attitude
facilities planning
facilities planning and student achievement
facilities planning and student behavior
facilities planning and student attitude
facilities planning and student achievement and behavior and attitude
facility design
facility design and student achievement
facility design and student behavior
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facility design and student achievement and behavior and attitude
light
light and acoustics and density and color
light and student achievement
light and student behavior
light and student attitude
light and student achievement and behavior and attitude
light and color
light and schools
maintenance
maintenance and student achievement
maintenance and student behavior
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new construction
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new facilities and old
new schools and student achievement
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noise
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research and behavior
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windows
windows and student achievement
windows and student behavior
windows and student attitude
windows and student achievement and behavior and attitude
# Appendix B

## Review of Research

<table>
<thead>
<tr>
<th>Name of Researcher(s):</th>
<th>____________________________________________________________</th>
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<tbody>
<tr>
<td>Title of Document:</td>
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<tr>
<td></td>
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<tr>
<td>Research Questions:</td>
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<td>Methodology:</td>
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<tr>
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<td>Variables Addressed in the Study:</td>
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<td>Classroom Structure</td>
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<td>Noise</td>
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Findings:  


## APPENDIX C

### MEASUREMENT OF DEPENDENT VARIABLES

<table>
<thead>
<tr>
<th>RESEARCHER</th>
<th>ACHIEVEMENT</th>
<th>BEHAVIOR</th>
<th>ATTITUDE</th>
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<tr>
<td>Al-Enezi</td>
<td>High school exam mean scores</td>
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<td>Standardized test scores</td>
<td>Attendance and discipline</td>
<td>Perceptions of self and others</td>
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<td>Delphi Technique and Concept Mapping</td>
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<td>Graduation rates, behavior and discipline, vandalism, attendance</td>
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<td>Missouri School Improvement Plan</td>
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# APPENDIX D

Notes for Educators and Architects

<table>
<thead>
<tr>
<th>Author</th>
<th>Summary</th>
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<tbody>
<tr>
<td>Al-Enezi</td>
<td>Classroom structure and adverse building conditions are related to student academic achievement in gender based schools in Kuwait.</td>
</tr>
<tr>
<td>Anderson</td>
<td>Georgia schools that had well designed building features typically had better student academic performance.</td>
</tr>
<tr>
<td>Ayers</td>
<td>Design variables of school buildings amongst Georgia high schools had a significant relationship to student academic achievement.</td>
</tr>
<tr>
<td>Battles</td>
<td>Students exposed to full spectrum lighting have less incidences of off task behavior. Student academic achievement is affected by the exposure to fluorescent lighting.</td>
</tr>
<tr>
<td>Bosch</td>
<td>Identified research priorities to gauge future research on the effects of physical variables on student outcomes.</td>
</tr>
<tr>
<td>Brannon</td>
<td>There is a correlation between school leadership and school building conditions. Schools of age need money for capital improvements, renovation, and general upkeep. Schools need to be properly maintained over time.</td>
</tr>
<tr>
<td>Broome</td>
<td>There are no relationships established between design features of schools in Mississippi and Tennessee and student academic achievement and student behavior.</td>
</tr>
<tr>
<td>Bullock</td>
<td>Students academically perform better in newer or recently renovated schools. Building age, windows in the instructional area, and overall building condition are positively correlated with student academic achievement.</td>
</tr>
<tr>
<td>Cervantes</td>
<td>The building conditions of classroom space, equipment, aesthetics, common areas for socialization, and parking are associated with student academic achievement.</td>
</tr>
<tr>
<td>Author</td>
<td>Statement</td>
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<tr>
<td>Crook</td>
<td>Student academic achievement is higher in reading and writing in schools that have standard building conditions compared to schools that are in substandard condition.</td>
</tr>
<tr>
<td>Dorgan</td>
<td>There was no statistical relationship between schools that were renovated compared to schools that were not renovated and student achievement.</td>
</tr>
<tr>
<td>Earthman</td>
<td>School building conditions have an effect of how students feel about their school.</td>
</tr>
<tr>
<td></td>
<td>Students in standard and satisfactory schools had more positive feelings about their school building compared to students in substandard or unsatisfactory school buildings.</td>
</tr>
<tr>
<td></td>
<td>Student attitudes affect student achievement as students in standard or satisfactory school buildings academically perform better than students in substandard or unsatisfactory school buildings.</td>
</tr>
<tr>
<td>Edwards</td>
<td>Academic achievement, motivation, and personal conduct is affected by adverse building conditions.</td>
</tr>
<tr>
<td></td>
<td>The condition of the educational facility is related to the value the school district places upon student safety and education.</td>
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<tr>
<td>Fuselier</td>
<td>Thermal factors influenced student achievement for students in math when this variable is considered with the environmental condition for students.</td>
</tr>
<tr>
<td>Geier</td>
<td>There is an indirect correlation between school building condition and student achievement.</td>
</tr>
<tr>
<td></td>
<td>Urban schools in Michigan had a higher instance of inadequate school building condition compared to rural schools.</td>
</tr>
<tr>
<td>Gentry</td>
<td>School size may not always affect student achievement but the resources available in larger school compared to smaller schools, such technology or the types of classes offered might.</td>
</tr>
<tr>
<td>Gravelle</td>
<td>Student achievement was not impacted by structural building condition.</td>
</tr>
<tr>
<td>Author</td>
<td>Statement</td>
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<td>------------------------</td>
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</tr>
<tr>
<td>Guy</td>
<td>Per pupil expenditure and larger school districts have an affect on student achievement. Students in schools that have standard building conditions academically perform better than students in substandard building conditions. There is a strong relationship between student achievement in language arts in standard school buildings compared to substandard school buildings.</td>
</tr>
<tr>
<td>Haines, et al</td>
<td>Children exposed to chronic noise experience increased levels of annoyance and diminished quality of life. More research should be conducted on the long term affects of adverse noise exposure to children and the impact on student achievement and student behavior.</td>
</tr>
<tr>
<td>Heschong (99)</td>
<td>Day lighting and sky lighting have a direct impact on student achievement. There is a valid predictable affect of day light on student performance.</td>
</tr>
<tr>
<td>Heschong (03)</td>
<td>The visual and acoustic environment is very important for learning. Poor ventilation and indoor air quality negatively affect student achievement.</td>
</tr>
<tr>
<td>Hickman</td>
<td>Transitioning to new schools from old schools decreases student suspension rates and expulsions, improves attendance rates amongst teachers and students, improves staff and student pride and morale, and has an impact on student behavior at the newer facility.</td>
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<tr>
<td>Hughes</td>
<td>The design variables have a direct relationship with reading performance and student achievement when associated with wall color.</td>
</tr>
<tr>
<td>Kilpatrick</td>
<td>Students had better perceptions and attitudes in newer schools compared to older ones. Older schools identify some negative influences such as smaller classroom space, lack of external space, limited areas for teachers, and smaller work areas compared to newer and more modern schools.</td>
</tr>
</tbody>
</table>
Lair Building age, maintenance, school size, cleanliness and structural and cosmetics of schools have an influence on student achievement. Students made academic improvements in older schools.

Lang Most teachers expressed that the size of their classroom and the spatial layout of their classroom was very important to instruction and their morale and attitude.

Lanham Adequate air quality control, mopping, cleanliness and general maintenance have a direct impact on student achievement in elementary school students.

Leung and Fung Most of the improved facilities management components have a correlation to student learning in newer schools. There needs to be further discussion with architects and designers in regards to spatial layouts of schools and the consideration of teaching tools for today’s primary school children.

Lewis Adverse facility conditions have an impact on math student achievement. Students had higher student achievement in standard schools compared to substandard schools.

Maniloff School size had a negative effect on teacher’s perceptions of their working condition. Decreased high school size did not produce a more meaningful work environment for teachers.

Maxwell Students that were in school buildings during renovation and construction may experience a decrease in student academic achievement.

Moses Classroom acoustics and the effect on speech discrimination ability and speech perception were critical components of early literacy and student academic achievement.

Narucki Students performed better in math and language arts in standard school buildings compared to substandard school buildings.
<table>
<thead>
<tr>
<th>Author</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osborne</td>
<td>Thermal comfort level was a key predictor in determining math achievement among students in elementary schools.</td>
</tr>
<tr>
<td>O’ Sullivan</td>
<td>Identified a positive relationship between schools that were renovated and improved student achievement compared to schools that were not renovated.</td>
</tr>
<tr>
<td>Ott</td>
<td>School administrators should be sensitive to the needs of teachers during school renovation.</td>
</tr>
<tr>
<td>Perez, et al</td>
<td>Poor classroom temperature had a significant impact on student attentiveness, which in return had an effect on student test performance.</td>
</tr>
<tr>
<td>Rosenberg</td>
<td>Students in amplified classrooms demonstrated significant improvement in listening and learning behaviors and progressed faster than their peers in non-amplified classrooms.</td>
</tr>
<tr>
<td>Ruszala</td>
<td>Practitioners should consider paint color when painting a new or existing buildings.</td>
</tr>
<tr>
<td>Samuels</td>
<td>The more daylight and daylight simulating artificial light that can be provided the better the student attentiveness, mood, behavior, health and student achievement is.</td>
</tr>
</tbody>
</table>
Shendell, et al  
Student attendance was found to be better and correlated to improved ventilation in student classrooms.

Smedje-Norback  
Installation of new ventilation systems increases the air exchange rate and reduces student exposure to pollutants, which in return reduces adverse health conditions of students such as asthma.

Stapleton  
Educational leaders and facility planners should not anticipate that school climate will necessarily improve with new building construction.

Stevenson  
Student achievement was adversely effected by the poor physical condition of the schools, overcrowding, lack of storage space, and laboratory space.

Swift  
Schools that had more than 100 square foot per student or more had a significant impact on student achievement.

Syverson  
Student achievement was higher in standard school buildings compared to substandard school buildings.

Thornton  
Student achievement was not effected by building condition amongst economically disadvantaged children in substandard school buildings.

There is a positive relationship between minority students and performance in standard schools compared to substandard schools.

Vilatarsana  
Environmental noise is associated with lower cognitive performance and reading capacity of children.

There is a strong relationship between noise and student achievement.

Wargocki, et al  
Reduced temperatures in the summer and increased outdoor air supply rates in elementary schools had a positive effect on the school work of elementary school children.

Wei  
Designers should pay careful consideration to classroom design and daylight, reflecting properties of interior surfaces, window size and placement during new construction.

Wicks  
Student grade point averages may not be significant in transitioning.
Staff attitude and perceptions were negative upon transitioning from an old school to new school, while student attitudes and perceptions showed a positive impact in newer schools.

**Williamson**

School size had an impact on student self esteem and attitude. As the size of the school increased, self esteem and attitude increased.

Student achievement tended to decrease in larger school buildings compared to smaller school buildings.

**Yarborough**

Design factors such as day lighting and views, color schemes, location, instructional neighborhoods, outside learning areas, and instructional laboratories impact learning and student achievement.
APPENDIX E

Permission to Use Linda Lemasters Meta-Matrix, Charts and Tables from 1997 Study

August 10, 2009

John:

You have my permission to use the necessary documents from my 1997 study to accomplish what is most beneficial to your analysis.

I appreciate your interest in this topic, as further research is necessary, especially a recent analysis. The preponderance of the research continues to indicate that the places where students learn are of the upmost importance.

I wish you the best with your research.

Sincerely,

Linda Lemasters, EdD
Associate Professor
The George Washington University