PLANNING SCIENCE CLASSROOM FACILITIES AND RESOURCES TO IMPROVE STUDENTS' ATTITUDES

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ABSTRACT

Over half of the school facilities in America are in poor condition. Unsatisfactory school facilities have a negative impact on teaching and learning. The purpose of this correlational study was to identify the relationship between high school science teachers' perceptions of the school's science environment (instructional equipment, demonstration equipment, and physical facilities) and ninth grade students' attitudes about science through their expressed enjoyment of science, boredom with science and value of science. A sample of 11,523 cases was extracted from the High School Longitudinal Study (HSLS:2009), a nationally representative survey of ninth graders located throughout the United States. The research design was multiple linear regression. The results showed a weak and yet significant relationship between the science classroom conditions and students' attitudes. Demonstration equipment and physical facilities were the best predictors of effects on students' attitudes. The results from this study show the importance of appropriate school facility and resource planning as well as areas for future research.

INTRODUCTION

Educators, policy makers, and industry leaders would like to see more qualified students moving into STEM fields. Evidence shows that American students are falling behind in STEM proficiency and interest (Chen, 2013; Peters-Burton et al, 2014). The significance of this study was to add to the existing body of knowledge by identifying educational facility condition and available resource variables that may improve high school students' attitudes toward science.

The physical conditions of high school buildings across the United States vary drastically. While many schools boast state-of-the-art facilities, many others are unattractive, unhealthy, and even unsafe. According to the National Center for Educational Statistics (NCES, 2014) over 53 percent of school facilities in the United States require improvements to be considered satisfactory. Likewise, the American Society of Civil Engineers (ASCE) gave the grade of "D" to the nation's schools due to their overall dilapidated conditions (ASCE, 2013). At a minimum, much work is needed to simply provide learning environments that are safe and comfortable for American children.

However, beyond the mere concern for safety and comfort, the condition of school facilities also affects the teaching and learning process (Cash, 1993; Bowers & Urick, 2011; Earthman & Lemasters, 2011; Tanner, 2008). Buildings in poor condition or disrepair are not as conducive to teaching and learning as those that are in satisfactory or excellent condition (Bowers & Urick, 2011; Earthman & Lemasters, 2011; Tanner, 2008). In essence, unsafe or uncomfortable conditions in schools prohibit learning, the very goal of schooling.

Earthman and Lemasters (2011) proposed a modern-day theoretical construct model, originally introduced by Cash (1993), for evaluating school building conditions (See Figure 1).

This model attempts to illustrate the relationship between school condition and the effects on work and learning in school spaces. Studies using this model or similar concepts support the proposition that teachers and students are affected by the conditions of the building and the condition of classrooms (Earthman & Lemasters, 2009; Earthman & Lemasters, 2011; Horng, 2009; Johnson, Kraft, & Papay, 2012; Johnson et al., 2011: Mompremier, 2012).

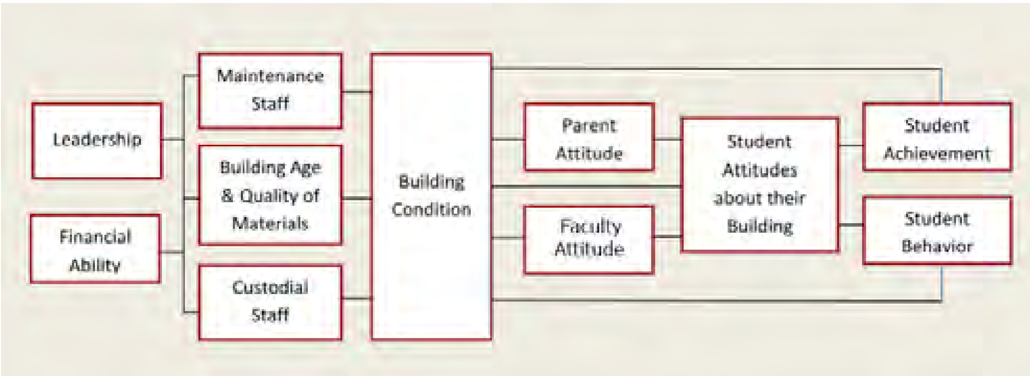

Figure 1. School building conditions are the result of various factors and those conditions affect the occupants.

It is imperative to understand how certain resources provided in learning spaces help to qualify the physical learning environment (Cleveland & Fisher, 2014; Savasci & Tomul, 2013). Educational resources, such as teaching materials, technical equipment, and student materials have been found to correlate with the quality and condition of school facilities (Kozol, 2012; Uline & Tschannen-Moran, 2008; Uline, Tschannen-Moran, & Wolsey, 2009; Uline, Wolsey, Tschannen-Moran, & Lin, 2010). Subsequently, there is evidence that the availability of educational resources correlates with academic achievement (Savasci & Tomul, 2013). Certainly, all classrooms and the learning that takes place within them stand to benefit from high-quality surroundings.

Specifically, Science education stands to benefit from improved standards for classroom upkeep and modernization. High school science classrooms are specific learning spaces within the school building requiring the consideration of design, resources and safety features (Motz et al, 2007; NSTA, 2007; NSTA, 2013). For example, science classrooms are unique in the need for lab work spaces, plenty of electrical outlets, running water, and other safety features such as eye washing stations (NSTA, 2007).

The United States Department of Education provides many guidelines for constructing quality science classrooms. However, many current science classrooms were built before modern science standards were instituted (Motz et al., 2007). Unfortunately, even new science classroom construction planning often ignores design standards that incorporate flexibility, increased space for movement, and ample equipment due to the increased costs of providing these features (Motz et al., 2007). Studies have been conducted about certain technologies and pedagogies within science classrooms (Berk et al., 2014; Campbell, Zhang, & Neilson, 2011; Chen, 2013; De Jong, Linn, & Zacharia, 2013; Freeman et al., 2014; Gilmore, 2013). However, research specifically examining the effects of high school science classroom conditions on students' attitudes about science is scarce. The focused examination of the effects of the science classrooms and available science resources could add to the existing body of literature by increasing understanding about possible variables affecting students' attitudes toward science. Such studies will be valuable for stakeholders and decision makers when planning school building funding and resource allocation. Effective school building improvements and effective distribution of resources could encourage teachers and students and ultimately increase academic achievement.

Given the established evidence that classroom resources affect student performance, this study identifies predictive relationships between the quality of science learning spaces and ways in which this quality affects students' feelings about the field of science. The purpose was to identify the relationship between science teachers' perceptions of their classroom facilities and students' attitudes toward science using archival and nationally representative data from the High School Longitudinal Study of 2009 (NCES, 2012).

Planning for modern, effective research-based teaching methods require appropriate educational facilities and resources. The research questions examined how accurately ninth grade students' enjoyment with science, boredom with science, and value of science could be predicted by the science classroom facility conditions and the available resources of demonstration and instructional equipment.

LITERATURE REVIEW

The end target of this review was to explore how science classroom conditions and available resources affect students' attitudes toward science. Searches for available and valid studies were conducted in the areas of school building conditions, school building effects on students' academics and behavior, available educational resources and the possible effects, current science classroom conditions, and the effects of the science classroom conditions and available resources on students' attitudes.

As stated earlier, many schools in America are in poor or unsatisfactory conditions. Kozol (2012) brought this to light when he wrote about the substandard K-12 facilities in low-income communities. Many schools in poor districts lack basic elements such as appropriate climate control, working plumbing, and adequate lighting. Research conducted over the last two decades has provided evidence that unsatisfactory or poor building conditions are correlated with a decline in academic success (Earthman, 2006; Earthman, Cash & Van Berkum, 1996, Lemasters, 1997).

Generally, evidence suggests that the condition of school facilities affects occupants' attitudes and performance (Bowers & Urick, 2011; Cleveland & Fisher, 2014; Earthman & Lemasters, 2011). Science students in satisfactory facilities have been shown to score 2-4%higher than students in unsatisfactory buildings (Bullock, 2007). Similar remarkable findings have been shown in several other academic disciplines among high school students (Buckley, Schneider, & Shang, 2004; Blincoe, 2008).

Three recent studies in particular have investigated facilities' effects on student academic achievement (Uline & Tschannen-Moran, 2008; Uline et al., 2009; Uline et al., 2010). School social climate was clearly identified as a link between school facility conditions and student achievement (Uline & Tschannen-Moran, 2008). In other words, if the school facilities are in poor quality the school climate is negatively affected and this in turn has a negative impact on achievement.

A second study in the series was a multiple case study that discovered themes relating to the perceived quality of the physical school structure (Uline et al., 2009). These themes consisted of movement, aesthetics, lighting, adaptable classrooms, and the density of the population of the building. The emerging themes showed the importance of students feeling a sense of ownership and autonomy within the learning spaces and the ability to move easily throughout the building (Uline et al., 2009). Recent literature has continued to support these findings (Baker & Bernstein, 2012; Tanner, 2015).

The third and final study in the series by Uline et al., (2010), conducted in a western state, found a strong relationship between the quality and condition of school buildings and school social climate. The use of different demographic areas for these studies supports the conclusion that effects of school building conditions are not merely regional. .

Teachers are also affected by the conditions of the school building. Current literature affirms that there is a relationship between the physical work environment of teachers and their resultant positive or negative attitudes about teaching (Earthman & Lemasters, 2009 Leigh (2012). Teachers tend to react with positive attitudes when buildings are maintained or improved (Bailey, 2009). Uline et al., (2010) also found evidence to indicate the physical school building can have an influence on a teacher's choice to work in a certain school. Teachers in less than satisfactory facilities feel less supported and are often less successful than those in facilities that provide clean, safe, and encouraging learning spaces (Ladd, 2011).

Science Classrooms and Available Science Resources

Science classrooms are not immune to the need for repair and improvement. However, an additional layer of concern for science classrooms specifically is the need for additional elements to be both functional and safe for the teachers and students to explore effectively the subjects inherent to studying science (NSTA, 2013). For example, Kozol (2012) identified a number of schools where science labs had broken plumbing, inadequate lab tables, little or no laboratory equipment, and a lack of basic supplies. Students are obviously underserved in classrooms where even the most basic science experiments cannot be adequately or safely conducted.

Early on in the research about the effects of school buildings on academic achievement, Cash (1993) stated "science achievement scores were better in buildings with better science laboratory conditions" (p. 7). Hands-on learning experiences are essential to learning science, and the need for the appropriate facilities and resources are critical for educators to provide these fundamental experiences (Berk et al., 2014; Campbell et al., 2011; Chen, 2013; De Jong et al., 2013; Freeman et al., 2014; Gilmore, 2013).

Science classrooms also need adequate space to be conducive to hands-on activities (NSTA, 2013). In order for teachers to use pedagogy that involves active engagement of students in the area of science, teachers must have access to appropriate classrooms spaces and stations in addition to appropriate demonstration and instructional equipment (NSTA, 2013).

In 2007, National Science Teachers Association (NSTA) listed declarations for science rooms that remain in place as current guidelines. These declarations include the following: science classrooms should only be used for science; enough space should be provided for each student as well as the adequate number of lab stations with access to gas, electricity, and water; correct safety equipment, correct technical, and support equipment for instruction should be provided; and adequate storage space for needed supplies should be readily available (NSTA, 2007).

First, science labs should not be used for non-science classes, especially by non-science teachers, because these teachers may not be aware of the safety precautions necessary around the specialized equipment (NSTA, 2007). Second, adequate space should be available, and therefore, a science lab should not be overcrowded. Overcrowding is a concern in any educational setting, however, it is of special concern in science classrooms, where overcrowding increases risks of accidents and injuries (Motz et al., 2007). Overcrowding includes the following factors: the number of students in the class, the workspace available to each student, and the maximum allowed occupancy for the classroom (NSTA, 2014).

Third, appropriate and adequate lab spaces and the equipment necessary for each student to participate in demonstrations are critical to provide a suitable learning environment and also to insure the highest level of safety (NSTA, 2013). The science classroom and lab should also provide workstations for students with disabilities (NSTA, 2007). Science curricula also require access to outdoor areas as part of the science classroom and curriculum, and these considerations should be part of science classroom design (NSTA, 2007). Fourth, adequate, appropriate, and secure storage should be provided for science lab chemicals that could be dangerous if handled inappropriately (Chan & Dishman, 2011, NSTA, 2007).

Technology in The Science Classroom

In addition to the science resources already mentioned, technology resources need to be considered. Classrooms for science related studies are more effective if they offer access to technology (Shen, Lei, Chang, & Namdar, 2013; Shieh, 2012). Technology has been found to help students become more interested in their science subject within the classroom as well as increasing their extra-curricular participation in science activities (Butler et al., 2014; Shen et al., 2013; Shieh, 2012). One study by Shieh (2012) found evidence to support the use of specific physics technology, Technology-Enabled Active Learning (TEAL). Another study found Technology Enhanced Model-Based Instruction (TMBI), another pedagogical technique that utilizes technology and group learning, to improve science achievement (Shen et al., 2013).

An important technology consideration of modern science classrooms is the inclusion of the required technology for virtual labs. De Jong et al., (2013) conducted a study comparing the value of physical and virtual laboratories, and found that both have advantages for learning. However, a combination of both physical and virtual lessons appeared to have the most positive impact on achievement. The use of science equipment in physical labs helped the students develop practical skills in a real-world situation that included problems with equipment, flaws in measurements, and observations over a long period of time (De Jong et al., 2013).

The virtual labs have advantages in that experiments do not need to take as much time to complete and elements such as heat and time can be altered in ways that are not possible within many physical laboratories (De Jong et al., 2013). Both physical labs and virtual labs are helpful as stand-alone features of a science classroom; however, the most advantage appeared to be when the two were used in combination.

Student Attitudes toward Science: Enjoyment, Engagement and Value

Students' attitudes toward science can be predictive of their achievement and future plans in the field; therefore, understanding variables that contribute to students' attitudes toward science could be beneficial in helping to encouraging positive attitudes and ultimately helping students to be more successful (Newell, Tharp, & Moreno, 2015). With studies showing that students' attitudes toward science, including their self-efficacy and interest in the subject, can reflect their future participation or career plans (Newell et al., 2015; Unfried, Faber, Stanhope, & Wiebe, 2015), and with the decrease in students entering the STEM field it is more important than ever to understand and promote positive attitudes toward the sciences. With this being the case, educators at all levels are encouraged to discover ways to improve students' attitudes toward science (PCAST, 2010; Unfried et al., 2015).

Certain ways to improve attitudes have already been identified. Such as evidence showing that students find more value in their science classes when they do hands-on experimentation than if they are just passively receiving the information (Campbell et al., 2011; Gilmore, 2013). Also, evidence supports the theory that active learning increases students' interest in science and their confidence in being able to perform and apply science concepts (Berk et al., 2014). One particular study demonstrated the success of using hands-on medical problem solving to increase student self-efficacy in that area of science (Berk et al., 2014). This type of problem solving requires specific equipment and classroom space. Another study by Freeman et al., (2014) also found that with all class sizes active learning helped to increase overall academic achievement and decrease failure rates. A meta-analysis that examined 225 studies supported the positive effects of active learning for STEM classes (Freeman et al., 2014).

Campbell et al., (2011) emphasized that in order to do true science experiments, teachers and students have to access to the correct lab space and resources. They also discussed the importance of hands-on activities that cause the students to get "messy" while learning science, in order to experience the true value of the subject.

Since science classrooms vary drastically along with the school facilities around the nation, an assumption could be made that students' attitudes about science could be affected by the quality of the facilities and resources available at their schools. The inequities may be contributing to lower interest and lower achievement for those students that do not have adequate access (Carter & Welner, 2013). As stated earlier, Kozol (2012) witnessed science classrooms in deplorable conditions and without science equipment for demonstrations or experimentation. How can educators be expected to help promote positive attitudes toward science if they are unable to demonstrate and draw their students into active participation?

Summary

Although much research has been conducted in the area of school facility effects, the need remains for replicate studies, studies with larger and more nationally representative samples, studies that examine subject specific classrooms, and studies that assess individual features within educational spaces. Currently, evidence shows that the conditions of the physical school buildings affect teaching and learning (Baker & Bernstein, 2012; Cash, 1993; Lemasters, 1997; Uline et al., 2010; Earthman & Lemasters, 2011) and the health of the occupants (Angelon-Gaetz et al., 2014; Baker & Bernstein, 2012; Muscatiello, 2015) and suggest that appropriate classrooms, and resources, including appropriate and adequate technology, increase academic achievement (Baker & Bernstein, 2012; Tanner, 2015).

In addition to researching the effects of the physical facilities, this review identified the importance of appropriate equipment and resources within classrooms, specifically within science classrooms. Research was scant on the need for appropriate science equipment; however, many studies discussed the benefits of hands-on learning in science classrooms, which require flexible spaces (Duncanson, 2014) and access to equipment and supplies (Savasci & Tomul 2013). To perform many types of hands-on learning, teachers and students need access to the appropriate instructional and demonstration equipment as well as appropriate technology.

This literature review highlights the need to focus on the effects of science classroom facilities and equipment on students' attitudes toward science. Antiquated, over-populated classrooms certainly do not provide appropriate learning spaces for teaching and learning in any discipline, especially science.

DATA AND PROCEDURES

This correlational study investigated a predictive relationship between high school science teachers' perceptions of the physical classrooms and school science resources and ninth grade students' attitudes about their current science class. The predictor variables obtained from HSLS:09 were science teachers' responses to questions about the effects of available instructional equipment, available demonstration equipment, and the available physical facilities for science instruction. Instructional equipment was defined as the equipment that students would use during instruction (NCES, 2011a). Demonstration equipment was defined as the equipment used by the teacher during instruction for the purpose of demonstrating science concepts (NCES, 2011a). The physical facilities were defined as the classroom in which the teacher was teaching the subject of science (NCES, 2011a). The criterion variables were the students' responses to questions about their attitudes toward the subject of science in which they were enrolled at the time they filled out the survey. The individual criterion variables were students' enjoyment of their science class, boredom with their science class, and perceived value of their science class (NCES, 2011a).

Participants and Setting

The High School Longitudinal Study of 2009 (HSLS:09) is the fifth and most recent in a series of longitudinal studies conducted by NCES to examine trends in education, and was intended to examine transitions of high school students from their high school freshman year into adulthood, focusing on their choices related to STEM education and careers (NCES, 2011a). The population of HSLS:09 was all ninth graders in 2009 from across the United States attending a school that had both ninth and eleventh grades (NCES, 2011a).

The sample collected for HSLS:09 consisted of a two-step process. First, 1,889 schools were randomly identified from across the nation. Of those 1,889 schools, 944 participated in the HSLS:2009. Second, approximately 25 ninth grade students were randomly chosen from each of those 944 schools (NCES, 2011a). Students with severe disabilities or barriers of language were excluded from the sample. The students were the primary unit of analysis and numbered 24,658. Science teachers were chosen for participation only if they were teaching one of the sampled students (NCES, 2011a). The variable used for this study, both from the ninth-grade students and the science teachers, was obtained in the fall of 2009 (NCES, 2011a).

Sample For The Study

The researcher of this study further refined the sample from the HSLS:09 dataset by deleting all cases with any of the missing predictor or criterion variables. The final number of cases totaled 11,523. The make-up of the student sample (N = 11,523) for the criterion variable is shown in Table 1.

Table 1: *Demographics of Student Sample*

Sex	
Male	5762
Female	5761
Race/ethnicity	
American Indian/Alaska Native	68
Asian/Pacific Islander	986
Black or African American	999
Hispanic	1627
White	6811
Other race, more than one race or missing	1032
Schools attended by Region	
Northeast	1689
Midwest	3156
South	4238
West	1719
Missing/Not Applicable	721
Schools attended by locale	
City	3002
Suburban	3264
Town	1366
Rural	3172
Missing/Not Applicable	719

The make-up of the teacher sample (N = 11,523) for the predictor variables consisted of the science teachers of the sampled students. Teacher gender, race/ethnicity and the highest degree earned are displayed in Table 2.

Table 2. *Science teacher demographics*

Sex	
Male	5066
Female	6456
Missing	1
Race/ethnicity	
Asian/Pacific Islander	219
Black or African American	423
Hispanic	395
White	10233
Other race, more than one race or missing	253
Highest degree earned	
Bachelor's degree	4911
Master's degree	5834
Educational Specialist diploma	380
Ph.D./M.D./law degree/other prof degree	398

Instrumental

The data used for this study came from two instruments that are both part of The High School Longitudinal Study of 2009 (HSLS:09). The instruments are *HSLS:09 Base Year Student* and *Base Year Science Teacher Questionnaire* (NCES, 2011a). The purpose of the HSLS:09 was to "attempt to identify factors such as motivation, beliefs, and interests that lead to academic goal-setting and decision-making" (NCES, 2011a, p. iii).

The student survey

The student survey contained questions about demographics, school related experiences, locating information, and subject related topics (NCES, 2011b). The student instrument was designed to take no more than 35 minutes and was to be administered by computer during a school day. However, a few of the surveys were administered by phone to students who were unable to complete them at school. The variables used for this study were taken from questions that consisted of four-point Likert scale responses.

The teacher survey

The web-based science teacher questionnaire was designed to take less than 30 minutes and could be completed at the convenience of the teachers (NCES, 2011b). The variables used for this study were taken from questions that consisted of four-point Likert scale responses.

Procedures

The complete dataset was acquired through the Education Data Analysis Tool (EDAT) section of the NCES website (NCES, n.d.) and was downloaded directly unto the researcher's password protected computer and then imported into SPSS 22. This dataset consisted of all surveyed students as individual cases. Each individual student case had all the variables from the student survey, the teachers' surveys, the parent's surveys, and the administrators' surveys.

The researcher identified the necessary variables to be extracted out of the 4000 plus available variables using the documentation available on the dataset (NCES, 2011a). The researcher used EDAT to create a syntax file that could be run through SPSS to sparse out the required variables from the complete HSLS:09 dataset. The researcher then ran the syntax file and extracted the necessary variables. The researcher then manually coded the remaining variables to ensure that missing data would be examined appropriately. Missing data had originally been entered as -9, -8, and -7. Through the discrete missing variable feature on SPSS those entries could be excluded from analysis. In other words, cases where responses on the necessary variables were missing from the student or science teacher were excluded from the dataset. The final number of cases with all the predictor and criterion variables equaled 11,523 cases. Once the dataset had been downloaded, extracted and prepared for the study it was ready for the data analysis.

DATA ANALYSIS AND SCREENING

Prior to data analysis, the data was screened for missing data and data inconsistencies using the sort function on SPSS. Data screening was conducted on each of the predictor variables (instructional equipment, demonstration equipment, physical facilities) and criterion variables (enjoyment of science, value of science, and boredom with science).

Box and whiskers plots were used to detect outliers on each of the predictor and criterion variables. Outliers were found on the criterion variable of students' value of science. The researcher then produced standardized z scores and found all within normal range (between -3.30 and +3.30) as defined by Warner (2013, p. 153). The lowest z-score was -2.72 and the highest z score was 1.13. Normality was then examined through a series of histograms and found tenable.

Assumption Testing

Multiple linear regression analysis required that assumptions of bivariate outliers, multivariate normal distribution, and the absence of multicollinearity be met (Warner, 2013). Scatterplots were used to determine the assumptions of bivariate outliers and multivariate normal distribution and the relationships between the criterion and predictor variables were found tenable.

The assumption of the absence of multicollinearity for the predictor variables was then assessed using the variance inflation factors (VIF). They were all within normal range of 1 and 5 indicating the predictor variables were not correlated strongly (Green & Salkind, 2011). See table 4 for variance inflation factors.

Table 4: *Variance Inflation Factors*

Variables	VIF
Predictor	
Instructional equipment - N1STUEQUIP	1.42
Demonstration equipment - N1DEMOEQUIP	1.42
Physical facilities - N1FACILITIES	1.42

After data screening was conducted and assumptions were tested, three multiple linear regressions were run to analyze each null at the 95% confidence level. A multiple regression analysis was conducted to evaluate how well science teachers' perceptions of their classroom and available resources predicted high school students' attitudes about science.

FINDINGS

Descriptive Statistics

The mean and standard deviation for each of the variables (N = 11,523) are displayed in Table 3.

Table 3: *Mean and SD for each variable*.

Variables	Mean	SD
Criterion		
Enjoyment of science - S1SENJOYING	2.20	.82
Science is a waste of time - S1SWASTE	3.12	.78
Boredom with science - S1SBORING	2.72	.89
Predictor		
Instructional equipment - N1STUEQUIP	1.88	1.04
Demonstration equipment - N1DEMOEQUIP	1.99	1.06
Physical facilities - N1FACILITIES	1.79	1.11

Research Question One

The first research question looked at students' *enjoyment* of science class and the teachers' perceptions of the instructional equipment, demonstration equipment, and the condition of the school building. The multiple linear regression, with all three of the predictors, was statistically significant, $R = .05$, $R^2 = .003$, adjusted $R^2 = .002$, $F(3,11519) = 9.68$, $p < .01$. Meaning approximately .2% of the variance of student *enjoyment* could be predicted from the linear regression of these variables. As the linear combination of predictors indicated an increase in the teacher's perception that their teaching was limited, student *enjoyment* decreased. The null hypothesis was rejected.

The best predictors of high school students' *enjoyment* of their science class were demonstration equipment ($p < .001$) and facilities ($p < .001$). Instructional equipment was not a significant predictor of students' *enjoyment* of their science class ($p = .34$). The strength of each individual predictor was analyzed through partial correlation. The partial correlations showed the relationship between the criterion variable and each predictor variable while controlling for the other predictors. These results showed that demonstration equipment ($r_{partial} = .04$) and the condition of the facilities ($r_{partial} = -.03$) were statistically significant ($p < .001$). Demonstration equipment shortage had a weak relationship with students' decreased *enjoyment* of their science classes. The correlation between facilities and students' *enjoyment* of science is significant, however it is below an extremely small effect size. Instructional equipment ($r_{partial} = -\ .01$) did not have a statistically significant relationship with student *enjoyment* ($p = .34$). See table 5.

Table 5: *Partial Correlations of Predictor Variables with Criterion Variable Enjoyment of Science*

Variable	B	Sig.	Partial Correlations	Sig.
Instructional Equipment	-.01	.34	-.01	.34
Demonstration Equipment	.05	.00	.04	.00
Facilities	-.03	.00	-.03	.00

Research Question Two

The second research question examined students' *boredom* of their science classes and the teachers' perceptions of the instructional equipment, demonstration equipment, and the condition of the school building. The multiple linear regression, with all three of the predictors, was statistically significant, $R = .05$, $R^2 = .003$, adjusted $R^2 = .002$, $F(3,11519) = 9.812$, $p < .01$. Meaning approximately .2% of the variance of student *boredom* could be predicted from the linear regression of these variables. The null hypothesis was rejected. The data could be interpreted as an increase in teachers' perceived limitations indicated a decrease in student *boredom*. The results are contradictory to the first null and should be interpreted with caution as the student question about *boredom* was negatively worded which can cause confusion (Johnson, Bristow, & Schneider, 2011).

The best predictors of high school students' *boredom* of their science class were demonstration equipment ($p < .001$) and facilities ($p < .001$). Instructional equipment was not a significant predictor of students' *boredom* of their science class ($p = .19$). The strength of each individual predictor was analyzed through partial correlation. See table 6. The partial correlations showed the relationship between the criterion variable and each predictor variable while controlling for the other predictors. These results showed that demonstration equipment ($r_{partial}$ = -.demonstration equipment shortages limited teaching the students' *boredom* with science increased. The correlation between facilities and students' *boredom* with science is significant, however it is however it is below an extremely small effect size. Instructional equipment ($r_{partial} = .01$) did not have a statistically significant relationship with student *boredom* ($p = .19$). See table 6.

Table 6: *Bivariate Correlations of Predictor Variables with Criterion Variable Science is Boring*

Variable	B	Sig.	Partial Correlations	Sig.
Instructional Equipment	.02	.19	.01	.19
Demonstration Equipment	-.06	.00	-.04	.00
Facilities	.04	.00	.02	.00

Research Question Three

The third research question looked at students' *value* of science class and the teachers' perceptions of the instructional equipment, demonstration equipment, and the condition of the school building. The multiple linear regression, with all three of the predictors, was statistically significant, R = .05, R^2 = .003, adjusted R^2 = .003, $F(3,11519)$ = 10.818, $p < .01$. Meaning approximately .3% of the variance of student *value* could be predicted from the linear regression of these variables. The null hypothesis was rejected. The data could be interpreted as when the linear combination of predictors indicated an increase in teaching hindrances, student *value* of science increased. The results are contradictory to the first null and should be interpreted with caution as the student question about *value* was negatively worded which can cause confusion (Johnson et al., 2011).

The best predictors of high school students' responses to *value* or whether science is *waste of time* were demonstration equipment ($p < .001$) and facilities ($p < .01$). Instructional equipment was not a significant predictor of students' *value* of their science class ($p = .45$). The strength of each individual predictor was analyzed through a partial correlation. See table 7. The partial correlations show the relationship between the criterion variable and each predictor variable while controlling for the other predictors. These results showed that demonstration equipment ($r_{partial}$ = -.04) was statistically significant ($p < .001$) and the condition of the facilities ($r_{partial}$ = .02) was statistically significant ($p < .05$). As demonstration equipment shortages increased the limitations on teaching, students *valued* science less. The correlation between facilities and students' *value* of science is significant, however it is so small that it is not considered even an extremely small effect size. Instructional equipment ($r_{partial}$ = -.01) did not have a statistically significant relationship with student enjoyment (p = .45). See table 7.

Table 7: *Bivariate Correlations of Predictor Variables with Criterion Variable Science is a Waste of Time*

Variable	B	Sig.	Partial Correlations	Sig.
Instructional Equipment	.01	.45	.01	.45
Demonstration Equipment	-.05	.00	-.04	.00
Facilities	.02	.00	.02	.01

DISCUSSION

The purpose of this correlational study was to examine whether science teachers' perceptions of their physical classroom environment and available resources had any relationship to their ninth-grade students' attitudes toward science. Evidence is growing that the physical school environment has effects on learning (Cash, 1993; Earthman & Lemasters, 2011). This study sought to add to the literature by examining a possible relationship between the effects of the physical science classroom and students' attitudes regarding science (enjoyment of science, boredom with science, and value placed on science).

A significant relationship was found among the linear combination of predictor variables and each of the criterion variables: *enjoyment, boredom,* and *value* or *perceived waste of time*. In other words, if the available equipment and facilities were inadequate, the students' attitudes were affected. The best predictors of high school students' attitudes toward their science class were demonstration equipment and facilities. However, these relationships were weak and should be interpreted with caution.

Enjoyment, an indicator of intrinsic motivation based on the self-determination theory (SDT), is one emotion or attitude that can be predictive of student engagement and academic success (Reeve, 2012). Reeve (1989) stated, "Enjoyment contributes to intrinsic motivation by sustaining the willingness to continue and persist in the activity." Evidence suggests that students' attitudes toward science, including *enjoyment*, correlate with their achievement in the subject (Newell et al., 2015). Meaning that a higher level of *enjoyment* will coincide with a higher level of achievement. Therefore, if students have higher enjoyment due to better demonstration equipment and facilities, then they would be more likely to have higher achievement. This logic would support other literature, which suggests a positive relationship between educational facility conditions and achievement (Baker & Bernstein, 2012; Blincoe, 2008; Buckley et al., 2004; Bullock, 2007; Lemasters, 1997; Uline et al., 2010; Earthman & Lemasters, 2011). Cash (1993) specifically stated that science achievement was higher in schools with higher quality science labs.

Boredom is the lack of interest and/or motivation to engage in an activity. Lack of engagement contributes to lack of achievement (Reeve, 2012), thus an increase in *boredom* could coincide with a decrease in achievement. This logic would support other literature, which suggests a positive relationship between educational facility conditions and achievement (Baker & Bernstein, 2012; Blincoe, 2008; Buckley et al., 2004; Bullock, 2007; Lemasters, 1997; Uline et al., 2010; Earthman & Lemasters, 2011). Just as with *enjoyment*, the results of this study on the variable of *boredom* suggest that facilities influence student boredom.

Value, or students' perceived importance or usefulness of science, is important to science achievement (Newell et al., 2015). The higher value students place on science could coincide with their effort and engagement (Newell et al., 2015; Reeve, 2012). Just as with *enjoyment* and *boredom*, the results of this study on the variable of *value* are in support of studies that suggest that facilities have effects on occupants (Baker & Bernstein, 2012; Blincoe, 2008; Buckley et al., 2004; Bullock, 2007; Lemasters, 1997; Uline et al., 2010; Earthman & Lemasters, 2011).

IMPLICATIONS

Studies have shown that school facility conditions affect the occupants (Bowers & Urick, 2011; Cash, 1993; Cleveland & Fisher, 2014; Earthman & Lemasters, 2011; Lemasters, 1997, Tanner, 2015) and that resources available can be correlated with the condition of facilities (Carter & Welner 2013; Kozol, 2012). Most educational facility studies have been conducted at a regional or state level (Tanner, 2015) and few have been conducted that specifically examine science classrooms. This study added to the body of knowledge by examining the relationship of a nationally representative sample of science teachers' perceptions of the physical high school science classroom environment and their ninth-grade students' attitudes about science.

Educators are encouraged to increase the interest and achievement of students in science fields; therefore, it is imperative to understand the factors that contribute to students' positive attitudes and success. This study helps to identify variables that appear to have an impact on students. Demonstration equipment, the equipment used by the teacher during instruction, appeared to have the most impact. These findings suggest that different types of science classroom equipment might play different roles in students' enjoyment and value of science. These findings also suggest that certain types of equipment in the science classroom have more impact than the physical classroom conditions.

LIMITATIONS

The threats to internal validity include all unknown variables that affected the responses of the teachers and students. There are many variables that studies such as these are unable to control for that would affect the teachers' perceptions of their classrooms and the students' attitudes toward science. The internal threat of subjectivity is also a concern as the survey questions for the teachers and students were about their perceptions. There is also the concern about the unclear definition of the variables chosen for this study as well as the use of the word attitude to encompass those variables.

On the teachers' survey the options available for the teachers to choose about the condition of the facilities and the availability of resources were not based on pre-defined levels. The school buildings could have been considered satisfactory or unsatisfactory with a standardized assessment and the teachers could have indicated the opposite conditions in their classrooms. Two teachers with similar classrooms and available resources could have answered the questions differently. There was no indication about important classroom conditions such as whether the classrooms were overcrowded or whether the classrooms being used for science were indeed designed for science instruction. There was also no indication as to whether or not classrooms were unsafe for any reason. A concern also exists about the reasoning of the high number of teachers who chose not to fill out the surveys.

Another limitation could have been the timing of the survey participation as it was filled out early in the ninth-grade year. Students could have been answering the questions based on their previous experiences in science rather than their current classroom experiences. Research also indicates that student attitudes toward science are established before they enter high school (Newell et al., 2015). The students' attitudes toward science could have been affected by many variables outside of the school condition and available resources.

Another consideration about the surveys is that both the student and teacher surveys used positively and negatively worded questions. Evidence shows that negatively worded questions can lead the answers to be more negative and they can confuse those taking the survey (Johnson et al., 2011). For the variables used for this study the students had one positively worded question and two negatively worded and the teacher had three negatively worded. This could have affected the way these questions were completed. Another concern about the results is that the statistical significance could have been due to the sheer number of cases (N = 11,523); however, the consistency with the three research questions suggests this is not likely.

The threats to external validity or whether the study is applicable to other groups include the fact that the dataset used for this study was from 2009 and the responses of students and or teachers being asked the same questions today or in the future might be different.

RECOMMENDATIONS FOR PLANNING AND FUTURE RESEARCH

Even though extensive planning already goes into the design of school facilities and many studies have already been conducted on the effects of school facilities that have influenced this planning, many gaps remain. This study contributes to the knowledge however, by no means completely fills in a gap. However, as studies advance the knowledge and these gaps are filled, planning and allocating for construction and distribution of resources will become more informed and more effective. Evidence has shown that planning classroom design and layouts appropriately can increase teachers' ability to choose the best teaching methods in order to engage students (Ford, 2016). This study raises awareness that science classrooms have specific needs to accommodate effective pedagogies to inspire and motivate students to remain interested in science fields.

One idea for future study of facilities in general would be to establish a nationwide dataset that investigates specific school building features and elements of school buildings and examines correlates of those variables with occupants' performance, behaviors, and attitudes. Specific types of classrooms could be examined, including science classrooms. Such a database would be strengthened if it were based on a specific theory that pertains to performance and attitudes which could offer a clearer understanding of combinations of variables. Such theories that could be helpful include, however, are not limited to Self-Determination Theory (SDT), (Deci, Vallerand, Pelletier, & Ryan, 1991) or expectancy-value theory (EVT), (Eccles et al., 1983). Examining students' attitudes in light of SDT could focus on occupants' feelings of well-being and levels of autonomous motivation (Ryan & Deci, 2017). Examining student attitudes in light of EVT could focus on their beliefs about the occupants' competence on a given task and the value of that given task (Wigfield & Eccles, 2000). The use of either of these theories in specifically examining students' attitudes toward science could be helpful as students' attitudes are often predictive of their achievement (Newell et al., 2015).

Baker and Bernstien (2012) as well as Tanner (2015) suggest changing the focus of school facility studies from those focused on whether school buildings are adequate or inadequate to those that are functional and high performing. Understanding about individual building elements and combinations of elements may further this research. With a nationwide dataset that focuses on facility questions, it might be easier to control for mediating variables such as school climate, socio-economic variables, community engagement, etc. A national study that was conducted longitudinally such as the one used for this study may be able to investigate relationships between facilities and occupants at different ages and grade-levels.

Future studies on the effects of science classroom conditions, available resources, and available technology on student attitudes could be conducted using different grade levels, and different ages of students. Such studies could provide more understanding about individual elements and also subject specific elements such as those necessary for biology, physics, earth science, or chemistry. With such studies, it would be critical to include an investigation of technology within the science classroom. With the continued increase in technology use this will be an ever-changing area in need of analysis.

Additional studies could be conducted that investigate how school building conditions affect teacher retention. Teacher retention is a concern in our nation especially with math and science teachers. Understanding how the physical school conditions affect teachers' health, attitudes, performance, and ultimately retention rates could be helpful. If building conditions could be identified that affect teacher turnover, then changes and/or improvements might be planned for that would remedy what is becoming an epidemic problem in America. Buckley et al. (2005) examined teachers' reasons for leaving specific schools, or for leaving the profession of teaching entirely, and found the quality of school facilities did influence their decisions.

Any studies that increase the understanding of school building conditions and more specifically those elements and features that have the most impact on occupants will increase the knowledge available to facility planners and maintainers. This study demonstrates that science classroom conditions and the available resources within those classrooms have an effect on the students' attitudes towards science. Planners will do well to be aware of this and to conduct further investigations into the elements and features that will have the most impact.

CONCLUSION

All the null hypothesis in this study were rejected yet the relationships between the conditions in science classrooms and students' attitudes were extremely weak. These results suggest that available science equipment and science classroom facilities do have a relationship with students' attitudes of *enjoyment*, *boredom* and whether students *value* science or perceive it is a waste of time. For the sake of this conclusion the three attitudes of *enjoyment*, *boredom*, and *value* will be combined and discussed as students' attitudes toward science. This is being assumed even though Reeve (1989) suggested a clear difference between enjoyment and interest, which can be seen as a value and/or the opposite of *boredom*, and the variance inflation factor (VIF) scores for these variables also clearly showed that each variable measured a unique aspect of attitude. The relationships between the predictors and each criterion variable were extremely weak; however statistically significant, meaning the conditions of the science facilities and available resources did affect different aspects of students' attitudes.

Extensive research exists on students' attitudes based on self-determination theory (SDT) and for that reason this researcher proposes using this theory to further examine these results considering what is known about students' attitudes and motivations. SDT proposes that optimal motivation occurs when a person feels autonomy, competence, and relatedness to others (Deci & Ryan, 1985). This researcher proposes that regardless of the physical conditions of the science classroom and adequacy of available resources, the influence of teachers who can promote the feelings of autonomy, competence, and relatedness within students outweighs these variables. This does not mean that educational facility conditions should not be considered; however, it suggests that many other variables are influencing classroom outcomes. In optimal conditions, teachers would not need to accommodate for poor facilities or lack of appropriate equipment.

The student-teacher dialectical framework within self-determination theory explains that the learning environment either supports or thwarts the positive emotions and positive attitudes of students such as those being examined in this study that in turn affect motivation (Reeve, 2012). This framework does not consider the physical facilities; however, evidence is available that shows the physical condition of learning spaces and the available resources contribute to the overall classroom environment and the climate within the school (Uline et al., 2010). Evidence also shows that the overall climate within the school influences the occupants (Uline et al., 2010).

In addition, studies are available on the effects of redesigned science classrooms at the college level. Improvements to college science classrooms have shown to produce increases in interest, engagement, and achievement (Park & Choi, 2014). Studies of college science classrooms have also shown that the more a classroom environment promotes student autonomy both socially and physically, the more likely students are to have positive attitudes about the subject (Ratelle et al., 2007).

With the considerations about the effects of the school climate it could be surmised that although the physical conditions of the learning spaces do influence the students, there are other variables that may have more of an effect. It can be assumed that other variables whether they correlate with the school conditions or not, have a stronger influence over students' attitudes. The climate of the classroom, whether it is in poor physical condition or not, can be more influenced by the attitude of the teacher and the techniques the teacher employs. Science teachers could be utilizing teaching methods that encourage students' feeling of autonomy, competence, and relatedness through maintaining students' attention and engagement.

The fact that demonstration equipment, the equipment used by the teacher, had the most predictive value may mean that if a science teacher has adequate demonstration equipment he is able to engage the students in learning the subject regardless of whether the classroom conditions are satisfactory or whether there is adequate instructional equipment. The demonstrations led by the teacher, if done effectively, could be successfully meeting the needs as identified by SDT. The teaching techniques used during demonstration could involve volunteers (autonomy), could engage the whole class (relatedness) and could help all the students feel successful (competence).

Instructional equipment used by the students during instruction, did not appear to have a significant relationship with any of the examined attitudes. This appears to be contradictory to studies that demonstrate that hands-on learning is preferred by students (Berk e al., 2014; Gilmore, 2013; Hofstein & Lunetta, 2003); however, there is evidence that experiments can be time consuming and even frustrating to some students (Hofstein & Lunetta, 2003).

Even though the effects of facilities and available resources in this study appear to have only an extremely small effect size on student attitudes, a consistent statistical significance was found with each null. With this as a consideration, and evidence provided from a long list of other studies that facilities affect occupants, it is imperative to continue examining how school facilities and resources affect occupants and how these effects need to be considered when planning the design and redesign learning spaces.

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