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The learning space: a study of the suggested principles and practices in designing the classroom environment

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THE LEARNING SPACE: A STUDY OF THE SUGGESTED PRINCIPLES AND PRACTICES IN DESIGNING THE CLASSROOM ENVIRONMENT

by
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ABSTRACT

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This study investigated learning space design and its suggested affect upon the learning process. The study also evaluated and compared existing classrooms in the southern New Jersey area by looking for the presence or absence of certain elements of design. Data were collected by reviewing previous research on the topic of classroom design and student achievement, and in field testing at eight educational facilities in southern New Jersey. Research has shown that the design of learning spaces has a direct influence upon students' attitudes towards learning and positive outcomes are attributed to these designs. Field testing, using a sound level meter and a lux meter, measured frequencies and light levels and evaluated the percentages of loss or gain, confirming some findings regarding students' abilities to properly hear and comprehend spoken material and to properly see visual images and text displayed at the front of the room. Other testing and research revealed that certain other elements in classroom design should be incorporated into the overall design and construction of educational facilities.

ABSTRACTETTE

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This study investigated learning space design using previous research in acoustics and its effects upon student achievement. It also investigated, evaluated and compared existing classrooms in the southern New Jersey for elements of classroom design, in addition to acoustics, that are thought to have an impact on the learning process.

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This work is dedicated to my wife, Marianne, and sons, Ted and Dan, who have been my inspiration and have supported me during these years of study. Despite missing events in their lives, they have unselfishly cheered me on to finish what we all agree is a noble and worthwhile endeavor. They have made my absence seem worth it.

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CHAPTER ONE

INTRODUCTION

New schools are being built to meet the demand for an ever-increasing population of students in the United States. Certain design elements, incorporated into the arrangement of the classrooms of these new schools are thought to promote student learning and achievement. Researchers, designers, architects, facilities planners, school administrators, and business executives are finding that the classroom environment plays an important role in academic achievement. It has been demonstrated that color, size and shape of classrooms, flexibility, lighting, furniture type and arrangement, window treatments, security, temperature, technology and acoustics, can effect academic achievement.

Statement of the Problem

Classroom construction has been going on for many years, but little concern was paid to document or codify what elements should be included to help promote the learning process. Most of today's school construction focuses on safety or construction code enforcement, as well as compliance with the *Americans with Disabilities Act*, (ADA). Possibly due to funding ties to state and federal bureaus, school districts and architects are keenly aware of these issues, but less aware of links between architectural designs and the learning process related to academic achievement. Previous research has suggested that, in designing the physical classroom environment, four elements must be taken into account; anthropometry, ergonomics, proxemics, and synaesthetics (Hiemstra & Sisco, 1990).

In designing a successful learning space, designers must look to accommodating a variety of learners in an unseen environment of social, cultural, and psychological situations and factors that the physical features of a room may affect. Satisfying learners of all sizes and shapes is what anthropometry is concerned with. Seating that is comfortable, secure, free of extraneous noise, and properly sized for proper posture will help to reduce fatigue and improve a student's listening and comprehension. Also, furniture that is easily configured for large or small group learning and large enough for writing and, in today's environment, for holding a laptop computer, is an optimal design approach.

In designing a space that adds to personal comforts, either with particular items within the room, or the room itself, ergonomics is this area of concern. This can extend to the size of the space. A room that is too small can affect performance. A room that is too large can leave a student feeling lost or insignificant, not to mention being less able to properly hear and/or see the lecture. Rooms must be designed with the type of class in mind, or vice versa, the class must be scheduled in the proper sized room to avoid these pitfalls. The shape of a room can also have a detrimental effect on teaching, as well as learning. Some teachers work best in a discussion or interactive-type of setting. In this case a smaller, square shaped learning space may work best, whereas a long, narrow, auditorium or lecture hall, where students are further away, would not.

By learning how people relate to a space, including their personal space, the designer can encourage or discourage student participation in learning. In a sociopetal setting, where learners engage in interaction with other learners, the space is oriented towards learners facing other learners. This enables discourse and conversation, thereby stimulating the learning process. Study in this area of design, called proxemics, designers can utilize the inherent advantages of social interaction to gain desirable educational outcomes. Furniture arranged in a circular or square fashion can help facilitate this interaction. Caution, however, must be taken as some cultures or, at some times, some learners may not want to interact and the furniture arrangement must be flexible enough so that it can be rearranged as needed. For individualized study, a sociofugal setting may be desirable. This setting, where furniture is arranged in rows and sometime bolted to the floor as in an auditorium or lecture hall, can minimize eye contact, encourage status distinctions, and provide for territorial security. While this can be good for lecture type instruction it is not considered a positive learning environment for student-centered other instructional delivery where student interaction is encouraged.

The way that the physical environment affects human senses is studied in the synaesthetics area of design. Certain colors can have an effect on a person's mood and can present a pleasing environment. Studies have found that cool colors such as blues, greens and grays can project an atmosphere of coldness, and can result in more passive learning. The opposite can be found in the warmer, pastel colors, like reds and yellows, where the learner can gain a warming and advancing sense of well-being. Room temperature can effect concentration and attention span. A room, either too cool or too warm, can be unfavorable for learning. Humidity, and the sun's radiation through a window, can also affect the learning space in either a positive or negative way. Lighting can either be enhancing or distracting and poor lighting can also affect one's sense of security or personal safety. Studies have suggested that natural sunlight can have a positive affect on learning and health in the way that it accentuates color, texture and the room's ambiance. Other studies counter with the claim that artificial lighting can be better controlled, thereby reducing visual distractions or eye fatigue. Negative olfactory sensory conditions can have an affect on learning in both positive and negative ways. The smell of brewing coffee or cooking in the cafeteria can produce feelings of warmth and security, but can also be distracting. A classroom close to a lavatory or an outside door where there are people smoking can cause distress among some learners. Other design criteria can influence learning in the classroom. Noise can have a negative impact on a person's well-being and concentration levels. A major concern is the ability of students who sit farthest from the teacher, to adequately hear the lecture. A study by the University of Florida suggests that as much as 50% of information is missed by students who sit farther back than the first two rows in a classroom (Waldecker, 2005). Possible solutions include voice amplification and/or acoustical treatments in the walls, floors, and ceiling of the classroom. The former increases the volume level of the voice but can also accentuate the poor acoustics in a room and can add to the unintelligibility of the speaker. The latter can help to reduce reverberation times, (RT), which, at high levels, can greatly add to unintelligibility.

Purpose of the Study

The purpose of this study was to look at design elements that make a learning space successful in helping to enhance the learning process. It looked at the benefits of each design feature and the possible impact upon student successes in the classroom. The study was conducted to determine ways to improve the design to help avoid common problems in constructing or rehabilitating the classroom environment. With this in mind, the study looked at 14 existing classrooms, in eight educational facilities in the southern New Jersey area, to determine what design elements were present in these classrooms and how they compared to each other. The reasoning behind these comparisons was to evaluate classroom design and construction from different eras and socioeconomic levels to determine commonality or differences in the designs.

Significance of the Study

This study examined design elements that contribute to the creation of a successful learning space. It also looked at the benefits students gain from working in a well-designed classroom. The study looked at various learning spaces to determine those common elements that distinguished properly designed spaces from those that were not and compared various classrooms looking at, or for, the presence of these elements. The outcome of the study may help individuals who are involved in the planning of classroom renovation or revitalization as well as those designing new classroom spaces. It is significant because of the continuing impact on the quality of education and the need for increased student academic achievement in a competitive world economy. Properly designed learning spaces can contribute to the successes in this endeavor.

Assumptions and Limitations

This study was conducted without human subjects looking only at the classroom space and the design elements inherent in classrooms. Attempts were made to be accurate in the observations and truthful in presenting the results. The scope of this study was limited to the currently available research on classroom design and learning achievement and field testing at eight facilities located in the southern New Jersey area. Also, testing was done with as much of a scientific and unbiased approach as possible, given the limited time, funds, and equipment that was made available at the time.

Operational Definitions

1. Achievement: Student academic accomplishment measured as successes in the classroom.
2. Anthropometry: "…the study of various human dimensions important in the design of furnishings and equipment that will be used in some space" (Murrell, 1965).
3. dB (decibel): A unit used to express relative difference in power or intensity, usually between two acoustic or electric signals, equal to ten times the common logarithm of the ratio of the two levels.
   decibel.(n.d.) The American Heritage Dictionary of the English Language, Fourth Edition. Retrieved February 24, 2007, from Dictionary.com website: http://dictionary.reference.com/browse/decibel
4. District Factor Grouping (DFG): From The New Jersey Department of Education as a way to rank school districts in New Jersey by their socioeconomic status. The D.F.G. is a composite statistical index created using income, occupation, and education as an indirect measurement of socioeconomic status. The range of the D.F.G. is from A-J, or from low to high, socioeconomic status. Retrieved March

7, 2007, from the NJDOE website:

http://www.state.nj.us/njded/finance/sf/dfg.shtml

5. Ergonomics: "…used in reference to human factor engineering and is related to the design of spaces and things within those spaces" (Bennett, 1977). "The comfort of those who occupy a space or use a particular piece of equipment is what is involved here" (Vosko & Hiemstra, 1988).
6. Foot candle: "a unit of illuminance on a surface that is everywhere one foot from a uniform point source of light of one candle and equal to one lumen per square foot" (http://www.merriam-webster.com, 2007)
7. Hard Architectural Spaces: Sociofugal setting. Rooms with anchored seating that do not encourage social interaction or mobility. (Vosko & Hiemstra, 1988).
8. Learning Environment: "…an optimal environment in which adult learners can thrive and the instructional process can be made most successful" (Vosko & Hiemstra, 1988).
9. Learning Space: Any physical environment in which learning takes place.
10. Learning Space Design: The design of classroom environments incorporating physical elements that are contribute to academic achievement.
11. Lux: "a unit of illumination equal to the direct illumination on a surface that is everywhere one meter from a uniform point source of one candle intensity or equal to one lumen per square meter" (http://www.merriam-webster.com, 2007)
12. Proxemics: "…interrelated observations and theories of [people's] use of space as a specialized elaboration of culture" (Hall, 1966). "The study of the nature, degree, and effect of the spatial separation individuals naturally maintain (as in

various social and interpersonal situations) and of how this separation relates to environmental and cultural factors" (http://www.merriam-webster.com, 2007)

13. Sociofugal: One of two distinct settings in how people define boundaries in a space that they occupy. Sociofugal discourages social interaction. Seating is arranged is rows and attention is directed to the front of the room for lecturing (Hall, 1966, 1974; Sommer, 1969).
14. Sociopetal: One of two distinct settings in how people define boundaries in a space that they occupy. Sociopetal encourages social interaction. Seating is oriented towards a central point, usually towards others, "such that interaction and conversation is facilitated" (Hall, 1966, 1974; Sommer, 1969).
15. Soft architectural spaces: Sociopetal setting. Rooms with flexible seating that can be moved around. (Vosko & Hiemstra, 1988).
16. SPL: Sound Pressure Level: the physical intensity of sound (http://dictionary.reference.com/search?q=Sound%20Pressure%20Level , 2006)
17. Synaesthetics: "...how the physical environment is perceived in a polysensory manner and how such perceptions affect learning" (Andrews & Giordano, 1980; Marks, 1975; Merleau-Ponty, 1962).
18. .wav file: WAV (or WAVE), short for Waveform audio format, is a standard for storing audio on PCs. The most common WAV format contains uncompressed audio in the pulse-code modulation (PCM) format. PCM audio is the standard audio file format for audio CDs. (http://en.wikipedia.org/wiki/Wav, 2007)

The Nature of the Study

Two studies were presented that examined external classroom noise and the implications on the academic achievement of the students in those classrooms. They took place in New York City and Los Angeles and testing in reading comprehension was conducted to determine if noise levels from elevated trains and freeways accounted for changes in the reading scores of affected students as compared to unaffected students. A third study, conducted by this author, looked at the internal physical characteristics of 14 classrooms in eight facilities in the southern New Jersey area. Testing was done on the acoustic and lighting levels and other physical factors inherent in these classrooms, and the results were noted and recorded in a spreadsheet. Comparisons were then made of the results of each classroom and a ranking system was devised to determine the quantity and quality of the design elements present. Addressed are the population and sample selection, the instrumentation, the methods of data collection as well as data analysis.

Research Questions

The study addressed the following research questions:

1. As postulated by the previous research referenced in this study, is there a relationship between learning space design and student achievement?
2. What are the design elements inherent in learning space design that can enhance learning? How do they compare to existing classrooms in use today?

Overview of the Report

Chapter two provides a review of existing research literature pertinent to the study. It looks at the history of classroom/learning space design, the changes over time, and looks at the current as well as the future trends and design characteristics of the learning space. It also looks at previous studies concerning academic achievement related to general classroom design and identification of the design elements that are thought to promote academic achievement. It concludes with a brief summary of literature review.

Chapter three presents the research methodology and testing procedures. A description is given of the context of the study, the population and sample, the instrumentation, data collection procedures, and how the data were analyzed.

Chapter four displays the finding and results of the study. The focus is on answering the questions in the introduction of the study. Narrative and statistical analysis are used to present the data in this section.

Chapter five presents a summary of the findings of the study and includes suggestions and recommendations for implementation. It also includes areas in which further study and research is needed.

CHAPTER TWO

REVIEW OF LITERATURE

Brief History of Learning Space Design

The design of today's learning spaces can be traced to public schools built between 1930 and 1950. They were modeled on the Quincy School in Boston, Massachusetts which was built around 1850. Educational planning and design followed the Quincy pattern for the next 100 years. As the population expanded after World War II, suburban areas needed new schools built. Educational philosophies and facilities design then began to change (Rydeen, 2002).

Today's schools are receiving billions of dollars for new construction and expansion of existing buildings. Designs should reflect new goals, such as technology integration and student achievement, but the schools are still being built as they were 200 years ago, as "passive spaces, a little red schoolhouse" (Taylor as cited in Kennedy, 1999).

In the 1960s and 1970s, in an effort to make schools more energy efficient, lower maintenance costs, increase security, and reduce outside noise, the design trend moved towards reducing the number of windows in buildings. This also reduced the amount of daylight exposure students were afforded (Kennedy, 2002). Studies have shown that daylighting makes colors more vibrant and natural and promotes learning by improving students' attention spans. They have also shown that people work more quickly and with more accuracy under better quality of lighting (Kennedy, 1999). These past designs are being proven inadequate for the needs of today's learners. Careful consideration of all of these design elements is crucial and should be an integral part of the overall architectural design if student academic achievement is to advance.

Current Design Trends

Current thought on the design of learning spaces focuses on a holistic approach looking at the many areas that can affect the learning process (Waldecker, 2005). In a study in Washington, D.C., researchers found that in schools with poor facilities, achievement scores were lower (Edwards, 1991). Another study in Virginia found that students in large, urban high schools scored lower in substandard buildings than those students in better designed buildings (Kennedy, 2002). As part of this holistic approach, natural light is thought to play an important role in the learning process and is being looked at more closely in designing classrooms. Current lesson planning, as well as student presentation, are relying more and more upon the use of multimedia and this is where audio and video quality and the ability to control adverse noise and to properly control lighting levels becomes important. Student-centered learning, group instruction and student presentations are becoming more prominent in the learning process and in this area it is even more important to provide proper lighting and acoustical treatments. Students generally do not achieve the same loudness level of speaking voice that teachers generally have, therefore it is important to provide the design elements necessary for the rest of the class to adequately hear the students' presentations.

Elements in Design That Promote Achievement

Anthropometry is an area that studies human dimensions and is considered important in designing equipment and furnishings for use in learning spaces. Poorly designed seating can have an adverse effect on comfort, leading to difficulties in attention and comprehension. Also, as a classroom becomes more flexible in its use pattern, furniture must be light enough to be easily moved around (Hiemstra & Sisco, 1990). It is also thought that physical comfort in the classroom can lead to emotional comfort in the learning process and can elevate student achievement. Research on emotions has shown that students experience a variety of emotions in academic settings and that these are related to student motivation, learning strategies, cognitive resources, self-regulation, and academic achievement (Jarvenoja & Jarvela, 2005). Rydeen (2003) found that facility design can enhance or inhibit teaching and learning. The classroom has to create a sense of space, community, presence, comfort, security, aesthetics, performance, and privacy. Studies have found that the design of wider hallways, especially in high schools, leads to less congestion and fewer student altercations. Also, curved hallways eliminate corners and nooks where students can hide improper activities and staff members can more easily monitor who enters the building and see the parking lot if the administrative offices are at the front entrance (Kennedy, 2002). Another reason for additional security is that more schools are being used as community environments. This situation will allow for members of the public to freely enter school buildings with security becoming even more of a concern. Some schools can cordon off sections of the building that will be off-limits to the community at large, but some will have to deal with this added sense of concern.

Unless students and teachers feel safe in a school, they will not be able to focus on learning or realize their full potential. Moreover, designers are looking at ergonomics in spatial design, which emphasizes people-oriented design in behavioral terms (Rydeen, 2003). Hiemstra and Sisco (1990) stated that the learning space can run the gamut of being too small and cramped, to where it hinders performance, or too large causing the student to feel lost and insignificant. In addition to size, the shape of the learning space can become a factor, to where it can work in one setting, but not in another.

There is a current emphasis on learning styles that include: independent student work, small group sessions, large group discussion, teacher-directed instruction, as well as lectures (Chambers, 2004). According to Hiemstra and Sisco (1990), the study of proxemics deals with how people use these spaces and includes factors such as: posture, body orientation, gestures, eye behavior, olfaction, thermal code, and seeking or avoiding touch. When students can arrange furniture in a group setting, they create distinct bounds where distance between their classmates is set to their own personal comfort levels. This establishes their personal space in the classroom and their individual comfort zone. The sociopetal setting orients learners towards a central focal point, which is towards each other and helps to establish interaction and conversation with their classmates. Conversely, in a sociofugal setting, where seating is arranged in rows facing the instructor, classmate interaction is not only discouraged, but just about impossible if the seating is bolted to the floor. Comfort level and emotional well-being, therefore, can vary among students in learning spaces, and can have varying degrees of impact on academic achievement based on this one factor alone.

Synaesthetics, or the way a room can affect the human senses, is another factor in the design of the learning space, which has an affect on learning and achievement. Colors, room temperature, lighting, and noise can affect the student's mood, comfort and emotional well-being (Hiemstra & Sisco, 1990). The sense of aesthetics humanizes space and stimulates learning, studying, and socializing experiences among students. It involves design of appropriate scale and proportion, symmetry and asymmetry, light and shadow, pattern and texture, and color and furnishings.

A 1999 study by the Heschong Mahone Group found that students performed better in classrooms that had more natural lighting. The reasons, while not entirely clear, may have to do with improved visibility and light quality, increased health benefits, and elevated mood and behavior, which lead to students working faster, more accurately, and with greater attention spans. Other research has shown that children in natural lighting environments scored better on standardized tests in reading and math (Waldecker, 2005). Still, other studies have found that control of lighting sources is equally important. Natural sunlight, without adequate shading, can also have a negative effect on students and scholastic achievement in the way of glare, unwanted reflections, increased body temperature, eye strain, fatigue, and decreased attention span. According to the National Clearinghouse for Education Facilities, (NCEF), there is a direct link between academic achievement and quality illumination in the classroom. Seven independent studies have shown that lighting in the learning space affects academic achievement (McCreery & Hill, 2005).

The use of the space is also an important consideration in lighting design. Elementary school classrooms with a small number of computers may have good results with a standard fluorescent fixture with a prismatic reflector, but where there are many computers, the use of parabolic reflectors can help prevent unwanted glare. One appealing option for lighting is found in the cove-style design. While not an easy or inexpensive retrofit it provides an attractive look and makes the room appear brighter and does not rely on direct lighting upon the desktop (McCreery & Hill, 2005).

Hearing and Understanding the Lecture

Perhaps the most important design element of the physical learning environment is acoustics. Research from the University of Florida suggests that as much as 50% of information is missed by students who sit farther back than the first two rows in a classroom (Waldecker, 2005). The ability to properly hear the instructor, and the degree of the speech intelligibility rating, can have a dramatic effect on learning. Many classrooms in the United States have a speech intelligibility rating of 75 or lower. This means that listeners with normal hearing can understand only 75% of the words read from a list, or, looking at it another way, miss every forth word of instruction. These students, along with students with learning disabilities, those with auditory processing problems, and those for whom English is a second language, can benefit by an increase in the intelligibility rating. Also, young children, who are unable to "predict from context" will gain from an increase in the quality of the acoustics in the classroom. With their limited vocabulary and experience, they are less able, than older children, to fill in any of the missing words or thoughts of the instructor if they are not heard clearly (Seep, Glosemeyer, Hulce, Linn, & Aytar, 2000). Older children and adults, hearing what came before and after the missing word or words, can predict what that word may be by the clues given by the words that they heard.

It is thought that children do not perform at high levels in a noisy environment, compared to adults (Soli and Sullivan, 1997). Elliott (1979), found that in a study that looked at 9-17 year olds, a descending scale of performers emerged with the older children scoring highest, followed by the 15 year old group, followed by the 11 year old group, followed by the youngest group. There is also compelling research by Litovsky (1997), who studied the precedence effect in children and adults. This anomaly relates to the ability of adults to perceive sound as a single unified sound in rooms that have a high RT value and more easily ignore the echoes that interfere with the sound of speech. Children are not born with this ability and it does not appear until well into childhood. While able to locate single sounds as well as adults, children are less able to suppress echo information and confuse these echoes as independent sounds, making reverberant rooms a barrier to their understanding of speech. All of these studies demonstrate that children have a hard time hearing and understanding speech in either a reverberant or a noisy room.

Even low levels of background noise can have a dramatic effect on the learning process and comprehension. Examples can include noise from the air handlers, blowers or fans, of a Heating, Ventilation, and Air Conditioning (HVAC) system, outside sound sources, or even a lecture from another classroom. As the noise level increases, teachers and students tend to speak louder to try to compensate which can ultimately lead to unruly behavior and an interruption in concentration for themselves and other students (Waldecker, 2005). Reverberation is an audio anomaly, inherent in many classrooms, that leads to this lower intelligibility rating. Sound moves in an endless number of circular rounds, as when a stone is thrown into smooth water. But, while in water, the circles move horizontally on a plane surface, voice travels in both horizontal and vertical directions by regular stages (Vitruvius, first century B.C.). Since this is the case with audio, all surfaces of a room are in play that will affect the sound of the spoken voice. In reverberation, the material of the walls, windows, doors, ceiling, cabinetry and floor are important in determining how quickly the sound decays in a room. Reverberation Time (RT) depends on these factors. Studies have shown that the ideal time for RT is 0.4 – 0.6 seconds (A.S.A. Classroom Acoustics Booklet, 2006). Longer RT times will decrease the amount of the intelligibility rating as well as comprehension and learning. According to Nabelek and Nabelek (1985), "Speech produced in one place in a room should be clear and intelligible everywhere in the room". There are two ways to effectively reduce the amount of RT in a classroom. The first is to decrease the volume, in this case meaning the physical size of a room, and the second is to increase the amount of sound absorbing materials in the room. Installing carpeting, acoustical ceiling tiles, or insulating wall panels can address the latter. The best design for a lecture style classroom would be to utilize acoustic ceiling tile on all of the ceiling area except for the area located directly above the instructor. This area would use a hard ceiling tile panel which could be angled towards the back of the room. This would allow the sound to be reflected off of the hard surface and towards the back of the room, allowing for an increase in the sound level and a greater intelligibility rating (Seep et al., 2000). Of course, adding hard ceiling tiles to a room which already has a higher than ideal RT level, will only add to that level and could make for a room that has a lower intelligibility rating. Care should be taken not to make a bad situation worse.

Heating, Ventilation and Air Conditioning systems contribute to an enormous amount of noise in a classroom. This can occur through moving air noise that occurs in the HVAC duct system or in the classroom window unit's blower, or though ambient noise from another location that is transmitted through the duct work system into adjacent rooms. Students, in such a room, have to struggle to hear or else become distracted and stop paying attention. This mechanical noise can be easily fixed in the design stage, but is expensive to correct once the building is constructed. Larger duct work for lower air velocities, longer duct runs to increase the distance from the air handlers, low sound-level air handlers, and locating mechanical equipment away from critical listening spaces is a good design for minimizing noise levels (Seep et al., 2000).

Another phenomenon that should be considered is the issue of ear fatigue. While it may not be clinically recognized or studied as part of the learning process, it is nonetheless prevalent among audio engineers who spend hours on end listening to music. Some engineers report that after listening to music for a long time, their ears get tired to a point where they no longer hear all of the frequencies. It is especially troublesome when listening to audio at high levels of dB. Today, there is an iPod generation that may stay connected to a music source for possibly inordinate lengths of time. Students may come into class while, or directly after, listening to loud music. Also, since the audio is digital in nature, it is most likely compressed so much that the music is left without much of the dynamic range left intact. This means that the sounds are left at a similar volume level throughout most of the time the music is playing. The effects of this similar level of sound for long periods of time without a break can increase the occurrence of ear fatigue. Could ear fatigue play a role in the learning process as well? Are students, consciously or unconsciously, tuning out the teacher? Very little research is available on this topic, however, especially where it relates to the learning process. It could be that since the iPod and devices like it are new technology in our culture, and the issue of ear fatigue among the student population is a new phenomenon, that the research is scarce.

Proper door layout paths are another design feature that can be employed to minimize unwanted noise. Solid doors with tight fitting sealed frames are best at locations that are not directly across from one another, or next to one another. This is another way to decrease noise levels from adjacent classrooms. The location of the building itself is a concern where external noise sources could disrupt learning. Aircraft flyovers, busy roads, playgrounds, ball fields, exterior mechanical equipment and other noisy machinery, even idling school buses can pose a threat to concentration (Seep et al., 2000).

Summary of the Literature Review

Holistic design of learning spaces is needed as new schools are built in the United States. Bricks and mortar, writing boards, and furniture alone, are not the only elements that should be addressed in the design phase. It is evident that research has been done to determine optimal learning space elements and it is the result of this type of research that should be included in the design. At issue is to how to make sure that these are included and codified in the design process and beyond, into the construction phase. As school districts struggle with obtaining funding for new building projects, greater care should be taken to avoid flaws in the design that may be more expensive to correct in the future, than if it was done correctly in the initial phases on design.

Studies have shown that there are benefits to including proper lighting, security, flexibility, noise reduction and other human factor engineering design elements. These studies point out that there are clear benefits to student academic achievement in integrating these elements into the classroom. The studies previously referenced in this work are specific in detailing the effects of failure in the acoustical design of learning spaces and the resultant levels in academic achievement directly related to this.

More research is needed to determine if any or all of these elements are being included into new school design. At this point in time it may be beneficial to standardize these elements; much like the American Disabilities Act, (ADA), requirements or building codes are standardized, in order to provide a blueprint to success in learning space design. It is especially important in a time of budget concerns to address these in the design phase. The alternative is to make corrections in the far more costly construction phase.

CHAPTER THREE

METHODOLOGY

This chapter is comprised of sections describing the methodology, context, and design of the study. It also includes the population and sample selection of two previous research studies, one in New York City and one in Los Angeles, and the evaluation and instrumentation used in those studies. These two studies were included here to support the idea of the importance of a properly designed physical learning space that can possibly enhance student learning and achievement. The inability of some of the students in these studies, especially those on the noisy side of the building, to properly hear the teacher was thought to decrease the level of achievement in reading scores. An evaluation and description of the instrumentation used in an on-site inspection and measurement of fourteen classrooms in eight educational facilities in New Jersey is also included here. Data were collected and analyzed and the specific results of the New Jersey collection of data is presented in spreadsheet form in Chapter 4, as Table 4.1, pages 1-4.

Utilizing the design and results of the two previous research studies and the New Jersey study's field inspections, an attempt was made to answer the following questions:

1. As postulated by the previous research referenced in this study, is there a relationship between learning space design and student achievement?
2. What are the design elements inherent in learning space design that can enhance learning? How do they compare to existing classrooms in use today?

Context of the Study

The two previous acoustic studies referenced here were documented in the 17th Meeting of the International Commission for Acoustics, Rome, Italy, Sept. 2-7, 2001. *The Impact of Classroom Acoustics on Scholastic Achievement* (Sutherland & Lubman, 2001). The first study compared noise levels in Public School 98; an elementary school located in upper Manhattan, NY, and situated approximately 220 feet from an elevated subway train track (Bronzaft & McCarthy, 1975). The second study was undertaken in fourteen schools in Los Angeles, California that were at varying locations and distances from freeways (Lukas, Dupree & Swing, 1981).

In addition, this researcher carried out on-site experimental research in fourteen classrooms in eight educational facilities in the southern New Jersey area. A convenience sampling of the 14 classrooms was used. Two of the high school classrooms examined were in the researcher's home town; two other high school classrooms examined were at a high school across the street from the university; and the remaining four high school classrooms, as well as the five elementary school classrooms, were elicited as a favor of the schools' teachers, who are fellow classmates in a M.A. Educational Technology degree program at Rowan University. The sole university classroom was from this same institution.

The New Jersey study looked at 11 design elements that are considered part of an overall classroom design that is conducive to learning and achievement. Each element was examined, measured, evaluated, rated and then compared to the other learning spaces.

The New Jersey study looked at a cross section of grade levels, from elementary school to university classes. Table 3.1, below, shows the breakdown of grade level.

Table 3.1 (School grade level sampling breakdown)

GRADE LEVEL	University	High School	Elementary School
NUMBER OF CLASSROOMS	1	8	5

The intent was to represent a wide range and variety of school-aged children in those classrooms for comparison among facilities at those age levels to determine how each rated.

It also represented varying economic status levels to determine if the level of income in a district pays any part in the quality of design in facilities in those school districts. The New Jersey Department of Education introduced the District Factor Grouping system (D.F.G.) in 1975 as a way to rank school districts in New Jersey by their socioeconomic status. The D.F.G. is a composite statistical index created using income, occupation, and education as an indirect measurement of socioeconomic status. The range of the D.F.G. is from A-J, or from low to high, socioeconomic status. The classroom samples were from varying District Factor Groups. The D.F.G. factors are presented in the following Table 3.2:

Table 3.2 (District Factor Grouping designation breakdown)

DISTRICT FACTOR GROUPING (A – J)	A	B	CD	DE	FG
NUMBER OF CLASSROOMS	2	4	2	1	4

NOTE: Universities are not part of the DFG rating

Facilities were selected to represent a cross section of classrooms built over a period of time. The oldest was built in 1923 and the latest in 2005. Table 4.2, Column C, lists the dates that the rooms were either originally built or were last renovated.

Each classroom was evaluated and measured in an attempt to rate the physical environment with a newly created "Ideal Learning Environment Composite Factor", (ILECF). Classrooms were evaluated and tested for distinct design elements and rated for their presence and quality. The resultant score was then totaled to determine a rank compared to the ILECF. In addition, varying socioeconomic levels of schools were included to determine if economic differences in the communities accounted for a difference in the ILECF.

Population and Sample Selection

The New York and Los Angeles studies are included here because of the implied link that these studies make between noisy learning spaces and declining academic achievement in reading scores. The target population for the New York study was elementary school students, second to sixth grade. In this study, as a series of three conducted by Bronzaft and McCarthy, the population was described as academically mixed with one bilingual class and one high ability class at each grade level. Reading scores for 161 second, fourth, and sixth-grade students were obtained. The Los Angeles study's target population was also elementary students, in 74 classrooms approximately 19 in each of the "noisy" and "quiet" schools in third and sixth grade classes. The noise in each type of classroom, in this study, differed by as much as 19dB between the noisiest and quietest. The New Jersey on-site field experiments evaluated empty classrooms in the five elementary schools, eight high schools, and one university, in southern New Jersey, looking at design elements and measuring acoustic and lighting levels in the rooms.

Instrumentation

As part of their study looking at noise levels and academic achievement, Bronzaft and McCarthy used sound level meters to measure sound prior to, and while, a subway train was passing. In the Lukas Los Angeles study the same method was used to determine the difference between the noisiest and the quietest classrooms. To check the validity of their initial findings related to the reading scores, the researchers in the New York study reduced the train noise by three to eight dB in the east side classrooms, that were on the track side of the building, as well as the west side classrooms. Further tests were conducted to see if differences in student achievement were in any way changed. If these studies established the link between noise and student achievement, then it would be logical to conclude that the physical space plays an important role in the learning process and that certain elements in that space can make it an enhanced learning environment. The New Jersey experiments utilized field observations and testing of various classroom design elements in empty classrooms, after school hours, or on a Saturday morning. Despite the absence of human subjects, this researcher completed all of the necessary requirements that the Institutional Review Board, (IRB), had requested. An online course, The Human Participants Protection Education for Research Teams, sponsored by the National Institutes of Health, was completed by this researcher on January 25, 2007. In addition, all necessary permissions were granted by either the specific school principals or the school district superintendent. Any information related to students in the school or in the classrooms, gleaned from the evaluations and observations, was agreed to be kept in the strictest of confidence, and used solely for measuring and comparing classroom environments. The instrumentation used for the acoustic study in these rooms was adapted, in part, from the New York and Los Angeles studies previously mentioned and acoustic measurements were made in those rooms using a Radio Shack, Catalog # 33-2055 sound level meter.

Most sound level meters use built-in frequency filters or "weighting networks" in the measurement process. The "A" weighting network discriminates against low-frequency and very high-frequency sounds. "A" weighting approximates the equal-loudness response of the ear at moderate sound levels, in the 500 – 10,000 Hz range. "C" weighting has C-curve (flat) frequency characteristics. The range is from 32 – 10,000 Hz range. (Human hearing is in the range of 20 – 20,000 Hz.). The sound level meter used in the New Jersey experiments was set to Fast Response and "C" weighting. The accuracy of the device is +/- 2 dB at 114 dB SPL.

For measuring the light levels in the classrooms, lux levels were recorded using a Lutron model LX-1108, 4-light type light meter with LCD and bar graph display. It utilizes a microprocessor circuit for high accuracy and measures Tungsten, Fluorescent, Sodium, and Mercury light types. For this study the Fluorescent type was chosen as all of the lamps in the lighting fixtures, in all of the classrooms, were of that type. While light meters require periodic calibration, this unit was brand new and the next calibration is due in December, 2007.

Data Collection

Measurements of the noise level in the New York PS 98 rooms on the east side of the building, closest to the passing trains, were at 59dB and, when a train passed, rose to 89dB. It was found that classes on the east side were disrupted a total of 30 seconds every four minutes, on average. In the Los Angeles study, a "C" weighted noise level network was used because it provided the best correlation with the reading scores. "C" weighting was also chosen for the New Jersey testing because of the desire to trap for low frequency rumbling that may be attributed to vibrations from large trucks passing by or vibrations caused by the HVAC systems. The testing of the New Jersey classrooms were at the 100Hz, 250Hz, 440Hz, 1KHz, and 10KHz frequency levels. A continuous tone at each frequency was measured at the front of the classroom, approximately 10' from the front wall and at the rear of the classroom, approximately 10' from the rear wall. The difference between the two, at each frequency, was noted in Column S of Table 4.1 and a percentage change was determined. Reverberation Time (RT) was calculated in Column U of Table 4.1, using the formula RT(60)=0.05V/(? S ?) to determine a speech intelligibility rating. If RT is too long intelligibility is lowered. RT(60) represents the length of time that it takes for sound to diminish or decay 60 dB from the initial level. In this formula, V represents the room's cubic volume, S, the square feet of the surface area, the ?, represents the absorption coefficient of all materials at a given frequency. In this test 500Hz is the frequency used to obtain the coefficient.

Two lighting levels were taken with the lights on; one measurement was recorded at the front of the room, approximately 10' from the writing board. A second was recorded at the rear of the class approximately 10' from the rear wall. The meter was set to Fluorescent mode and a lux level was entered for each room. The two scores were then averaged to represent the average lux level in the classroom. All measurements were recorded with the window treatments up; no note was made as to the orientation of the room relative to the sun. All rooms were measured and recorded in the late afternoon period, with the exception of the DRHS rooms which were done on a Saturday morning.

Data Analysis

Reading scores in the New York PS 98 study were compared between classes held on the east side, closet to the train, with those on the west side of the building. Reading progress was also analyzed with comparisons made to east side versus west side, both before, and after the three to eight dB noise reduction techniques. In the Los Angeles study, the physical distance of a classroom from a freeway was analyzed. In addition to reading scores, math and classroom behavior was evaluated with respect to freeway noise levels. In the New Jersey study each of the design elements were rated to determine the overall score which was then compared to the ILECF thereby establishing the specific classroom's ranking. An ILECF of 11 was given to be the best score in this particular study, using 1 as the optimal score, and a higher number for lower performance, for each specific design element present. The range of scores in the New Jersey study ranged from 30 to 57, with the lower the score, the better the performing classroom. The best score, however, DRHS's room S-108, was achieved partly because the HVAC air handler was not functioning at the time of the measurement, and should be viewed with that in mind. The other DRHS room, S-217, did not have any windows in the room. While there are downsides to this classroom arrangement, in the way of the absence of natural light, there are positives as well in that the room's RT could have measured lower due to the fact that there was less hard surface, namely the glass from the windows, in which acoustic reflection would occur. Since this study did not consider natural light as an element for the ILECF rating, the lower RT was considered to be a beneficial element, natural light benefits notwithstanding.

CHAPTER FOUR

ANALYSIS OF THE DATA

Profile of the Sample

The two previous studies in New York City and Los Angeles, on classroom noise and reading scores, are included here to support the idea that the physical learning environment can play an important role in the learning process and therefore leads to this researcher's study on the physical characteristics and design elements of specific classroom environments.

In the New York audio studies substantial differences in the reading scores remained despite the decrease in the noise from the train at both the noisy and quiet sides of the building. This could suggest that, despite the decrease of the three to eight dB in noise levels, the effects of even a small amount of noise on reading concentration was still a factor and accounted for a similar difference in scores. Their data also found that the children in the lower grades, in classrooms on the noisy side of the building, were between three or four months behind in reading development, compared to the children in classrooms on the quiet side of the building. In addition, the children in the upper grades in the noisy classrooms were found to be as much as 11 months behind in reading skills than their counterparts on the quiet side of the building.

In the Los Angeles study, however, there exhibited a much greater decrease in the reading scores for the sixth grade classes than for the third grade classes. The result was a more marked difference, in academic achievement, compared to Bronzaft and McCarthy. The reasons for this could be due to many factors and suggests a lack of reliability in repeated tests. The results of both studies also seem to contradict other studies that have determined that younger children, who are unable to "predict from context" are more likely to see a decrease in reading scores from an increase in acoustical noise. In the New York study this could be explained as they found that the teacher provided more one-on-one instruction for the younger children, thereby minimizing any missing instructions.

Another explanation for this could lie in the proposition that learning deficiencies were being compounded as the children progressed through the grade levels. There is yet another, possibly more important, effect of a noisy learning environment that may have been touched upon in both the N.Y. and Los Angeles studies. It is the presumption that a child who cannot clearly hear instruction may not become actively involved in his or her learning, and may withdraw from participation in classroom activity. Young children are less apt to raise a hand when information is not heard and if they are constantly missing out on teacher instruction the child may develop a decreased sense of self-esteem. The process could be exponential in nature, taking this paradigm further and further into subsequent school years and the child falling further and further behind in achievement.

In the New Jersey study the 14 classroom physical spaces were evaluated on the 11 physical design elements in the classroom. Not all elements of classroom design were included in the New Jersey study, however. Left out, for reasons related to the scope of this project, were elements such as color, shape of classrooms, security, natural lighting, temperature, emotions, learning strategies and other student or teacher relational social, cultural and psychological components, as well as more in-depth study into anthropometry, ergonomics, proxemics and synaesthetics.

The Classroom design elements inspection spreadsheet of 14 classrooms in 8 facilities in southern New Jersey, represented as Table 4.1, (pages 1-4), follows on pages 35-38 of this chapter. It is the central depository of data recorded during the observation, evaluation and measurement of the classrooms. It records, in detail, the following elements and the results of the South Jersey school districts field testing. They are briefly listed here:

1. Heating, Ventilation, & Air Conditioning noise levels.

    Measured in dB, at the unit. (Represented as HVAC VENT LOC. dB (near), on the spreadsheet, column H).

2. Heating, Ventilation, & Air Conditioning noise levels.

    Measured in dB, across the room. (Represented as HVAC VENT LOC. dB (far), on the spreadsheet, column H).

3. Door location. (staggered, non-staggered, or directly across from another classroom). (Represented as DOORS, on the spreadsheet, column G).

4. Zoned lighting controls, re: TV/projection screen. (parallel, perpendicular, no zone). (Represented as ZONED LIGHTING Y/N, on the spreadsheet, column I).

5. Furniture flexibility. (separate tables/chairs, attached tables/chairs, or fixed seating). (Represented as FURN., on the spreadsheet, column L).

6. Ceiling tile material. (hard-acoustical/reflective or soft-acoustical/absorbent). (Represented as CEILING H/S, on the spreadsheet, column N).

7. Flooring material. (sound-absorbing carpet or sound-reflective tile). (Represented as FLOOR, on the spreadsheet, column O).

8. Frequency loss, dB, as a percentage, front of room to rear. (total of all five frequencies). (Represented as FREQ., on the spreadsheet, column P).
9. Reverberation Time (RT). (from formula, Classrooms Acoustics Booklet, Acoustical Society of America), measuring classroom materials and their Noise Reduction Coefficient, (N.R.C.). (Represented as REVERBERATION TIME on the spreadsheet, column U).
10. Lighting levels. (average of front and rear of room, measured in lux). (Represented as LIGHT LUX Front of Room, column V, and LIGHT LUX Rear of Room, column X, on the spreadsheet.
11. Projection (TV) size. (measured diagonally). (Represented as TV or SCREEN SIZE, on the spreadsheet, column Y).

Table 4.1 Classroom design elements inspection spreadsheet of 14 classrooms in 8 facilities in southern New Jersey (Page 1 of 4)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1																									
2	SCHOOL:	District Factor Group (DFG) A-J	ROOM # Date built	DIM. Ft. (L)	DIM. Ft. (W)	DIM. Ft. (H)	DOORS	HVAC VENT dB (near) dB (far)	ZONED LIGHTING Y/N	WINDOWS (QTY.) SIZE SQ. FT. NRC=.18 @600hZ	SHADES BLINDS MANUAL or POWER	FURN.	WRITING BOARDS "WHITE" "CHALK" SQ. FT. NRC=.01	CEILING H/S SQ. FT. NRC .06 or .75	FLOOR SQ. FT. NRC Carpet .45 Tile .03	FREQ.	AUDIO dB Front of room	AUDIO dB Rear of room	PCT. CHANGE FRONT TO REAR	NRC	REVERBERATION TIME RT(60)= 0.05V (? S ?)	LIGHT LUX Front of room FL.	LIGHT LUX Rear of room FL.	PCT. CHANGE FRONT TO REAR	TV or SCREEN SIZE (dia.)
3																									
4																									
5	GHS (High School)	B	A103 Renovated in 2004	32	28	9.5	staggered	window unit 76dB (near) 58dB (far)	N	6 30" x 48"	Shades manual	Separate chairs & tables	Chalk 10'	Soft-drop	Tile					RT	2.76				25"
6										60			40	896	896	10KHz	86	70	-18.60%	WINDOWS	10.80	235	295	25.53%	SQ. FT.
7										0.18			0.01	0.06	0.03	1KHz	88	73	-17.05%	BOARDS	0.40				NRC
8										10.8			0.4	53.76	26.88	440Hz	89	92	3.37%	CEILING	53.76				TOTAL
9																250Hz	72	71	-1.39%	FLOOR	26.88				
10																100Hz	73	69	-5.48%	VOLUME	8512.00				
11																				PLASTER	1936.00				
12																TOTAL			-39.15%	TTL NRC	154.24	Avg.	265		
13	GHS (High School)	B	A109 circa 1961	28	28	9.5	staggered	window unit 72dB (near) 52dB (far)	N	5 30" x 48"	None	Separate chairs & tables	Chalk 10'	Soft-drop	Tile					RT	2.69				25"
14										50			40	784	784	10KHz	79	70	-11.39%	WINDOWS	9.00	115	265	130.43%	SQ. FT.
15										0.18			0.01	0.75	0.03	1KHz	85	76	-10.59%	BOARDS	0.40				NRC
16										9			0.4	588	23.52	440Hz	84	95	13.10%	CEILING	588.00				TOTAL
17																250Hz	81	65	-19.75%	FLOOR	23.52				
18																100Hz	79	68	-13.92%	VOLUME	7448.00				
19																				PLASTER	1758.00				
20																TOTAL			-42.56%	TTL NRC	138.4	Avg.	190		
21	WTHS (High School)	FG	C-13 Computer circa 1965	32	28	9.5	staggered	window unit 78dB (near) 54dB (far)	Y perpendicular	5 36" x 60"	Blinds manual	Rows Chairs & tables attached	Whiteboard 14'	Soft-drop	Tile					RT	2.74				25"
22										75			56	896	896	10KHz	83	72	-13.25%	WINDOWS	13.50	216	420	94.44%	SQ. FT.
23										0.18			0.01	0.75	0.03	1KHz	83	80	-3.61%	BOARDS	0.56				NRC
24										13.5			0.56	672	26.88	440Hz	97	78	-19.59%	CEILING	672.00				TOTAL
25																250Hz	77	80	3.90%	FLOOR	26.88				
26																100Hz	71	61	-14.08%	VOLUME	8512.00				
27																				PLASTER	1905.00				
28																TOTAL			-46.64%	TTL NRC	155.24	Avg.	318		
29	WTHS (High School)	FG	A-25 circa 1965	40	28	9.6	non -staggered	window unit 90dB (near) 54dB (far)	Y perpendicular	8 36" x 54"	Blinds manual	Rows Chairs & tables attached	Chalkboard 14'	Soft-drop	Tile					RT	2.84				25"
30										108			56	1120	1120	10KHz	78	72	-7.69%	WINDOWS	19.44	73	420	475.34%	SQ. FT.
31										0.18			0.01	0.75	0.03	1KHz	73	85	16.44%	BOARDS	0.56				NRC
32										19.44			0.56	840	33.6	440Hz	79	87	10.13%	CEILING	840.00				TOTAL
33																250Hz	67	68	1.49%	FLOOR	33.60				
34																100Hz	59	64	8.47%	VOLUME	10752.00				
35																				PLASTER	2261.60				
36																TOTAL			28.84%	TTL NRC	189.296	Avg.	246.5		

Table 4.1 Classroom design elements inspection spreadsheet of 14 classrooms in 8 facilities in southern New Jersey (Page 2 of 4)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
2	SCHOOL:	District Factor Group (DFG) A-J	ROOM # Date built	DIM. Ft. (L)	DIM. Ft. (W)	DIM. Ft. (H)	DOORS	HVAC VENT dB (near) dB (far)	ZONED LIGHTING Y/N	WINDOWS (QTY.) SIZE SQ. FT. NRC=.18 @500hZ	SHADES BLINDS MANUAL or POWER	FURN.	WRITING BOARDS "WHITE" "CHALK" SQ. FT. NRC=.01	CEILING H/S SQ. FT. NRC .96 or .75	FLOOR SQ. FT. NRC Carpet .45 Tile .03	FREQ.	AUDIO dB Front of room	AUDIO dB Rear of room	PCT. CHANGE FRONT TO REAR	NRC	REVERBERATION TIME RT(60)= 0.05V (? S ?)	LIGHT LUX Front of room FL.	LIGHT LUX Rear of room FL.	PCT. CHANGE FRONT TO REAR	TV or SCREEN SIZE (dia.)
3																									
4																									
5	RU (University)		2104 circa 2005	36	25	9	staggered	ceiling 58dB (near) 54dB (far)	Y perpendicular	5.5 48" x 66"	Shades manual	movable detached chairs tables on 2-wheels	Whiteboard (2) 10'	Soft-drop	Tile					RT	2.52				100"
6										121			20	900	900	10KHz	76	66	-13.16%	WINDOWS	21.78	125	225	80.00%	SQ. FT.
7										0.18			0.01	0.75	0.03	1KHz	86	81	-5.81%	BOARDS	0.20				NRC
8										21.78			0.2	675	27	440Hz	94	84	-10.64%	CEILING	675.00				TOTAL
9																250Hz	74	72	-2.70%	FLOOR	27.00				
10																100Hz	66	69	4.55%	VOLUME	8100.00				
11																				PLASTER	1857.00				
12																TOTAL			-27.77%	TTL NRC	160.4	Avg.	175		
13	WE School (K-5)	B	11 circa 1949	37.25	21.75	11	across from open hallway	floor-to ceiling unit (2006) 68 dB (near) 58 dB (far)	Y perpendicular	9 36" x 64"	Shades manual	Separate chairs & tables	Both 16'	Soft-tile	Carpet					RT	0.88				100"
14										142			64	814	814	10KHz	77	63	-18.18%	WINDOWS	25.56	103	228	121.36%	SQ. FT.
15										0.18			0.01	0.75	0.45	1KHz	77	76	-1.30%	BOARDS	0.64				NRC
16										25.56			0.64	610.5	366.3	440Hz	92	78	-15.22%	CEILING	610.50				TOTAL
17																250Hz	78	61	-21.79%	FLOOR	366.30				
18																100Hz	63	63	0.00%	VOLUME	8912.06				
19																				PLASTER	1906.00				
20																TOTAL			-56.49%	TTL NRC	506.86	Avg.	165.5		
21	WE School (K-5)	B	20 circa 1999	34	28	9.5	directly across other classroom door	floor-to ceiling unit (2006) 68 dB (near) 58 dB (far)	Y perpendicular alternating lamps	4 36" x 64"	Shades manual	Separate chairs & trapezoid tables	Chalkboard 14'	Soft-drop	5/8 Carpet 3/8 Tile					RT	0.81				100"
22										63			56	952	952	10KHz	81	68	-16.05%	WINDOWS	11.34	330	565	71.21%	SQ. FT.
23										0.18			0.01	0.75	0.45	1KHz	81	79	-2.47%	BOARDS	0.56				NRC
24										11.34			0.56	714	428.4	440Hz	90	81	-10.00%	CEILING	714.00				TOTAL
25																250Hz	67	69	2.99%	FLOOR	428.40				
26																100Hz	72	62	-13.89%	VOLUME	9044.00				
27																				PLASTER	2011.00				
28																TOTAL			-39.42%	TTL NRC	560.96	Avg.	447.5		
29	DRHS (High School)	CD	S-217 MATH circa 1996	35	18	9.5	staggered	ceiling 58 dB (near) 56 dB (far)	Y alternating lamps	NONE	N/A	moveable chairs / tables attached	Whiteboard 10' AND Chalkboard 4'	Soft-drop	Tile					RT	2.62				90" proj screen 20" TV
30													56	630	630	10KHz	81	69	-14.81%	WINDOWS	0.00	172	565	228.49%	SQ. FT.
31													0.01	0.75	0.03	1KHz	83	69	-16.87%	BOARDS	0.56				NRC
32													0.56	472.5	18.9	440Hz	91	82	-9.89%	CEILING	472.50				TOTAL
33																250Hz	74	73	-1.35%	FLOOR	18.90				
34																100Hz	64	61	-4.69%	VOLUME	5985.00				
35																				PLASTER	1581.00				
36																TOTAL			-47.61%	TTL NRC	114.32	Avg.	368.5		
37																									

Table 4.1 Classroom design elements inspection spreadsheet of 14 classrooms in 8 facilities in southern New Jersey (Page 3 of 4)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
2	SCHOOL:	District Factor Group (DFG) A-J	ROOM # Date built	DIM. Ft. (L)	DIM. Ft. (W)	DIM. Ft. (H)	DOORS	HVAC VENT dB (near) dB (far)	ZONED LIGHTING Y/N	WINDOWS (QTY.) SIZE SQ. FT. NRC=.18 @500hZ	SHADES BLINDS MANUAL or POWER	FURN.	WRITING BOARDS "WHITE" "CHALK" SQ. FT. NRC=.01	CEILING H/S SQ. FT. NRC .06 or .75	FLOOR SQ. FT. NRC Carpet .45 Tile .03	FREQ.	AUDIO dB Front of room	AUDIO dB Rear of room	PCT. CHANGE FRONT TO REAR	NRC	REVERBERATION TIME RT(60)= 0.05V / (?S?)	LIGHT LUX Front of room FL.	LIGHT LUX Rear of room FL.	PCT. CHANGE FRONT TO REAR	TV or SCREEN SIZE (dia.)
3																									
4																									
5	DRHS (High School)	CD	S-108 MATH circa 1965	32	24	9.5	staggered	ceiling not on	Y Banked perpendicular to screen	6 36" x 64"	shades manual	moveable chairs / tables attached	Whiteboard 14' AND Chalkboard 10'	Soft-drop	Tile					RT	2.61	220 25	310 60		projector on whiteboard 32" TV
6										95			96	768	768	10KHz	82	72	-12.20%	WINDOWS	17.10	220	310	40.91%	SQ. FT.
7										0.18			0.01	0.75	0.03	1KHz	85	80	-5.88%	BOARDS	0.96	25	60	140.00%	NRC
8										17.1			0.96	576	23.04	440Hz	89	81	-8.99%	CEILING	576.00				TOTAL
9																250Hz	72	71	-1.39%	FLOOR	23.04				
10																100Hz	65	61	-6.15%	VOLUME	7296.00				
11																				PLASTER	1641.00				
12																TOTAL			-34.61%	TTL NRC	139.56	Avg.	265		
13	PHS (High School)	A	204 computer classroom circa 1923	29.75	20.75	12	diagonal	window unit 75 dB (near) 52 dB (far)	Y perpendicular to screen	(2) - 4' x 8' (4) - 3' x 8'	shades manual	fixed rows of tables	Chalkboard 4' x 25' 4' x 15'	hard tin	hardwood					RT	2.65	70	180		SmartBoard 60"
14										160			160	618	618	10KHz	84	70	-16.67%	WINDOWS	28.80	70	180	157.14%	SQ. FT.
15										0.18			0.01	0.06	0.03	1KHz	89	78	-12.36%	BOARDS	1.60				NRC
16										28.8			1.6	37.08	18.54	440Hz	89	90	1.12%	CEILING	37.08				TOTAL
17																250Hz	77	72	-6.49%	FLOOR	18.54				
18																100Hz	64	57	-10.94%	VOLUME	7407.75				
19																				PLASTER	1510.00				
20																TOTAL			-45.33%	TTL NRC	139.54	Avg.	125		
21	PHS (High School)	A	Exam / Conference circa 2004	32.75	27	9.25	Hall	ceiling 56 dB (near) 67 dB (far)	Y perpendicular to screen	(4) 40" x 60" (1) 3068 door	shades manual	moveable tables and chairs	Whiteboard 4' x 8'	soft-drop	Carpet					RT	0.78				72" projection screen 27" TV
22										65			32	885	885	10KHz	78	68	-12.82%	WINDOWS	11.70	280	132	-52.86%	SQ. FT.
23										0.18			0.01	0.75	0.45	1KHz	86	75	-12.79%	BOARDS	0.32				NRC
24										11.7			0.32	663.75	398.25	440Hz	87	81	-6.90%	CEILING	663.75				TOTAL (W)
25										21						250Hz	78	70	-10.26%	FLOOR	398.25				SQ. FT.
26										0.09						100Hz	67	68	1.49%	VOLUME	8179.31				NRC
27										1.89										PLASTER	1893.38				TOTAL (D)
28																TOTAL			-41.27%	DOORS	1.89				
29																				TTL NRC	525.76	Avg.	206		
30	UVES (Elementary School)	DE	300 circa 2001 Transitional Students	32	28	9.5	directly across other doors	window radiator 50dB ambient noise level	Y alternating lamps	(4) 32" x 60"	Blinds manual	moveable separate tables and chairs tennis ball feet	Chalkboard 4' x 16'	soft-drop	Tile					RT	2.79				48" projection screen 19" TV
31										55			64	896	896	10KHz	85	69	-18.82%	WINDOWS	9.90	69	232	236.23%	SQ. FT.
32										0.18			0.01	0.75	0.03	1KHz	85	77	-9.41%	BOARDS	0.64				NRC
33										9.9			0.64	672	26.88	440Hz	98	89	-9.18%	CEILING	672.00				TOTAL
34																250Hz	82	78	-4.88%	FLOOR	26.88				
35																100Hz	63	65	3.17%	VOLUME	8512.00				
36																				PLASTER	1917.00				
37																TOTAL			-39.12%	TTL NRC	152.44	Avg.	150.5		

Table 4.1 Classroom design elements inspection spreadsheet of 14 classrooms in 8 facilities in southern New Jersey (Page 4 of 4)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
2	SCHOOL:	District Factor Group (DFG) A-J	ROOM # Date built	DIM. Ft. (L)	DIM. Ft. (W)	DIM. Ft. (H)	DOORS	HVAC VENT dB (near) dB (far)	ZONED LIGHTING Y/N	WINDOWS (QTY.) SIZE SQ. FT. NRC=.18 @500hZ	SHADES BLINDS MANUAL or POWER	FURN.	WRITING BOARDS "WHITE" "CHALK" SQ. FT. NRC=.01	CEILING H/S SQ. FT. NRC .06 or .75	FLOOR SQ. FT. NRC Carpet .45 Tile .03	FREQ.	AUDIO dB Front of room	AUDIO dB Rear of room	PCT. CHANGE FRONT TO REAR	NRC	REVERBERATION TIME RT(60)= 0.05V (? S ?)	LIGHT LUX Front of room FL.	LIGHT LUX Rear of room FL.	PCT. CHANGE FRONT TO REAR	TV or SCREEN SIZE (dia.)
3																									
4																									
5	BES (Elementary School)	FG	200 circa 1997 ART	38	28	9.25	directly across other doors	window radiator 51dB ambient noise level	Y parallel with screen 75% switch 25% switch	(8) 32" x 60"	Blinds manual	moveable separate tables and chairs	Whiteboard 4' x 14'	soft-drop	Tile					RT	3.00				60" projection screen 19" TV
6										110			56	896	896	10KHz	75	69	-8.00%	WINDOWS	19.80	280	603	115.36%	SQ. FT.
7										0.18			0.01	0.75	0.03	1KHz	81	75	-7.41%	BOARDS	0.56				NRC
8										19.8			0.56	672	26.88	440Hz	85	72	-15.29%	CEILING	672.00				TOTAL
9																250Hz	64	67	4.69%	FLOOR	26.88				
10																100Hz	61	58	-4.92%	VOLUME	9842.00				
11																				PLASTER	1951.00				
12																TOTAL			-30.93%	TTL NRC	164.3	Avg.	441.5		
13	BES (Elementary School)	FG	N/A circa 1961	36	28	9.75	staggered	window unit 68 dB (near) 53 dB (far)	Y perpendicular	(5) 48" x 72" (1) 2868 door	Blinds manual	moveable separate tables and chairs	Chalkboard 4' x 20'	soft-drop	Tile					RT	2.76				25" TV
14										120			80	1008	1008	10KHz	81	73	-9.88%	WINDOWS	21.60	180	260	44.44%	SQ. FT.
15										0.18			0.01	0.75	0.03	1KHz	87	72	-17.24%	BOARDS	0.80				NRC
16										21.6			0.8	756	30.24	440Hz	97	75	-22.68%	CEILING	756.00				TOTAL (W)
17										21						250Hz	78	75	-3.85%	FLOOR	30.24				SQ. FT.
18										0.09						100Hz	63	60	-4.76%	VOLUME	9828.00				
19										1.89										PLASTER	2056.00				
20																TOTAL			-58.41%	DOORS	1.89				
21																				TTL NRC	177.89	Avg.	220		NRC
22																									
23																									
24																									
25																									
26																									
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The following tables, in the rest of this chapter, are taken from the main depository spreadsheet, Table 4.1, pages 1-4, the data recorded during the classroom visits of observation, evaluation and measurement. They are re-presented here for the purpose of clarifying the data in displaying the columnar information related to the specific design element or elements discussed. Table 4.2, on page 40, lists the school properties, the name, the DFG, the room number and the dimensions of the room. The size of the classroom is needed to plug into the formula for determining the RT of the room. The information begins with the school's name and designation in column A, the District Factor Grouping in column B, the classroom number and date of build or latest renovation in column C, and the length, width, and height, respectively, in columns D, E, and F. An attempt was made to select classrooms that were relatively similar in size, but were of varying grade levels as well as disciplines. The subjects taught in these rooms were general purpose, math, computer lab, art, conference/library-type, and transitional.

Table 4.2 (School properties and dimensions)

A	B	C	D	E	F
SCHOOL:	District Factor Group (DFG) A-J	ROOM # Date built	DIM. (L) in ft.	DIM. (W) in ft.	DIM. (H) in ft.
GHS (High School)	B	A103 Renovated in 2004	32	28	9.5
GHS (High School)	B	A109 circa 1961	28	28	9.5
WTHS (High School)	FG	C-13 Computer circa 1965	32	28	9.5
WTHS (High School)	FG	A-25 circa 1965	40	28	9.6
RU (University)		2104 circa 2005	36	25	9
WE School (K-5)	B	11 circa 1949	37.25	21.75	11
WE School (K-5)	B	20 circa 1999	34	28	9.5
DRHS (High School)	CD	S-217 MATH circa 1996	35	18	9.5
DRHS (High School)	CD	S-108 MATH circa 1964	32	24	9.5
PHS (High School)	A	204 computer classroom circa 1923	29.75	20.75	12
PHS (High School)	A	Exam / Conference circa 2004	32.75	27	9.25
UVES (Elementary School)	DE	300 circa 2001 Transitional Students	32	28	9.5
BES (Elementary School)	FG	200 circa 1997 ART	38	28	9.25
BES (Elementary School)	FG	N/A circa 1961	36	28	9.75

Each of the 11 design elements, of concern in the New Jersey study are listed, in detail, before each table presenting the results of the specific observations and measurements.

1. Doors: The door to each classroom was measured and viewed in relation to the doors of adjacent classrooms. The doors were rated as being #1, across or opened to a hallway; #2, staggered, (diagonally across from another door); or #3, non-staggered, (directly across from another classroom door), from high to low in the rating. Doors opened to a hallway would not allow for acoustical competition from other classrooms. The assumption here is that hallway noise would be minimal while classes are in session, but teaching and learning noise could be at a maximum also while classes are in session. The closer, in proximity, the doors are to each other, the more sound would be entering adjacent classrooms. Previous acoustical research mentioned has documented an acoustical advantage to a classroom whose door was further away from another classroom. Also, the size of the door, in area, was used to determine RT of the room. The Noise Reduction Coefficient, (NRC) of the material of a typical door, in this case 0.09 @ 500Hz, is used in the formula for determining RT (http://asa.aip.org/classroom/booklet.html, 2006).

Table 4.3, from column G of the spreadsheet, Table 4.1, shows how the doors were observed in relation to a hallway and adjacent classrooms.

Table 4.3 (Door layout design)

A	C	G
SCHOOL:	Room #	DOORS
GHS (High School)	A103	staggered
GHS (High School)	A109	staggered
WTHS (High School)	C-13 Computer	staggered
WTHS (High School)	A-25	non-staggered
RU (University)	2104	staggered
WE School (K-5)	11	across from open hallway
WE School (K-5)	20	non-staggered
DRHS (High School)	S-217 Math	staggered
DRHS (High School)	S-108 Math	staggered
PHS (High School)	204 Computer	staggered
PHS (High School)	Exam/ Conf.	across from open hallway
UVES (Elementary School)	300 Trans.	non-staggered
BES (Elementary School)	200 Art	non-staggered
BES (Elementary School)	N/A	staggered

2. Heating, Ventilation and Air Conditioning, (HVAC) noise level (near): The HVAC unit was measured at the source to determine the level of noise, in dB. The lower the noise level, the higher the ILECF score. The range was from an astonishing 90dB in the WTHS room A-25, to 50dB, UVES room 300, at the unit. The latter measurement was from a radiator-type heat system that did not have a noisy blower unit and the acoustical measurement was considered the ambient noise of the environment. The data was taken from column H of the spreadsheet, Table 4.1.
3. Heating, Ventilation and Air Conditioning, (HVAC) noise level (far): The HVAC unit was measured across the room from the source to determine the level of noise, in dB. Again the lower the noise level, the higher the ILECF score. The range of noise ran from 67dB to, again, the 50dB, representing the ambient sound level in the room. Table 4.4, on the next page, shows each room's rating, both at the unit (near) and across the room (far), again, the data was taken from column H of the spreadsheet, Table 4.1. Note that the measurement at DRHS, room S-108, was taken on a Saturday morning and the unit's air handler was not powered on. This will eventually affect the ILECF ranking and allow this room to be favorably ranked because no noise levels were present.

Table 4.4 (HVAC noise levels)

A	C	H
SCHOOL:	Room #	HVAC VENT LOC. dB (near) dB (far)
GHS (High School)	A103	Window unit 76dB (near) 58dB (far)
GHS (High School)	A109	Window unit 72dB (near) 52dB (far)
WTHS (High School)	C-13 Computer	Window unit 78dB (near) 54dB (far)
WTHS (High School)	A-25	Window unit 90dB (near) 54dB (far)
RU (University)	2104	Ceiling unit 58dB (near) 54dB (far)
WE School (K-5)	11	floor-to ceiling unit (installed in 2006) 68 dB (near) 58 dB (far)
WE School (K-5)	20	floor-to ceiling unit (installed 2006) 68 dB (near) 58 dB (far)
DRHS (High School)	S-217 Math	Ceiling unit 58 dB (near) 56 dB (far)
DRHS (High School)	S-108 Math	Ceiling unit not powered on
PHS (High School)	204 Computer	window unit 75 dB (near) 52 dB (far)
PHS (High School)	Exam/ Conf.	Ceiling unit 56 dB (near) 67 dB (far)
UVES (Elementary School)	300 Trans.	Window unit radiator 50dB ambient noise level
BES (Elementary School)	200 Art	Window unit radiator 51dB ambient noise level
BES (Elementary School)	N/A	Window unit 68 dB (near) 53 dB (far)

4. Table 4.5 lists lighting controls from column I. Each classroom was evaluated on the light control of the room. Out of all 14 rooms there was only one room that allowed a row of lights to be turned off that was parallel to the viewing screen. And, conversely, only one room had a single switch that either turned on or off all of the lights in the room. The other rooms allowed for zoned lighting but the rows were perpendicular to the screen. This meant that the TV or projection screen was either bathed in light in the row's ON condition, or the students had diminished lighting for note-taking when the row's switch was in the OFF condition.

Table 4.5 (Lighting scheme)

A	C	I
SCHOOL:	Room #	ZONED LIGHTING YES / NO
GHS (High School)	A103	NO
GHS (High School)	A109	NO
WTHS (High School)	C-13 Computer	(perpendicular) YES
WTHS (High School)	A-25	(perpendicular) YES
RU (University)	2104	(perpendicular) YES
WE School (K-5)	11	(perpendicular) YES
WE School (K-5)	20	(perpendicular-alternating lamps) YES
DRHS (High School)	S-217 Math	(perpendicular-alternating lamps) YES
DRHS (High School)	S-108 Math	(banked perpendicular to screen) YES
PHS (High School)	204 Computer	(perpendicular to screen) YES
PHS (High School)	Exam/ Conf.	(perpendicular to screen) YES
UVES (Elementary School)	300 Trans.	(alternating lamps) YES
BES (Elementary School)	200 Art	(parallel with screen) YES 75% switch-25% switch
BES (Elementary School)	N/A	(perpendicular) YES

The best lighting control scenario was in the Art room of BES, room #200. This room's light switching controlled the light directly above the screen, adequately dimming the area for viewing, but leaving the area above the students well lit for note-taking. This parallel control rated the highest ILECF, while all ON/OFF control rated the lowest ILECF score.

5. Furniture flexibility: Table 4.6 shows the type of furniture that was present in the rooms. The classroom furniture was rated, from highest to lowest, as being *flexible*, with such-shaped tables such as trapezoidal with wheels that can easily be arranged in group settings, to being *separate*, with separate tables and chairs, to *attached*, where the tables and chairs are as one unit, to *fixed*, where the tables and chairs cannot be moved, at

Table 4.6 (Furniture type and layout)

A	C	L
SCHOOL:	Room #	FURN.
GHS (High School)	A103	Separate chairs & tables
GHS (High School)	A109	Separate chairs & tables
WTHS (High School)	C-13 Computer	Rows; Chairs & tables attached
WTHS (High School)	A-25	Rows; Chairs & tables attached
RU (University)	2104	Movable detached chairs tables on 2-wheels
WE School (K-5)	11	Separate chairs & tables
WE School (K-5)	20	Separate chairs & trapezoid tables
DRHS (High School)	S-217 Math	Moveable chairs / tables attached
DRHS (High School)	S-108 Math	Moveable chairs / tables attached
PHS (High School)	204 Computer	fixed rows of tables
PHS (High School)	Exam/ Conf.	Moveable tables and chairs
UVES (Elementary School)	300 Trans.	Moveable separate tables and chairs tennis ball feet
BES (Elementary School)	200 Art	Moveable separate tables and chairs
BES (Elementary School)	N/A	Moveable separate tables and chairs

all, from their location. Column L shows this distinction. The highest rated room, RU #2104, came from the newest building, built in 2005, and the lowest rated came from the oldest classroom, PHS, room #204, built in 1923. It should be noted, however, that PHS, room #204 was retrofitted to become a teaching computer lab, which accounted for the attached seating.

6. Ceiling tile material: The ratings were for soft (acoustical tile), and hard (plaster or tin). Table 4.7 lists the materials of the ceilings in the rooms and the NRC values that are used to determine RT, taken from column N of the Table 4.1 spreadsheet.

Table 4.7 (Ceiling type and material, and Noise Reduction Coefficient values)

A	C	N
SCHOOL:	ROOM # Date built	CEILING Hard / Soft NRC .06 or .75
GHS (High School)	A103 Renovated in 2004	Soft-drop
GHS (High School)	A109 circa 1961	Soft-drop
WTHS (High School)	C-13 Computer circa 1965	Soft-drop
WTHS (High School)	A-25 circa 1965	Soft-drop
RU (University)	2104 circa 2005	Soft-drop
WE School (K-5)	11 circa 1949	Soft-tile
WE School (K-5)	20 circa 1999	Soft-drop
DRHS (High School)	S-217 MATH circa 1996	Soft-drop
DRHS (High School)	S-108 MATH circa 1964	Soft-drop
PHS (High School)	204 computer classroom circa 1923	hard tin
PHS (High School)	Exam / Conference circa 2004	Soft-drop
UVES (Elementary School)	300 circa 2001 Transitional Students	Soft-drop
BES (Elementary School)	200 circa 1997 ART	Soft-drop
BES (Elementary School)	N/A circa 1961	Soft-drop

All of the rooms had some sort of either drop-in or stapled-in acoustical tile with the one exception of, again, the oldest classroom, PHS, room #204, which had the tin-type ceiling that was prevalent of the era. The NRC of a hard-type ceiling is 0.06 @ 500Hz (http://asa.aip.org/classroom/booklet.html, 2006) and the NRC of an acoustical tile soft-type ceiling is in the range of .55-.85 (http://www.norliteagg.com/maps/sound.htm, 2006). In the calculations for RT, a median figure of .75 was used for the acoustical ceiling.

7. Flooring material: Table 4.8 lists the materials of the floors in the rooms.

Table 4.8 (Flooring material and Noise Reduction Coefficient values)

A	C	O
SCHOOL:	ROOM # Date built	FLOOR SQ. FT. NRC: Carpet .45 Tile .03
GHS (High School)	A103 Renovated in 2004	Tile
GHS (High School)	A109 circa 1961	Tile
WTHS (High School)	C-13 Computer circa 1965	Tile
WTHS (High School)	A-25 circa 1965	Tile
RU (University)	2104 circa 2005	Tile
WE School (K-5)	11 circa 1949	Carpet
WE School (K-5)	20 circa 1999	5/8 Carpet 3/8 Tile
DRHS (High School)	S-217 MATH circa 1996	Tile
DRHS (High School)	S-108 MATH circa 1964	Tile
PHS (High School)	204 computer classroom circa 1923	Hardwood
PHS (High School)	Exam / Conference circa 2004	Carpet
UVES (Elementary School)	300 circa 2001 Transitional Students	Tile
BES (Elementary School)	200 circa 1997 ART	Tile
BES (Elementary School)	N/A circa 1961	Tile

The N.R.C. values are also listed here. The ratings for carpet were 1, due to the acoustical absorbing nature of its material, and tile, which scored a lower 2, due to the acoustical reflective nature of the material. The oldest room, PHS, room #204, had what looked like the original oak hardwood flooring in the room. While the creaking and groaning of the material made for a nostalgic sound, reminiscent of an old historic building, the reflective nature of the wood and the additional noise component, made for a less than ideal noise level in the room. The NRC for carpet is .45 @500Hz (http://www.norliteagg.com/maps/sound.htm, 2006), and the NRC for tile is 0.03 @ 500Hz (http://asa.aip.org/classroom/booklet.html, 2006). The data was taken from column O of the Table 4.1 spreadsheet.

8. Frequency loss: A total of five audio frequencies, (100Hz, 250Hz, 440Hz, 1KHz, and 10KHz), were measured. A .wav file of each frequency was uploaded to a Verizon XV6700, PocketPC, Phone/PDA. Each file was then played back while being amplified through a pair of standard computer speakers. Each was played at the front wall of the room and was first measured by the Radio Shack dB meter at a distance of app. 10 feet and then again at a distance of app. 10' from the rear wall of the classroom. The readings were recorded as a measurement of decibels and the difference between the two was represented as a percentage of decrease or increase. The total differential was combined as average frequency loss or gain and each room was rated accordingly. Out of the 14 rooms, only one actually had increased in level, while the rest

decreased at varying degrees. The one room was given the highest score of 1 and the rest of the rooms were given scores commensurate with the degree of frequency loss. Less loss equaled a higher score. Interestingly, the one room with the lowest loss of frequency, WTHS A-25, had the next to highest RT time. This could be construed as meaning that the room consisted of many hard surface in which the frequencies tended to reflect, as opposed to being absorbed, with the end result of having a much lower intelligibility factor, as the high RT score suggests. Table 4.9 shows the calculated change in frequency levels as a percent change from

Table 4.9 (Frequency difference from the front of the room to the rear of the room)

A	C	S
SCHOOL:	ROOM # Date built	FREQUENCY CHANGE AS % FRONT TO REAR
GHS (High School)	A103 Renovated in 2004	-39.15%
GHS (High School)	A109 circa 1961	-42.56%
WTHS (High School)	C-13 Computer circa 1965	-46.64%
WTHS (High School)	A-25 circa 1965	28.84%
RU (University)	2104 circa 2005	-27.77%
WE School (K-5)	11 circa 1949	-56.49%
WE School (K-5)	20 circa 1999	-39.42%
DRHS (High School)	S-217 MATH circa 1996	-47.61%
DRHS (High School)	S-108 MATH circa 1964	-34.61%
PHS (High School)	204 computer classroom circa 1923	-45.33%
PHS (High School)	Exam / Conference circa 2004	-41.27%
UVES (Elementary School)	300 circa 2001 Transitional Students	-39.12%
BES (Elementary School)	200 circa 1997 ART	-30.93%
BES (Elementary School)	N/A circa 1961	-58.41%

the front of the room to the rear. Note: WTHS, room A-25 is the only room that actually had an increase in the levels at the rear of the room. The data was taken from column S of the spreadsheet, Table 4.1.

9. Reverberation Time (RT): Every room had a higher than the an RT factor of 0.4 – 0.6 seconds, as identified in the Acoustical Society of America's Classroom Acoustics Booklet as being the ideal rate of reverberation. (http://asa.aip.org/classroom/booklet.html, 2006). The room closest to that figure was the PHS Exam/Conference room which had a factor of 0.78, followed by the WE room #20, at 0.81, and the WE room #11 at 0.88. The rest had factors ranging from 2.52 – 3.00, well above the ideal factor. These rooms will have a much lower intelligibility factor, making teacher verbal instruction or other audio content harder to understand.

The human speech range is from 50 – 70 db. With an RT of 0.5 seconds, (assuming a +10dB Signal to Noise (S/N) ratio), intelligibility will be app. 90%. If the S/N falls to 0dB intelligibility falls to app. 55%. If the RT time is increased to 1.5 seconds (assuming +10dB S/N), intelligibility comes in around 75%. If the S/N drops to 0dB with the same RT of 1.5 seconds, intelligibility drops to an astounding 30%, again with only 30% of verbal instruction easily comprehended. With HVAC noise levels as high as 90dB it is easy to see that S/N can be driven down to a low level. This situation easily makes for a low intelligibility rating. The following Table 4.10 shows the RT values that were obtained through the room audio testing and subsequent calculations. This data was taken from column U of the Table 4.1 spreadsheet.

Table 4.10 (Reverberation Time)

A	C	U
SCHOOL:	ROOM # Date built	RT VALUE
GHS (High School)	A103 Renovated in 2004	2.76
GHS (High School)	A109 circa 1961	2.69
WTHS (High School)	C-13 Computer circa 1965	2.74
WTHS (High School)	A-25 circa 1965	2.84
RU (University)	2104 circa 2005	2.52
WE School (K-5)	11 circa 1949	0.88
WE School (K-5)	20 circa 1999	0.81
DRHS (High School)	S-217 MATH circa 1996	2.62
DRHS (High School)	S-108 MATH circa 1964	2.61
PHS (High School)	204 computer classroom circa 1923	2.65
PHS (High School)	Exam / Conference circa 2004	0.78
UVES (Elementary School)	300 circa 2001 Transitional Students	2.79
BES (Elementary School)	200 circa 1997 ART	3.00
BES (Elementary School)	N/A circa 1961	2.76

10. Lighting levels: Windows were included in the study, not for natural lighting ratings, but for sizing to determine the RT of the room. An NRC of 0.18 was used to calculate the RT in a room with windows. The square footage was determined and multiplied by the NCR factor and the product contributed to the total as the denominator in the formula of determining

Reverberation Time. Table 4.11, however, lists the level change in lux, as a percentage, from column X of the spreadsheet, Table 4.1.

Table 4.11 (Lighting levels, as a difference from the front of the room to the rear)

A	C	X
SCHOOL:	ROOM # Date built	LUX LEVEL CHANGE as % FRONT TO REAR
GHS (High School)	A103 Renovated in 2004	25.53%
GHS (High School)	A109 circa 1961	130.43%
WTHS (High School)	C-13 Computer circa 1965	94.44%
WTHS (High School)	A-25 circa 1965	475.34%
RU (University)	2104 circa 2005	80.00%
WE School (K-5)	11 circa 1949	121.36%
WE School (K-5)	20 circa 1999	71.21%
DRHS (High School)	S-217 MATH circa 1996	228.49%
DRHS (High School)	S-108 MATH circa 1964	40.91%
PHS (High School)	204 computer classroom circa 1923	157.14%
PHS (High School)	Exam / Conference circa 2004	-52.86%
UVES (Elementary School)	300 circa 2001 Transitional Students	236.23%
BES (Elementary School)	200 circa 1997 ART	115.36%
BES (Elementary School)	N/A circa 1961	44.44%

The intent here was to also see how light played on the surfaces in the classroom and how a student might be exposed to varying light levels at different areas in the classroom, mainly the front and the rear. The recorded light levels listed in Table 4.12 on the following page, show the light levels at the front and rear. All of the rooms, with the exception of one, the PHS Exam / Conference room, had an increase in the lux levels at the rear of the room. While good for note-taking, these students may have more difficulty seeing the writing board in the front of the room if the area above them, or around the room, is appreciably brighter.

The Occupational Safety and Health Administration, (OSHA), in its standards for the construction industry, 1926.56 for illumination, states that lecture rooms, assembly halls, stairs, and bathrooms, must be between 75-300 lux. All of the rooms except WTHS room #A-25 and PHS #204, had levels that met or exceeded the minimum lighting levels for this type of room. These two were also within the margin of error (+ or - 3% rdg + 0.5% F.S.), of the light meter. Six of the rooms, however, exceeded the maximum levels set forth by OSHA, with two of the rooms almost double the maximum in the range. This could mean that these children could possibly have a more difficult time seeing the front writing board with the area around them almost twice the recommended brightness. While these lux levels are more than adequate for general learning, they are higher than what is desired for viewing video content. Lighting flexibility, especially for multimedia A/V presentation, is a more specific schema. Perhaps even more important is the quality of light, more so than the quantity of light. Even rooms that measure up to OSHA standards can exhibit the negative effects of glare, unwanted reflections, or lack of natural light control. “Up lighting” provides uniform illumination on walls and ceilings, while providing a full degree of down lighting towards the teacher’s face and towards students’ desks. A “Down lighting” scheme is what’s needed for A/V or multimedia presentation where the focus of the light can de directed downward and away from reflective walls and ceilings, reducing brightness in the room (Public Interest Energy Research Program, 2006).

Table 4.12 (Lux levels at the front and rear of the room)

A	C	V	W
SCHOOL:	ROOM # Date built	LIGHT LEVEL LUX Front of room Fluorescent	LIGHT LEVEL LUX Rear of room Fluorescent (AVG.)
GHS (High School)	A103 Renovated in 2004	235	295 (265)
GHS (High School)	A109 circa 1961	115	265 (180)
WTHS (High School)	C-13 Computer circa 1965	216	420 (318)
WTHS (High School)	A-25 circa 1965	73	420 (246.5)
RU (University)	2104 circa 2005	125	225 (175)
WE School (K-5)	11 circa 1949	103	228 (165.5)
WE School (K-5)	20 circa 1999	330	565 (447.5)
DRHS (High School)	S-217 MATH circa 1996	172	565 (368.5)
DRHS (High School)	S-108 MATH circa 1964	220	310 (265)
PHS (High School)	#204 circa 1923 computer classroom	70	180 (125)
PHS (High School)	Exam / Conference circa 2004	280	132 (206)
UVES (Elementary School)	300 circa 2001 Transitional Students	69	232 (150.5)
BES (Elementary School)	200 circa 1997 ART	280	603 (441.5)
BES (Elementary School)	N/A circa 1961	180	260 (220)

The ability to view the video content is then greatly enhanced with this method.

Control of lighting should be near the instructor's desk, so as to avoid having to walk across the room after lowering the lighting. Most light switches are installed opposite the hinge side of the entrance door, as per building safety codes. Very rarely is a three-way switch located at the instructor's area, mostly due to either economic reasons or the architectural design did not call for the added control in its design phase. This can cause an interrupt in the rhythm or flow of a teaching assignment or can make for a dangerous journey back to the instructor's desk when the lights are lowered for an A/V presentation.

11. The last element considered in the ILECF was the size of the viewing area of the projection screen or TV/monitor. Column Y of Table 4.1 lists the diagonal measurement of this element. While not part of the permanent structure of the room, and can easily be replaced, it was noteworthy to consider as many rooms had screens that were too small to be considered seriously as a source to view content. Only three of the rooms scored highest with screens of 100" diagonal and five had screens of 25" diagonal which made it difficult to see from a distance of 28' – 40' Interestingly, of the three that scored well, two of the rooms were elementary classes and the third was the university classroom. Combined with improper lighting, the result of viewing content in most of these rooms may not be sufficient for learning. Not only were the screen sizes

inadequate, poor lighting controls contributed to the washing out of the contrast of the images making them hard to see clearly.

Analysis of the Data

Research Question 1: As postulated by the previous research referenced in this study, is there a relationship between learning space design and student achievement?

In looking at the previous research on the noise studies in New York and Los Angeles, there appears to be a relationship between excessive noise and student academic achievement, particularly in reading scores. While it is still not entirely clear as to what the extent of this relationship is, it is nonetheless apparent that there is one and that it had affected the children's reading scores, in both studies, in a negative way. In looking at the data in the New Jersey study, related to the design element of acoustics, or the ability to properly hear in a classroom, there appears to be a relationship between classroom design and construction, frequency loss, distance from the instructor, and intelligibility. Most of the rooms had an RT value that was much higher than is recommended. The combination of a high RT, a door layout that is close to another classroom, high levels of noise coming from the HVAC system and a hard tile floor and/or ceiling makes for a very noisy environment in which to learn. Student achievement cannot be expected to increase if the acoustics of the classrooms are not adequate or intelligibility is not at a high level. Also, a logical extension of thought can be applied that if the student has as much difficulty seeing the instruction as hearing the instruction, then academic achievement can suffer.

Research Question 2: What are the design elements inherent in learning space design that can enhance learning? How do they compare to existing classrooms in use today?

The data suggest that proper classroom acoustics enable students to clearly hear the instructions and that this enhances their capabilities in the learning process. Data also suggest that it is important to employ this thought process into the design phase of classroom construction or rehabilitation as it is an easy and inexpensive alternative to having to do this after the building or room is already built.

The design element of proper lighting and proper lighting control is equally important. Up and down lighting schemes and controls, as well as banks of lights parallel to a viewing screen, are design elements that should also be present in classrooms, especially for A/V multimedia instruction. Also, three-way lighting controls that can be controlled close to the instructor's station, as well as the classroom door, are also important for instruction and for safety.

Flexible furniture that can be easily rearranged to suit either the instruction or the students' learning styles, is also an important factor in the design.

Research has shown that other elements, not addressed in this study, are equally important to be included in the learning space design and construction process.

The data in the New Jersey study, although from a small sampling of fourteen classrooms, revealed that the results were mixed in how they compared to the desired rating. There were rooms that compared favorably to the recommended values in RT, lux, furniture type, door location, and HVAC noise levels. There were also some rooms that were outside of the maximum levels of the same elements. What is clear is that there was no standard for how these learning spaces were designed and built; one that would allow these measurements to be much closer in value to each other.

Table 4.13, on page 60, lists the rooms as they ranked according to the ILECF. The scores, ranked from the highest at the top of the list, to the lowest at the bottom, were based upon how each classroom performed in the testing, measuring, and evaluation of the 11 design elements. A top score was given a 1 and lower scores given subsequent numbers so that the lowest rated number was given the highest award in the ranking. As previously mentioned, however, the top ranked classroom, DRHS S-108, at an ILECF of 30, should be disregarded as the overall winner because the HVAC air handler was not powered on at the time of the measurement. This gave the room a lower ILECF than would have been possible if it had been turned on. As the system had ceiling-mounted air vents a certain degree of noise would have been evident and would have, most likely, but not assuredly, lowered the score. The winner, therefore, was the WE Elementary School, room #20, with a score of 31. This was surprising, in that this room, as well as its sister room, WE #11, had a newly installed, massive, floor-to-ceiling heating and cooling system, with an integrated window located fan/blower unit. It appeared to be noisy but the db levels turned out to be somewhere at the middle ground and the ratings of the other elements, especially the average lighting levels, for general classroom lighting, helped to provide a higher overall ILECF score.

Table 4.13 (Ideal Learning Environment Composite Factor (ILECF), ranking spreadsheet)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	ROOM RANK Lower # = Higher rank	ROOM #	HVAC Db < Best Near	HVAC Db < Best Far	HVAC Db <Best Near Rank	HVAC Db <Best Far Rank	DOORS SCALE 1-3 < BEST	ZONED LIGHTING Y/N Parallel=1 Perpend.=2 No Zone =3	Furniture Flexible=1 Separate=2 Attached=3 Fixed=4	Ceiling Soft = 1 Hard = 2	Flooring Carpet=1 Tile=2	Freqency loss (Avg.) Front to Rear of room	RT	Lighting Avg. Front & Rear	Proj./ TV Screen Size	TOTAL SCORE
2	DRHS	S-108	0	0			2	2	3	1	2	4	5	5	6	30
3	WE	20	68 (5)	58 (7)	5	7	3	2	1	1	1	7	2	1	1	31
4	RU	2104	58 (4)	54 (5)	4	5	2	2	1	1	2	2	4	10	1	34
5	BES	ART	51 (2)	51 (2)	2	2	3	1	2	1	2	3	13	2	4	35
6	PHS	CONF. RM.	56 (3)	67 (8)	3	8	1	2	2	1	1	8	1	8	3	38
7	DRHS	S-217	58 (4)	56 (6)	4	6	2	2	3	1	2	12	6	3	2	43
8	UVES	300	50 (1)	50 (1)	1	1	3	2	2	1	2	5	11	12	5	45
9	WE	11	68 (5)	58 (7)	5	7	1	2	2	1	1	13	3	11	1	47
10	GHS	A109	72 (6)	52 (3)	6	3	2	3	2	1	2	9	8	9	7	52
11	GHS	A103	76 (8)	58 (7)	8	7	2	3	2	1	2	6	9	5	7	52
12	WTHS	A-25	90 (10)	54 (5)	10	5	3	2	3	1	2	1	12	6	7	52
13	WTHS	C-13	78 (9)	54 (5)	9	5	2	2	3	1	2	11	10	4	7	56
14	PHS	204	75 (7)	52 (3)	7	3	2	2	4	2	2	10	7	13	4	56
15	BES	GENERAL	68 (5)	53 (4)	5	4	2	2	2	1	2	14	11	7	7	57

CHAPTER FIVE

SUMMARY, DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Study

This study investigated the possible relationship between classroom design elements and student academic achievement. It did so by looking at previous research into classroom noise levels and its effect on reading scores in elementary schools in Manhattan, New York, and Los Angeles, California and found that noise levels contributed to a decrease in the reading scores of elementary students on both coasts.

The on-site examination and testing, conducted to determine the presence or absence of classroom architectural design elements in fourteen classrooms in eight educational facilities in the southern New Jersey area, found that certain design elements need to be included into the construction of learning spaces. The comparison of the classrooms to one another resulted in the creation of an Ideal Learning Environment Composite Factor, (ILECF) for ranking classrooms as to the existence and quality of these elements. This factor takes into account the design elements that exist in the classroom that can allow it to enhance the learning process by enabling the student to more easily hear, see, and interact with the instructional process. By being exposed to these proper fundamentals of design, many students can benefit by being more comfortable and thus more interactive in their learning. There were no human subjects in the New Jersey study, but the New York and California studies' subjects were second to sixth grade students at elementary PS 98 in upper Manhattan, and third to sixth grade students in Los Angeles.

In the Manhattan and Los Angeles studies, testing consisted of measuring noise levels in classrooms adjacent to elevated train and freeway noise and also classrooms farther away from these sources of noise, and comparing reading scores of students in both the noisy and quiet rooms. In the New Jersey study the investigation looked at elements of classroom design that have been found to be conducive to the learning process. The fourteen classrooms in the New Jersey study were rated by evaluating 11 architectural design elements in the rooms. Each room was measured in length, width, and height to help determine the reverberation time (RT) of the specific classroom. The classroom entrance doors were located and the proximity of adjacent classroom doors' locations was notated and the classroom rated for these locations. Heating, Ventilation, and Air conditioning, (HVAC), noise levels were measured both at the source and across the room, using a sound level meter and the results recorded. The classrooms' lighting controls were observed and their function was notated as being perpendicular or parallel to the viewing projection or TV screen. The ability to dim the area above the viewing screen was determined to be an important characteristic in the ability to properly view multimedia video content. A parallel lighting control scheme, that controlled lighting above the screen, was rated the highest. Windows, writing boards, ceiling tiles, flooring materials, and doors were measured and the square footages of each were notated and used as a multiplier for the Noise Reduction Coefficient, (NRC). These combined square footages in any particular room were added to a total and used as the denominator in determining the RT of the room. Furniture flexibility was evaluated and rated as to the ability to arrange the tables and chairs into various configurations relative to and complementary of, the instructional delivery style or student learning comfort. A flexible furniture arrangement was given a higher rating. Ceiling tile and flooring materials were rated as being soft or hard and carpet or tile, respectively with the former given a higher rating than the latter. The materials were absorbent or reflective, in dealing with sound waves, with the soft acoustical ceiling tiles and carpeting helping to reduce the RT in the room. These ratings were added to the score for determining a rating, as well. The balance of the materials in each room contributed to frequency loss or, gain in one instance. The differences, at each of the five frequency ranges were combined and the lower of the loss of the combined frequencies was used in determining the rating level. Each classroom's lighting levels were determined by measuring the levels at the front of the room and again at the rear of the room and the two levels averaged for the lux level of the room. The higher the average lux level, in this instance, contributed to a better score. This high level was important for general classroom lighting not related to multimedia viewing and use. And, lastly, the viewing screen size of a projection or TV screen was rated. The larger the size of the screen, the better the ability to see the content and the higher the rating.

All of the above ratings were combined to form the newly created Ideal Learning Environment Composite Factor, (ILECF), rating system. The highest scored design elements rated a score of 1, with subsequent numbers rating consecutively lower in the rating. The total of all of the rated design elements became the ILECF ranking. By using this system of ranking, this researcher was able to determine which rooms performed better than others, in any of the 11 elements present, and recommendations could then be made for improvements to the design or rehabilitation of learning spaces in the future. It is a fairly quick and easy system of determining what needs to be addressed in a classroom environment and could help in facilities maintenance, planning, budgeting and presentation to concerned parties involved in deciding the future use of learning spaces in institutions.

Discussion of the Findings

The most obvious, and perhaps the most important, findings in looking at the tables related to acoustics and lighting, is in the way that the results on Reverberation Time, (RT), and the lighting design portrayed the lack of respect for both of these architectural design elements. Especially, looking at the previous research at the University of Florida which found that as much as 50% of information is missed when seated further back than the third row of seats in a classroom. This is astounding in that, combined with younger children's inability to decipher pertinent information from background noise, and predict from context the information they missed, the RT of elementary school classrooms has not been a major concern when designing learning spaces. As also suggested in Seep et al. (2000), ceilings should be constructed of a hard material angled towards the rear of the classroom to deflect the voice of the instructor at the front of the room. This design can allow for greater amplification and intelligibility of the sound and can have the effect of increasing the intelligibility factor from its present 75%. An excess in ambient noise can also be a determining factor in intelligibility and this and other positive acoustical design elements must be taken into consideration.

It appears that the primary concern in these buildings has been placed in the economics of keeping the rooms operating at minimal cost to the public. The suggestions by researchers for improvements in designing learning spaces come at a cost. Some of these costs are more substantial than others. It is much cheaper to install a single light switch than to install multiple switches, both at the entrance door and at the teacher station. And to further separate the lighting zones into banks of lights that work better in situations utilizing multimedia A/V instruction, adds even more to the cost. But, there are costs associated with children not getting a quality education, as well. According to The Technical Committee on Architecture of the Acoustical Society of America, people with normal hearing have a 75% speech intelligibility rating, meaning that they miss 25% of what is being presented (Waldecker, 2005). With that figure as a basis for measurement, schools should be built to help minimize the inability to hear and understand the lecture in a classroom, not add to the problem of intelligibility.

Conclusions

The combination of the results of previous studies along with the results of this study confirmed much of what was found in previous research. The proper design of classrooms appears to be important for learning and for academic achievement. The ability of students, both close to and far from the instructor, to clearly hear and understand the spoken lecture can be crucial in a learning environment. Proper acoustical design figures to be a critical element of the overall classroom design. Also, lighting needs to be thought of as an integral part of today's classroom environment. Design and construction must take into account the use of multimedia, computer presentation, and other audio visual instructional methods, when designing new, and remodeling older, learning space environments. Electric lighting control that is more directional in addition to being general in nature is what is needed in today's, as well as tomorrow's classrooms.

Additional design elements such as flexible furniture layout, natural lighting and the ability to control it, color choices, acoustically complementary flooring and ceiling materials, are just a few that should be an integral part of the design of the learning space.

Recommendations for Further Practice and Research

As Educational Standards are an integral part of the educational process, so too should be the design of learning spaces. Design elements of this process, such as in HVAC ductwork, door placement, ceiling construction, lighting, color, furniture, security, temperature, and windows should be included in the state and federal standards, as in other areas where standards have been established, and codified into school building standards for designing learning spaces.

Facilities personnel should include those with a working knowledge of these positive design elements of learning space design, and who can work closely with architects to develop designs that encompass these elements into the final form of construction. What is clear is that there are no standards for how these learning spaces are designed, as far as these design elements are concerned, apart from safety, fire ADA and other federal, state, and local building codes; one that would allow these field measurements to be much closer in value to each other.

While not proven by this study, the belief is that a holistic approach to learning space design can only be beneficial to the student if all of the essential elements of learning space design are incorporated.

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APPENDIX
Institutional Review Board
Human Research Review Application

Rowan University
INSTITUTIONAL REVIEW BOARD
HUMAN RESEARCH REVIEW APPLICATION

INSTRUCTIONS: Check all appropriate boxes, answer all questions completely, include attachments, and obtain appropriate signatures. Submit an **original and two copies** of the completed application to the Office of the Associate Provost.
NOTE: **Applications must be typed.**
Be sure to make a copy for your files.

FOR IRB USE ONLY:
Protocol Number: IRB-___________
Received:______Reviewed:_______
Exemption: ___Yes ___ No
Category(ies):_________
Approved _______ ___________ (date)

Step 1: **Is the proposed research subject to IRB review?**
All research involving human participants conducted by Rowan University faculty and staff is subject to IRB review. Some, but not all, student-conducted studies that involve human participants are considered research and are subject to IRB review. Check the accompanying instructions for more information. Then check with your class instructor for guidance as to whether you must submit your research protocol for IRB review. If you determine that your research meets the above criteria and is not subject to IRB review, **STOP**. You do not need to apply. If you or your instructor have any doubts, apply for an IRB review.

Step 2: **If you have determined that the proposed research is subject to IRB review, complete the identifying information below.**

Project Title:
THE LEARNING SPACE: A STUDY OF THE SUGGESTED PRINCIPLES AND PRACTICES IN DESIGNING THE CLASSROOM ENVIRONMENT

Researcher: Theodore J. Colanduno

Department: Instructional Technology Services Location Memorial Hall

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Co-Investigator/s:

Faculty Sponsor (if student)* Dr. Louis Molinari
Department: Teacher Education Location: Education Hall
E-Mail: molinari@rowan.edu Telephone: 856-256-4500 x3803

Approved For Use by Rowan IRB: 7/04

Step 3: Determine whether the proposed research eligible for an *exemption* from a full IRB review.

Federal regulations (45 CFR 46) permit the exemption of some types of research from a full IRB review. If your research can be described by one or more of the categories listed below, check the appropriate category(ies), complete questions 1-5, and complete the Assurances on the last page of the application.

If your research cannot be described by any of these categories, your research is not exempt, and you must complete the entire "Human Research Review Application."

☐ **Category 1** - Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as: (a) research on regular and special education instructional strategies; or (b) research on the effectiveness of, or the comparison among, instructional techniques, curricula, or classroom management methods.

☐ **Category 2** - Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, unless: (a) information obtained is recorded in such a manner that the human participants can be identified, directly or through identifiers linked to the participants; and (b) any disclosure of the human participants' responses outside the research could reasonably place the participants at risk of criminal or civil liability or be damaging to the participants' financial standing, employability, or reputation.
*(**Note:** Exemption for survey and interview procedures does not apply to research involving children. Exemption for observation of public behavior does not apply to research involving children except when the investigator does not participate in the activities being observed.)*

☐ **Category 3** - Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under Category 2 above if: (a) the human participants are elected or appointed public officials or candidates for public office; or (b) federal statute requires without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

☑ **Category 4** - Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that participants cannot be identified, directly or through identifiers linked to the participants.

☐ **Category 5** - Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (a) public benefit or service programs; (b)procedures for obtaining benefits or services under those programs; (c) possible changes in or alternatives to these programs or procedures; or (d) possible changes in methods or levels of payment for benefits or services under those programs.

☐ **Category 6** - Taste and food quality evaluation and consumer acceptance studies: (a) if wholesome foods without additives are consumed; or (b) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.
*(**Note:** Exemption categories cannot be applied to research involving fetuses, pregnant women, human in vitro fertilization, or prisoners.)*

Please answer Questions 1-5 below

1. WHAT IS THE OBJECTIVE OF THE RESEARCH?

To investigate the relationship between inherent learning space design elements and how they may affect the learning process.

2. DESCRIBE THE DESIGN OF THE RESEARCH INCLUDING WHAT WILL BE REQUIRED OF SUBJECTS (ATTACH ADDITIONAL SHEET IF NECESSARY):

There will be no research conducted upon human subjects. Data were collected after school hours and in empty classrooms.

3. DESCRIBE THE SUBJECTS WHO WILL BE PARTICIPATING (NUMBER, AGE, GENDER, ETC):

N/A

4. DESCRIBE HOW SUBJECTS WILL BE RECRUITED (e.g. ADVERTISEMENTS, ANNOUNCEMENTS IN CLASS, E-MAIL, INTERNET)

N/A

5. WHERE WILL THE RESEARCH BE CONDUCTED:

In various schools and classrooms in the southern New Jersey area.

NOTE: IF THE RESEARCH IS TO BE CONDUCTED IN ANOTHER INSTITUTION (e.g. A SCHOOL, HOSPITAL, AGENCY, etc.) A PERMISSION LETTER FROM AN ADMINISTRATOR ON THE LETTERHEAD OF THAT INSTITUTION MUST BE ATTACHED.

IF THE RESEARCH IS TO BE CONDUCTED AT ANOTHER UNIVERSITY, A SIGNED COPY OF THE IRB APPROVAL FORM FROM THAT UNIVERSITY MUST BE ATTACHED.

ATTACH THE CONSENT FORM TO THIS APPLICATION. The Consent Form must address all of the elements required for informed consent (SEE INSTRUCTIONS).

NOTE: IF THE ONLY RECORD LINKING THE SUBJECT AND THE RESEARCH WOULD BE THE CONSENT DOCUMENT, AND THE RESEARCH PRESENTS NO MORE THAN MINIMAL RISK OF HARM TO SUBJECTS, YOU MAY USE AN ALTERNATIVE PROCEDURE FOR CONSENT. IF YOU WISH TO REQUEST PERMISSION FROM THE IRB TO USE AN ALTERNATIVE PROCEDURE, ATTACH A COPY OF THE FIRST PAGE OF YOUR RESEARCH INSTRUMENT OR A LETTER WITH THE REQUIRED INFORMATION (see Instructions).

If you are requesting an exemption from a full IRB review, STOP. Complete the last page of this application ("Certifications"), and forward the completed (typed) application to the Office of the Associate Provost for Research, The Graduate School, Memorial Hall.

IF YOU CANNOT CLAIM ONE OF THE EXEMPTIONS LISTED ABOVE, COMPLETE ALL OF THE ABOVE AS WELL AS THE FOLLOWING ADDITIONAL QUESTIONS FOR A FULL IRB REVIEW.

Does your research involve a special population?

☐ Socioeconomically, educationally, or linguistically disadvantaged racial/ethnic group
☐ Pregnancy/fetus
☐ Cognitively impaired
☐ Elderly
☐ Terminally ill
☐ Incarcerated
☐ No special population

At what level of risk will the participants in the proposed research be placed?
*(**Note:** "Minimal risk" means that the risks of harm anticipated in the proposed research are not greater, considering probability and magnitude, than those ordinarily encountered in daily life or during performance of routine physical or psychological examinations or tests. The concept of risk goes beyond physical risk and includes risks to the participant's dignity and self-respect as well as psychological, emotional, or behavioral risk.)*

☐ Minimal Risk ☐ More than Minimal Risk ☐ Uncertain

1. HOW WILL SUBJECTS BE RECRUITED? IF STUDENTS, WILL THEY BE SOLICITED FROM CLASS?

____
____
____
____

2. WHAT RISKS TO SUBJECTS (PHYSIOLOGICAL AND/OR PSYCHOLOGICAL) ARE INVOLVED IN THE RESEARCH?

____
____
____
____

3. IS DECEPTION INVOLVED IN THE RESEARCH? IF SO, WHAT IS IT AND WHY WILL IT BE USED?

____
____
____

4. WHAT INFORMATION WILL BE GIVEN TO THE SUBJECTS AFTER THEIR PARTICIPATION? IF DECEPTION IS USED, IT MUST BE DISCLOSED AFTER PARTICIPATION.

5. HOW WILL CONFIDENTIALITY BE MAINTAINED? WHO WILL KNOW THE IDENTITY OF THE SUBJECTS? IF A PRE-AND POSTTEST DESIGN IS USED, HOW WILL THE SUBJECTS BE IDENTIFIED?

6. HOW WILL THE DATA BE RECORDED AND STORED? WHO WILL HAVE ACCESS TO THE DATA? ALL DATA MUST BE KEPT BY THE PRINCIPAL INVESTIGATOR FOR A MINIMUM OF THREE YEARS.

CERTIFICATIONS:
Rowan University maintains a Federalwide Assurance (FWA) with the Office of Human Research Protection (OHRP), U.S. Department of Health & Human Services. This Assurance includes a requirement for all research staff working with human participants to receive training in ethical guidelines and regulations. "Research staff" is defined as persons who have direct and substantive involvement in proposing, performing, reviewing, or reporting research and includes students fulfilling these roles as well as their faculty advisors.

Please attach a copy of your "Completion Certificate for Human Participant Protections Education for Research Teams" from the National Institutes of Health.

If you need to complete that training, go to the Web Tutorial at http://cme.nci.nih.gov/

Responsible Researcher: I certify that I am familiar with the ethical guidelines and regulations regarding the protection of human participants from research risks and will adhere to the policies and procedures of the Rowan University Institutional Review Board. I will ensure that all research staff working on the proposed project who will have direct and substantive involvement in proposing, performing, reviewing, or reporting this research (including students fulfilling these roles) will complete IRB approved training. I will not initiate this research project until I receive written approval from the IRB. I agree to obtain informed consent of participants in this project if required by the IRB; to report to the IRB any unanticipated effects on participants which become apparent during the course or as a result of experimentation and the actions taken as a result; to cooperate with the IRB in the continuing review of this project; to obtain prior approval from the IRB before amending or altering the scope of the project or implementing changes in the approved consent form; and to maintain documentation of consent forms and progress reports for a minimum of three years after completion of the final report or longer if required by the sponsor or the institution. I further certify that I have completed training regarding human participant research ethics within the last three years as indicated below my signature.

Signature of Responsible Researcher: ________________________________ Date: ______________

Faculty Advisor (if Responsible Researcher is a student): I certify that I am familiar with the ethical guidelines and regulations regarding the protection of human participants from research risks. I further certify that I have completed training regarding human participant research ethics within the last three years as indicated below my signature (attach copy of your "Completion Certificate for Human Participant Protections Education for Research Teams" from the National Institutes of Health).

Signature of Faculty Advisor: ____ Date: ______________