PHYSICAL ENVIRONMENT IN SCHOOL SETTING: CONCEPTUAL REVIEWS

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ABSTRACT

Increasing numbers of educators have begun to believe that the physical environment might have an impact on students' outcomes. There are several research findings indicate that students academic outcomes are affected positively or adversely by the visual, acoustical, and thermal characteristics of the classroom environment (Bowers et al. 1987) such as student behavior (Cash, 1993); attitudes (Weinstein, 1979); and achievement (Cash, 1993; O'Sullivan, 2006); personality development (Roberts and Robins, 2004); student preferences and comfort (Corgnati et al., 2007). Concrete foundation is needed to discuss the circumstances of the physical environment in school setting. The valuable theorists mostly cited as a guidance is person-environment fit theory (Caplan and Van Harrison, 1993). The match between attributes of the person and attributes of the environment reflects the concept of person-environment (PE) fit (Roberts and Robins, 2004). This paper will reviews the related concept of physical environment from ergonomics perspectives which is mostly applied in workplaces setting in order to relate it with the condition or situation in classroom setting.

1.0 Introduction

Classroom is most important supporting elements in teaching and learning processes. Traditionally, it is a space which is design by the architect to accommodate various elements such as chair, desk, cupboard, whiteboard, and audio-visual equipment. Recently, increasing numbers of educators have begun to believe that the physical environment might have an impact on students' outcomes either in short or long terms. Physical environment from ergonomics science perspectives consist of various elements such as temperature, humidity, noise, thermal, air pressure, ventilation, air quality, acoustic, dust, vibration, lighting, air flows, radiation, etc. In fact, students have to spend lots of time in listening and understanding lessons, remaining sitting at their desk, performed several other activities such as discussing, and writing to a certain extent. They are interact with all those elements in physical environment simultaneously without knowing their circumstances may contribute to their performances, safety, and health.

The main glorious expected outcomes at the end is students will achieving an excellence grade result. When many students fail to perform, several traditional reason arouse include improper student attitudes toward teaching and learning, student efforts are weak, student not interested in subject, peer influences, family supports, etc. Teachers, educator, and policy maker is very comfortable to pin-point the reason to the student and parent without any effort to recognizes the weakness of their sides especially related to school facilities, equipment, and environment. This paper will reviews the related concepts of physical environment from ergonomics

perspectives in-terms of thermal environment, air temperature, humidity, indoor air quality, air movement, noise, ventilation, odor, color, and lighting.

2.0 Thermal Environment

Thermal environments can be divided conveniently into hot, neutral (or moderate) and cold conditions. In a simple practical assessment of thermal environments two types of scale are generally used. One type is concerned with thermal, sensation and the other is concerned with acceptability (i.e., a value judgement) (Parsons, 2005). Thermal environment is an important factor that contributes to the health problems in many workplaces. Three factors that determine the thermal environment consist of air temperature, humidity, and air movement (Kohn, 1998). In a proper thermal environment, comfortable conditions for physical work should range between 60^{o} and 68^{o} Fahrenheit. Thermal comfort in built environments is an everyday issue for architects and engineers and one that has been dealt with widely in scientific literature, it is presently gaining a new and increasing interest among designers. Thermal comfort is defined as a state of mind, which expresses satisfaction with the thermal environment (Nicol and Humphreys, 1995; Parsons, 2005), and influenced by individual differences in mood, personality, individual and social factors (Nicol and Humphreys, 1995). As the internal core temperature of human varies only slightly between 36.1^{o}C and 37.2^{o}C, it is often the subjective perception of the thermal environment that is most influential in determining overall comfort (Oborne, 1995). The perception of thermal environment in educational setting was studied by a number of researchers. Physical parameters that always has been used to measure thermal environment consist of air temperature, mean radiant temperature, air relative humidity an air velocity (Corgnati et al., 2007; Olesen et al., 1995; Parsons, 2003) and the clothing worn and the activity of the person (Parsons, 2003). Human physiology varies significantly among individuals, and these differences can affect perceptions of thermal comfort; e.g., higher metabolic rate or increased body fat can cause people to feel warmer (Huizenga et al., 2001).

3.0 Air Temperature

World Health Organization (WHO) recommends a maximum air temperature of 24^{o}C for comfortable work. The Workplace (Health, Safety & Welfare) Regulation, state that a reasonable temperature should be maintained during working hours and the Approved Code of Practice to the regulations state, “that all reasonable steps should be taken to achieve a comfortable temperature” (HMSO, 1992). Indeed, when air temperature increases, workers are more likely to report dissatisfaction over an increase in general humidity, illustrating that this is an important factors in workplace design and the way workers perceived their environment (Palonen et al., 1993). The thermal comfort parameters included room air, mean radiant, plane radiant asymmetry, and dew point temperatures, as well as air velocity and turbulence intensity Haghighat and Donnini (1999). Physiologically, when environmental temperature increases people will sweat and blood will be redirected to the surface of the skin in order to maintain homeostasis. As such, fatigue and de-hydration can occur sooner than it would in a cooler environment with alertness and metal ability suffering as consequences (Wilson and Corlett, 1995). Indeed, “the frequency of accidents, in general, appears to be higher in hot environments than in more moderate environmental conditions. One reason is that working in a hot environment

lowers the mental alertness and physical performance of an individual" (NIOSH, 1992). Currently, there are many evident to support the strong relationship between temperatures and student performance (Wargocki et al., 2005; Kahl, 2005; Shaughnessy, et al., 2006; and Wargocki and Wyon, 2007) and their behaviors. Temperature up to 25^{o}C has a psychological effect in which could be reduce mental abilities, work output and performances. Temperature should be considered when assessing human response to thermal environments (Parsons, 2000). However, the effects of room temperature on performance, arousal, and comfort in different tasks (reading, mathematics, and memorization) found participants' physical comfort was dependent on ambient temperature (Kahl, 2005). Air temperature can be measured in several ways includes liquid thermometer, resistance thermometer, and thermocouples (Olesen and Madsen, 1995).

The Education (School Premises) Regulations 1999 (ATL 2008) prescribe minimum standards for temperature as shown in Table 1.

Table 1 Minimum standards for temperature

Use of area	Minimum temperature
Lower than normal level of physical activity, eg sick rooms	21^{o}C
Normal level of physical activity, eg classrooms and libraries	18^{o}C
Higher than normal levels of physical activity, eg gyms and drama workshops	15^{o}C

4.0 Humidity

Humidity does not usually affect comfort in normal temperature, but in extreme conditions with high temperatures, very high humidity makes it difficult for the body to regulate its temperature. Very low humidity also causes discomfort through its drying effect on the nose and throat, especially if the temperature is very high. Standards for indoor thermal conditions and for ventilation have traditionally put upper limits on the amount of humidity permissible in interior spaces because of concern for the health effects that might occur should the humidity become too high (Avens and Baughman, 1996). Humidity can be expressed in many different ways including absolute humidity, water vapour pressure, dew point, wet bulb temperature, relative humidity (Olesen and Madsen, 1995). In school setting, relative humidity is considered as important factor that contribute to the indoor air quality problem (see Ramachandran et al., 2005). Indoor relative humidity is reported to be the most important determinant of dust mite growth, and reducing humidity would be expected to be the most effective means of decreasing indoor mite growth (Korsgaard, 1982).

5.0 Air Movement

The amount of comfortable air movement depents on the work conditions. The ideal air movement in normal conditions should be around 0.15 m/s (meter per second). Air movement above 0.51 m/s is considered to be "drafty". However, when

temperatures reach uncomfortable levels, air movement in excess of 0.51 m/s is desirable. Haghighat and Donnini (1999) observed a positive relationships between the job satisfaction and satisfaction with office air quality, ventilation, work area temperature, and ratings of work area environment in their study. Toftum (2002) found the clear impact of activity and overall thermal sensation on human sensitivity to air movement, whereas no interaction effects of exposure to several local thermal discomfort factors were observed.

There is strong and sufficient evidence to demonstrate the association between ventilation, air movements in buildings and the transmission/spread of infectious diseases such as measles, tuberculosis, chickenpox, influenza, smallpox and SARS (Li et al., 2007). Air movement can also be controlled by air-conditioning (through recirculation of exhaust air, momentum and buoyancy) and can be affected by physical barriers in a building or movement of people, and so on. In the crude analysis, Norback and Nordstrom (2008) found there is a significant correlation between measured room temperature and a number of occupant's perceptions including perceived higher temperature, lower air movement, more odor and poorer air quality, both during the last hour and in the initial 15 min.

6.0 Indoor Air Quality

Evidence continues to emerge showing that poor indoor air quality (IAQ) can cause illness requiring absence from school, and can cause acute health symptoms that decrease performance while at school. In addition, recent data suggest that poor IAQ may directly reduce a person's ability to perform specific mental tasks requiring concentration, calculation, or memory (Mendel and Heath, 2003).

National Academy Press (2006) conclude that there is considerable evidence concerning the effect of indoor air on occupant productivity. In school setting Ajiboye et al. (2006) identify a number of potential indoor air quality (IAQ) factors that could impact on the health, comfort and performance of the school occupants. These include internally generated pollutants, such as human bio-effluents, organic emissions from building materials and furnishings (e.g. the furniture, carpets, surface finishing), as well as allergens from house dust mites etc. There may also be external pollutants, such as the ingress of combustion products from traffic, or fungi.

7.0 Noise

Noise is defined as disturbing, annoying, strenuous and hazardous sounds influencing the hearing organ and other senses of a human body (Engel et al., 2006). Existing approaches that explain the behavior of people in noisy environments rarely include quantitative variables related to central factors such as noise exposure levels and workers' hearing status (Arezes and Miguel, 2005). Noise has been linked to physiological problems other those of the hearing organ, including hypertension, heart irregularities, extreme fatigue, and digestive disorders. Most physiological responses of this nature are symptomatic of stress-related disorder. Because the presence of high noise levels often induces other stressful feeling (such as sleep disturbance and interference with conversing in the home and fear of missing oncoming vehicles or warning signal on the job, there are second-order effects of noise on physiological functioning that are difficult to predict. Noise in many occupational setting will affect the workers range from minor annoyance to major risk

of hearing damage workers complain about the negative effects of noise on their abilities to communicate, hear warning and other signals and concentrate on tasks at hand. Noise can be loosely defined as a subset of sound. Noise is a physical stimulus that is readily measurable and quantifiable using transducers (microphone) and instrumentation (sound level meter). The unit of decibel (dB) is the most common metric applied to the quantification of noise amplitude on physical scale. While, it does not yield on absolute or relative basis for quantifying the human perception of sound amplitude, commonly called loudness. Loudness and noisiness are related but not synonymous. Noisiness can be defined as the "subjective unwantedness" of a sound whereas perceived noisiness may be influenced by a sound's loudness, tonality, duration, impulsiveness and variability (Kryster, 1994). Low level of loudness might be perceived as enjoyable or pleasing, even a low level of unwantedness,that is, noisiness, is by definition undesirable. Equal noisiness contours, analogous to equal loudness contours, have been developed based on a unit (analogous to the phon) called the perceived noise level (PNdB). Low frequency noise has been found to cause annoyance and relationships between annoyance and subjective reports of lack of concentration, sleepiness, and tiredness (Waye, 2005).

Bracket (1998) claimed the current OSHA noise standard specifies a maximum permissible noise exposure level (PEL) of 90 dBA for an 8 hours duration, with higher levels allowed for shorter duration's. This level is known as a time weighted average sound level, or simply a TWA. Typically for an increase of five dBA the permissible exposure time is halved. This permissible noise level is contained in 29 CFR 1910.95 (Table 2). It is based on what is believed to be the upper limit of a daily dose of noise that will not produce a disabling loss of hearing of more than 20% after working 35 years (OSHA, 1995)

Table 2 Allowable amount of time and employee can exposed to specified noise levels (29 CFR, 1991)

Permissible Noise Exposure Time	
Duration (hrs)	**Sound Level (dBA)**
8.00	90
6.00	92
4.00	95
3.00	97
2.00	100
1.50	102
1.00	105
0.50	110
0.25	115

There is increasing evidence that noise may have adverse effects on physiological and psychological aspects of a person's general health. Study have found noise to be a causative factor in stress related illnesses such as hypertension, ulcers, allergies and neurological disorders. Excessive noise exposure may also have psychological effects. Noise has been shown to cause nervousness, fear, and psychosomatic illnesses as well as disturb sleep. Noise will cause slight impairment of the ability to detect lights in the periphery of vision. High noise levels are also

known to create elevated thresholds of flicker fusion and slow adaptation to night vision (Bernard, 1983).

A predominant theory suggests that high noise levels, like other stressors, activates a startle response inducing a widespread change in the body's activities. The changes often include a rise in blood pressure, increased cranial pressures, and sweating Normally, these physiological changes are brought on by intense sound of sudden onset. When the body receives constant levels of excessive noise, it causes the body's metabolism to "tense up" and release adrenaline. Under circumstances of the body being in danger, this "alert" reaction may be lifesaving. However, when the body must remain in a state of "alertness" for an extended amount of time, the body begins to fatigue and physical conditioning deteriorates. Blood vessels may constrict and force the heart to work harder to pump the same amount of blood to vital organs and extremities. Long-term effects of prolonged vascular constriction are known to cause cardiac hypertension (Clayton, 1978). The main sources of community noise (also known as environmental noise or residential noise) are traffic, industries, construction, public work, and neighborhood.

Based on their research finding, Walinder et al. (2007) concluded that noise should be focused on as a risk factor in the school environment. School children exposed to elevated noise level had significantly decreased attention, and social adaptability, and increased opposing behavior in comparison with school children who were not exposed to elevated noise levels. Chronic noise exposure is associated with psychosocial effects in school children and should be taken as an important factor in assessing the psychological welfare of the children (Ristovska et al., 2004). Psychological health in children is usually measured in one of the three ways: psychiatric evaluation, self-reported questionnaire, or teachers' or parents' rating of mental health.

8.0 Ventilation

Ventilation refers to the process of introducing and distributing outdoor and/or properly treated recycled air into a building or a room (Etheridge and Sandberg, 1996). The ventilation process can involve airflow by either natural forces such as thermal buoyancy and wind, or by fan force. It is known that ventilation is necessary to remove indoor generated pollutants from indoor air or dilute their concentration to acceptable levels. Inadequate ventilation in workplace resulting the various illness, and disorder either physiologically or psychology. The existing literature indicates that ventilation has a significant impact on several important human outcomes including: (1) communicable respiratory illnesses; (2) sick building syndrome symptoms; (3) task performance and productivity; and (4) perceived air quality (PAQ) among occupants; (5) respiratory allergies and asthma (Seppanen and Fisk, 2004). Reported ventilation and CO2 data strongly indicate that ventilation is inadequate in many classrooms, possibly leading to health symptoms (Daisey et al., 2003).

Currently, there are many evident to support the strong relationship between temperatures and student performance and their behaviors. Temperature up to 25^{o}C has a psychological effect in which could be reduce mental abilities, work output and performances. Temperature should be considered when assessing human response to thermal environments (Parson, 2000). However, the effects of room temperature on performance, arousal, and comfort in different tasks (reading, mathematics, and

memorization) found participants' physical comfort was dependent on ambient temperature (Kahl, 2005).

9.0 Odor

Uncovering the mechanisms of odor perception offers a unique approach for the understanding of human perception and behavior (Pause, 2005). Historically, unpleasant odors have been considered warning signs or indicators of potential risks to human health, but not necessarily direct triggers of health effects (Phillips, 1992; Gardner et al., 2000; Persaud et al., 2003). Such odors are often mixtures of several chemically discrete substances that are present at very low concentrations and biological agents (microorganisms) also will be contribute as a potential source of objectionable odors. The evaluation and control of objectionable odors in the work-place appears to be an increasing challenge for the industrial hygienist (McJilton et al., 1990). Human olfactory perception differs enormously between individuals, with large reported perceptual variations in the intensity and pleasantness of a given odor (Keller et al., 2007). The complaint of 'bad odor of the air' was associated with high CO2 level (Daisey et al., 2003).

There are at least three mechanisms by which ambient odors may produce health symptoms. First, symptoms can be induced by exposure to odorants (compounds with odor properties); second, health symptoms from odorants at nonirritant concentrations can be due to innate (genetically coded) phenylketonuor learned aversions; and third, symptoms may be due to a copollutant (such as endotoxin) that is part of an odorant mixture (Schiffman and William, 2005). Unpleasent odor come from a variety of sources including common environmental chemicals such as perfume, pesticides, solvents and gasoline, building material, garbage, organic fertilizer and furnishing. Different methods of odor emission investigation are available. Among that includes "electronic nose" (Romain et al., 2008); systematic field observations (Steinheider and Winneke, 1993)

10.0 Lighting

Lighting is one of the main environmental factors in the work area. Good lighting is required for good visibility of the environment. Good lighting practice is not just limited to compliance with the requirements of standards but also should take into consideration the lighting preferences of users and the characteristics of those users, such as age or gender (Wolska 2003). Light is radiant energy that is capable of exciting the human retina and creating a visual sensation (Rea 1993). Generally, there are two kind of light, natural light and artificial light. Artificial light is common in build environment and mostly dominated by fluorescent tubes. According to Veitch et al., (2001), there are wide variety of fluorescent lamp types exists, which may described by two quantities, the correlated colour temperature (CCT) and colour-rendering index (CRI). Differences in the indoor lighting environment (levels, spectral distribution, temporal patterns, etc.) do seem to affect people in various ways (Kuller et al., 2006). Full-spectrum fluorescent lighting (FSFL) has been credited with causing dramatic improvements in vision, perception and cognitive performance as compared with other fluorescent lamp types (Veitch and McColl, 2001).

The comprehensive conceptual framework (Figure 1) which elaborates the ways of lighting conditions influences the human performance will be found in Boyce (2003).

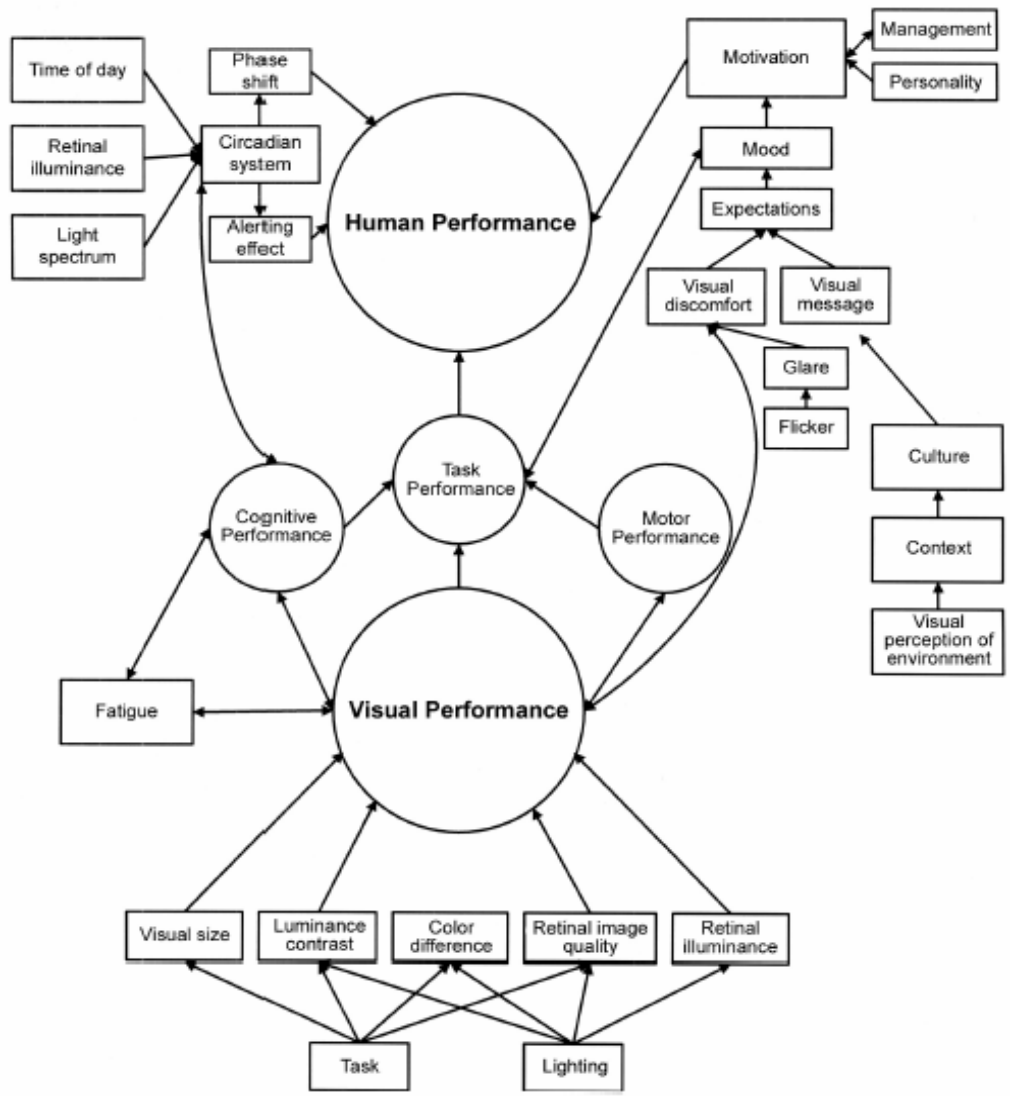

Figure 1 A conceptual framework setting out the three routes whereby lighting conditions can influence human performance. The arrows in the diagram indicate the direction of effect.

11.0 Color

The color of a school has shown to have an influence on students (Hughes, 2005). Color is a subjective effect created by the brain to facilitate distinguishing various wavelengths and intensities of light incident on the retina (Nilsson, 2006). Color can attract attention, improve recognition, and organize information but studies have indicated that the colors in a classroom can affect how students behave and perform (Kennedy, 2005). In particular, color can affect a student's attention span, eye strain, work productivity and accuracy. Paint colour on the exterior and interior of the school facility and the colors and textures around the school was referred as visual environment by Hughes (2005). Blue and pink are known to calm behavior while earth tones tend to raise heart rates and increase brain activity (Flannery, 2005; Grangaard, 1993). Based on the presentation made by educational planner from Perkins + Will

design firm (Kathie Engelhrecht), Kennedy (2005) outline several important issues: 1) When discussing color in school, it is important to approach color choices as functional color rather than from a standpoint of aesthetics dimension; 2) Younger children stimulating high-contrast and bright colors such as red, orange and yellow otherwise adolescent students may respond better to colors such as blue or green that are less distracting or stress-inducing; 3) Monotone environments may induce anxiety and lead to irritability and an inability to concentrate, therefore can influence classroom success; and 4) A school's overall color scheme should support the function of the building and the tasks that are carried out in it; avoid overstimulation and under-stimulation; and create positive emotional and physiological effects.

12.0 Conclusion

Empirical evidence shows that physical environment has a multiple impacts on student in school setting such as behaviour, attitudes, achievements, personality developments, preferences and comfort. Comprehensive study should be conducted in order to ensure teaching and learning session running in conducive manner. In the future, these valuable concepts should be adopted in the way we prepare an alternative responses to the problems of our school systems. Furthermore, educational consultants, architects, and administrators should be apprised of the importance of the compatibility between physical environment and student teaching and learning.

References

Arezes, P. M., & Miguel, A. S. (2005). Individual perception of noise exposure and hearing protection in industry. *Human Factors, 47*(4), 683-692.

ATL. (2008). *Temperature*. Retrieved 10/10/2008, 2008, from http://www.atl.org.uk/health-and-safety/work-environment/temperature.asp

Bowers, J. H., & Burkett, C. W. (1987, October 3-7, 1987). *Relationship of Student Achievement and Characteristics in Two Selected School Facility Environmental Settings.* Paper presented at the Annual International Conference of the Council of Educational Facility Planners, 64th, Edmonton, Alberta, Canada.

Boyce, P. R. (2003). *Human Factors in Lighting* (Second edition ed.). London New York: Taylor & Francis.

Caplan, R. D., & Van Harrison, R. (1993). Person-Environment Fit Theory: Some History, Recent Developments, and Future Directions. *Journal of Social Issues, 49*(4), 253-275.

Cash, C. S. (1993). A Model for Building Condition and Student Achievement and Behavior. *Educational Facility Planner, 32*(4).

Corgnati, S. P., Filippi, M., & Viazzo, S. (2007). Perception of the thermal environment in high school and university classrooms: Subjective preferences and thermal comfort. *Building and Environment, 42*(2), 951-959.

Daisey, J. M., Angell, W. J., & Apte, M. G. (2003). Indoor air quality, ventilation and health symptoms in schools: an analysis of existing information. *Indoor Air, 13*(1), 53–64.

Etheridge, D. and Sandberg, M. (1996) Building Ventilation – Theory and Measurement, Chichester, UK, John Wiley & Sons.

Flannery, M. E. (2005, April). Classroom cool. Design aesthetics. National Education Association. Retrieved October 5, 2008 from http://www.nea.org/neatoday/0504/classroomcool.html

Gardner, J.W., H.W. Shin, and E.L. Hines. 2000. An electronic nose paint. Eur. Respir. J. 10:563–566. system to diagnose illness. Sens. Actuators B B70:19–24.

Grangaard, E. M. (1995). *Color and light effects on learning*. Washington, DC: U. S. Government Printing Office. (ERIC Reproduction Service No. ED 382 381)

Henderson, J. M. (1999). *Architecture For The Imagination Study Of An Elementary Educational Environment.* Unpublished Master of Architecture, Virginia Polytechnic Institute and State University.

Hughes, S. M. (2005). *The Relationship between School Design Variables and Student Achievement in a Large Urban Texas School District.* Unpublished Ph. D, Baylor University.

Huizenga, C., Hui, Z., & Arens, E. (2001). A model of human physiology and comfort for assessing complex thermal environments. *Building and Environment, 36*(2001), 691-699.

Keller, A., Zhuang, H., Chi, Q., Vosshall, L. B., & Matsunami, H. (2007). Genetic variation in a human odorant receptor alters odour perception. *Nature, 449*(7161), 468-472.

Kennedy, M. (2005). Classroom Colors. *American School and University, May 2005*.

Korsgaard, J. (1982): Preventive measures in house-dust allergy. *Am. Rev. Respir. Dis. 125*:80–84.

Li, Y., Leung, G. M., Tang, J. W., Yang, X., Chao, C. Y. H., Lin, J. Z., et al. (2007). Role of ventilation in airborne transmission of infectious agents in the built environment - a multidisciplinary systematic review. *Indoor Air, 17*(1), 2-18.

Mendell, M., & Heath, G. (2003). *Indoor Air Quality & Student Performance* (No. 402-K-95-001). Washington: Indoor Environments Division Office of Radiation and Indoor Air. United States Environmental Protection Agency.

Nilsson, T. (2006). Legibility of Colored Print. In W. Karwowski (Ed.), *International Encyclopedia of Ergonomics and Human Factors* (Second Edition ed., Vol. Volume 1). Boca Raton London New York: CRC Press LLC.

Norback, D., & Nordstrom, K. (2008). An experimental study on effects of increased ventilation flow on students' perception of indoor environment in computer classrooms. *Indoor Air*.

Olesen, B. W., & Madsen, T. L. (1995). Measurements of the physical parameters of the thermal environment. *Ergonomics, 38*(1), 138-153.

O'Sullivan, S. (2006). *A Study of the Relationship between Building Conditions and Student Academic Achievement in Pennsylvania's High School.* Unpublished Ph. D.

Parsons, K. C. (2003). *Human Thermal Environments: The effects of hot, moderate, and cold environments on human health, comfort and performance* (Second edition ed.).

Parsons, K. (2005). Ergonomics assessment of thermal environments. In J. R. Wilson & N. Corlett (Eds.), *Evaluation of Human Work* (Third Edition ed.). Boca Raton, Florida: CRC Press, Taylor & Francis Group, LLC.

Pause, B. M. (2005). Psychophysiology of Odor Perception. *Psychophysiology, 42*(Supplement 1), S4-S4.

Persaud, K.C.,A.M. Pisanelli, and P. Evans. 2003. Medical diagnostics and health monitoring. p. 445–460. *In* T.C. Pearce, S.S. Schiffman.

Phillips, M. 1992. Breath tests in medicine. Sci. Am. 267(1):74–79.

Ristovska, G., Gjorgjev, D., & Jordanova, N. P. (2004). Psychosocial Effects of Community Noise: Cross Sectional Study of School Children in Urban Center of Skopje, Macedonia. *Public Health, 45*(4), 473-476.

Roberts, B. W., & Robins, R. W. (2004). Person-Environment Fit and Its Implications for Personality Development: A Longitudinal Study. *Journal of Personality and Social Psycholog, 72*(1), 89-110.

Schiffman, S. S., & Williams, C. M. (2005). Science of Odor as a Potential Health Issue. *Journal of Environment Quality, 34*, 129-138.

Toftum, J. (2002). Human response to combined indoor environment exposures. *Energy and Buildings, 34*(2002), 601-606.

Veitch, J. A., & McColl, S. L. (2001). A critical examination of perceptual and cognitive effects attributed to full-spectrum fluorescent lighting. *Ergonomics, 44*(3), 255 – 279.

Walinder, R., Gunnarsson, K., Runeson, R., & Smedje, G. (2007). Physiological and psychological stress reactions in relation to classroom noise. *Scandinavian Journal of Work Environment and Health, 33*(4), 260-266.

Waye, K. P. (2005). Adverse Effects of Moderate Levels of Low Frequency Noise in the Occupational Environment. *ASHRAE Transactions, 111*(1), 672-683.

Weinstein, C. S. (1979). The Physical Environment of the School: A Review of the Research. *Review of Educational Research, 49*(4), 577-610.

Wolska, A. (2003). Visual strain and lighting preferences of VDT users under different lighting systems, *JOSE* 9(4), 431–440.