Physical Environmental School Conditions and Student Performance or Behavior: A Summary of Several Studies

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
Ahrentzen, S. and G. W. Evans (1984)	- more open and nonpermanent structures on perimeter of classroom, greater distraction, less satisfaction - Spaciousness in classroom, less kinetic and visual distraction, and greater satisfaction - Modified activities to reduce noise in open classrooms - Private areas and desks, greater satisfaction and perceived privacy	13 fourth, fifth and sixth grade teachers and 65 randomly selected students from 5 schools	Interior spaciousness, Perimeter, privacy amenities	Distraction, activity restrictions, privacy	Distraction affects teachers more than students. Greater structural wall area, less distraction, greater satisfaction and less restriction of activities. Open perimeter - less kinetic distraction and more satisfied teacher. Students associate higher ceilings with more kinetic distraction, but less visual distraction.
Bowers, J. H. and C. W. Burkett (1987)	Differences will exist between the new and old schools in achievement, disciplinary actions, health and attendance between new and old schools (better in new)	Two hundred eighty fourth and sixth grade students (some in a new and old school) to determine academic achievement.	Age of the school	Attendance, health, discipline, achievement	Higher achievement in math, reading, listening and language, fewer health problems, fewer discipline problems and higher attendance in new school
Cash, C. S. (1993)	Better building conditions will improve student achievement and behavior	rural schools in VA, 47 schools total	Building condition: as determined by the Commonwealth Assessment of Physical Environment. These assessments were conducted by school personnel in the divisions of the schools	Student Achievement: Scale scores of the Test of Academic Proficiency for grade 11; Student Behavior: number of expulsions, suspensions, and incidences of violence/ substance abuse compared to the number of total students.	Student achievement was higher in schools in better condition; Science achievement was higher in schools with better lab facilities; cosmetic conditions impact achievement more than structural conditions; "varying climate control, locker, and graffiti conditions were factors which were positively related to student achievement scale scores." Higher quality buildings were correlated to higher incidents of undesirable behavior.

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Chan, T. C. (1980)	Physical conditions including AC, carpeting, fluorescent lighting and pastel colors affect student achievement.	8th grade students in 191 public standard schools in Georgia	presence or absence of 1. air conditioning 2. carpet 3.fluorescent lighting 4. interior pastel coloring	academic achievement, as measured by scores on the Iowa Test of Basic Skills (1975-1976)	Vocabulary scores for students were higher in air-conditioned schools when compared to non-air conditioned schools. No difference was found in the composite, reading, language, work-study and mathematics sections of the ITBS; No significant differences were observed in academic achievement were observed for the presence or absence of fluorescent lighting, carpeting or pastel coloring.
Chan, T.C. (1982)	Is there a difference in student attitude toward a new and old school; Are there differences in attitude according to race, sex, socio-economic status?	Control group= 119 students (grades 2,3,4) in an old school building (1936) Experimental group = 96 students (grades 2,3,4) in an old school building (1923) who were moved to a new school (1980)	building-condition related variables, including age	attitude	More positive attitudes towards the newer school; Females had higher ratings than males in the control group, but no difference in experimental group; Race, SES "had no effect on pupil attitudes toward school buildings."

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Cheng, Y.C. (1994)	Is there a relationship between “student affective performance and classroom physical environment, social climate, and management style?”	21,622 students from 678 classes of mainly sixth-grade students in 190 sampled primary schools	include 11 items to assess the quality of the physical environment in the classroom including physical facilities, cleanliness, spacing, neatness and a lack of pollution. Student perceptions are used to evaluate these physical conditions; Class master's leader behavior; Use of power; Social climate in the classroom	Individual student affective performance (self-concept, attitudes toward peers, attitudes toward school, attitudes toward teachers, self-efficacy of learning, feeling of homework overload and intention to drop out).	quality of physical environment, social climate, and class master's management style related substantially to nearly all the measures of student affective performance except self-concept."
Christie, D. J. and C. D. Glickman (1980)	How does noise level affect student intellectual performance? As children age, they will be better at ignoring distracting noise.	156 children from a public school in Central Ohio. All of the children were from traditional self-contained classrooms	noise level	Achievement on Standard Progressive matrices	"Children's performance on the Standard Progressive Matrix task increased consistently with age." "the current research offers evidence for the notion that boys are able to solve more complex matrix problems in a noisy environment." "Females tend to perform higher in a quiet rather than noisy environment." “the effects of classroom noise do not vary with age.”
Cohen, S. and S. L. Trostle (1990)	What are the preferences of school-aged children for physical environmental features of a school?	78 kindergarten and 1st-grade children in public schools.	size, shape, color, complexity, texture, lighting, as presented on test cards for a “pretend” school and school yard	Preferences	Girls had mean scores higher than boys for complexity, color, texture and lighting. Boys preferred larger features. Older children preferred multi-shaped objects, complex items and more dramatic colors, as well as more intense lighting than younger children, who also preferred larger characteristics.

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Cotterell, J. L. (1984)	Lower student anxiety expected in open school; Lower anxiety in low conceptual level Students anticipated	142 intake students from 4 suburban high schools, 2 open and 2 conventional,	Open vs. closed school plan	Student personality (CL); Classroom; Student Behavior; Anxiety	"Students in open plan high schools, compared with those in high schools of conventional design, experienced less initial anxiety pertaining to locating school buildings, but greater anxiety within the classroom. Observations found greater amounts of student off-task behavior in open plan classrooms, and higher rates of managerial intervention by teachers in the transitions from one activity to another."
Edwards, M. M. (1991)	1. Does parental involvement impact building conditions? 2. Do building conditions impacts student achievement?	Uses 2 data sets – a larger set, and a subset of 52 schools that were surveyed – all in the Washington DC area.	Size of Parent Teacher Association budget, Overall condition of school building	Academic achievement	Age predicts building conditions; Higher enrollment related to better building conditions; Higher PTA budget correlated with improved building conditions; as income in surrounding area increased, so does building condition; Improvement in building condition is associated with improved student achievement.
Evans, G. W. and L. Maxwell (1997)	1. Does language acquisition act as a mediator between noise exposure and reading deficits? 2. Is short (acute) or long-term (chronic) exposure to noise contributing to reading problems?	116 first and second graders (53% female), for whom English is their first language, from 2 elementary, predominantly Black schools in New York City	Noise: Inside or outside a 65 Leq flight contour	Reading skills; language acquisition (speech and sound perception)	chronic noise exposure is correlated with reading scores. Speech perception, not sound perception, acts as a partial mediator.

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Grandgaard, E. M. (1995)	What is the effect (behavioral and physiological) of color and light on young children?	five 6-yr old boys and six 6-yr old girls in a public school.	white walls and cool-white fluorescent lights versus light blue walls and full-spectrum lighting	Off-task behavior; mean blood pressure	“The study found that the students accumulated a total of 390 off-task behaviors in the standard classroom compared to 310 in the modified classroom, a decrease of 22 percent. It also found that students' mean blood pressure readings were nine percent lower in the modified classroom when compared to their readings in the standard classroom."
Heschong Mahone Group (1999)	Daylighting form windows or skylights will impact student performance	21,000 students from 3 school districts	demographics, window tint and size, presence and type of skylights, amount of daylight expected.	test scores in math and reading (unclear what test was used)	“students with the most daylighting in their classrooms progressed 20% faster on math tests and 26% on reading test in one year than those with the least. Similarly, students in classrooms with the largest window areas were found to progress 15% faster in math and 23% faster in reading than those with the least. And students that had a well-designed skylight in their room, one that diffused the daylight throughout the room, also improved 19-20% faster than those students without a skylight. We also identified another window-related effect, in that students in classrooms where windows could be opened were found to progress 7-8% faster than those in rooms with fixed windows.

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Hood-Smith, N. E. and R. J. Leffingwell (1983)	What are “the effects of the rearrangement of the desks in an open classroom on the incidents of disruptive behavior occurring in that classroom”?	Students in one disruptive classroom in a secondary school	Furniture arrangement	Various behaviors, observed before and after modifications	Teacher felt more in control; students were more comfortable, felt less threatened and were more willing to interact with one another; actual class work time increased; class members were better able to interact with the teacher;
Lackney, J. A. (1996)	1. "What is the perception of the nature of environmental quality within the context of schools?" 2. "Within the context of schools, what are the attributes of environmental quality that are perceived to have an impact on educational outcomes?" 3. "What perceived impact does facility management have, if any, on the perception of environmental quality in schools?" 4. "How can environment-behavior research contribute t the improvement of the environmental quality in schools?" 5. How can environmental quality be assessed in local school contexts?" 6. "How effective is action research in defining problems, providing solutions and increasing knowledge and awareness of environmental quality in schools?"	Parents, teachers, students, administrators, non-instructional staff	physical comfort and health, classroom adaptability, safety and security, building functionality, aesthetics and appearance, (environmental perceptions of students and environmental quality concerns of both teachers and students were included)	"perceived differences in environmental quality, facility management processes and practices and three educational outcome indicators: student academic performance, student social development and teacher instructional performance."	1. action research is an appropriate tool for learning about environmental features that matter the most to school stakeholders. 2. school building occupants perceive that several physical features affect educational outcomes, particularly physical comfort and health, and classroom adaptability impacts on student and teacher performance.

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Ott, J. N. (1976)	Does lighting affect student behavior?	1st grade children in 4 different windowless classrooms.	standard cool-white fluorescent tubes and fixtures with solid plastic diffusers (2 rooms) versus full-spectrum fluorescent tubes with lead foil shields on the ends of the tubes.	Observed behaviors (no specific behaviors sought)	Children in the room with standard lighting were more fidgety, and seen “leaping from their seats, flailing their arms, and paying little attention to their teachers”. Those in the full-spectrum lit rooms were less nervous and paid more attention to the teacher.
Winett, R. A., C. D. Battersby, et al. (1975)	What effects will architectural changes, individualized instruction, and group contingencies on academic work have on student performance in math and language and on behavior?	27 children in a 6th grade public school classroom from a wide range of ability and socioeconomic levels. Only 10 children were observed for behavior.	The architectural intervention consisted of swapping one-piece chair-desks with desks with movable chairs arranged in four groups of eight. Other smaller changes were also made. The changes allowed students to work in groups of heterogeneous ability. (There were other non-arch. Modifications made during the study)	Behavioral observations measured eight children activities (e.g., working independently, interacting with teacher). Four codes pertained to children's communication. Several teacher instructional codes included. Academic work was measured for completion and accuracy for math and language assignments.	“Individualized instruction along had lesser effects, while the architectural changes produced no significant changes in the academic or social behavior or the children or in teacher behaviors."

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Wollin, D. D. and M. Montagne (1981)	"an amiable classroom environment would beneficially affect human performance and interaction. H1:Specifically, it was hypothesized that improved learning would occur in a congenial room." H2: "Student evaluation of the teacher would be more positive and that there would be increased interaction between teacher and students in the experimental room." H3: "Student (user) attitudes toward the experimental room would be more positive than toward the control room and vandalism to the experimental room would be minimal."	Students in 2 introductory Psychology college classes	Interior décor – carpet, plants, furniture, paint, etc.	student scores on tests, student evaluation of the teacher, amount of teacher-student interaction, student reaction to a direct questionnaire inquiring about the room décor, and the amount of vandalism or theft in the experimental room	"The conclusion drawn here is that improving the interior of public buildings in general and college classrooms in particular can have a very beneficial effect on the activity therein. Students perform significantly better on academic tests taken in a congenial room, and they see their teachers in a much more favorable light. The teachers themselves may actually improve their teaching performance in a congenial environment." No significant differences were observed for vandalism or teacher-student interaction."
Downing, C. C. and C. Bayer (1993)	Purpose is to provide a comparison of indoor pollutant concentrations under different outdoor air ventilation rates.	students and employees at an elementary school (only complaints were recorded). Conditions in 3 classrooms were compared.	presence or absence of a total energy recovery wheel system to control humidity. (many measurements were taken)	Number of complaints and results from 4 interview with school staff about problems they experienced before and after intervention	"Implementation of the ventilation rate procedure of ANSI/ASHRAE 62-1989 to achieve 15 cfm (7.5 l/s) per student in classrooms is necessary to reduce CO2 levels below the 1,000-ppm guideline. Reduction s in other pollutant levels, including VOCs and formaldehyde, ranged between 28% and 60% at the ventilation rate of 15 cfm/student"

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Fischer, J. (1996)	"the majority of IAQ problems experienced by school facilities occur as a result of inadequate outdoor air and/or lack of humidity control"	Students and teachers in 8 schools in which serious IAQ problems had been addressed and resolved by incorporating a total energy recovery system.	Type of retrofit equipment, costs, Hydrocarbon contaminant levels, relative humidity,	complaints from students and employees	"Based on established research, the free humidification provided by the total energy recovery technology will reduce the incidence of respiratory illness and absenteeism in the classroom environment, especially in colder climates." "inadequate outdoor air and/or lack of humidity control are the cause of, or at the very least primary contributors to, most IAQ problems encountered by schools."
Green, G. H. (1974)	Reviews 3 studies	kindergarten children in Switzerland	Humidity, temperature	Reported symptoms of the common cold (e.g., sneezing, coughing, sore throat, fever)	"It shows that 3% (test unit) and 5.7% (control unit) of the total maximum study days were absent. These results seem to indicate that an increase in relative humidity from 40% to approximately 50% is favorable under the given conditions."
Green, G. H. (1974)	Reviews 3 studies	Canadian school students in 6 schools (plus 6 more in the later part of the study)	Temperature, relative humidity	Absenteeism and associated records with explanations for absences	"When the schools in the Canadian investigation were divided into humidified and unhumidified groups, the average 10-year absenteeism in the unhumidified schools was found to be 5.08 % and in the humidified schools 4.63%, values which differ at the 95% confidence level."

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Rindel, A., E. Bach, et al. (1987)	"the presence of readily visible man-made mineral-fiber (MMMF) products in the ceiling should be mainly responsible for the occurrence of symptoms and/or disease related to indoor exposure in kindergartens.	Approximately 900 children and 200 adults in 24 kindergartens in Frederiksborg County, Denmark. The facilities were built in the 1970's, did not have wall-to-wall carpeting, and had mo fresh air supplied by mechanical means.	The buildings were assigned to one of 3 categories including, A. MMMF-products with water-soluble binders in the ceiling B. MMMF-products with resin-binders in ceilings C. No readily visible MMMF-products in the ceilings (control), included 8 facilities. Data from a number of indoor environment parameters were collected (e.g., air concentration of VOCs and formaldehyde, air exchange rates, airborne MMMF concentrations, etc.) .	a host of symptom-related information (e.g., irritation of eyes, nose, throat and skin, headaches, tiredness, dizziness, nausea, inflammatory disease, colds, sinusitis, angina and pneumonia) was collected.	"symptoms from eyes and skin were reported more frequently in A and B institutions than in control institutions. The frequencies of diseases and symptoms were uniformly distributed in A and B institutions." “On their own, the technical investigations do not indicate that the symptoms are caused by MMMFs derived from the ceilings." For adults, however, the average concentrations of air-borne MMMFs were positively correlated to eye symptoms, and the presence of settled MMMFs on surfaces occasionally cleaned were positively correlated to skin irritation."