THE American Journal of Humanities and Social Sciences Research (THE AJHSSR) 2022

E-ISSN: 2581-8868
Volume-05, Issue-01, pp-74-82
www.theajhssr.com

Research Paper Open Access

The Effects of Air Temperature to the Cognitive Performance of Grade Five Pupils

Myrna C. Bigueja[1], Rosemarie A. Tabardillo[2], Sheila E. Amoroso[3], Joselito D. Tabardillo[4]

[1]*Partido State University Sagñay Campus, Nato Sagñay, Camarines Sur, Philippines*
[2-3]*Partido State University, College of Education, Goa, Camarines Sur, Philippines*
[4]*Partido State University, College of Business and Management, Goa, Camarines Sur, Philippines*

ABSTRACT

High temperature makes the children uneasy during classroom activities. This study examines the effect of air temperature to children's cognitive performance. The school profile was determined such as: the total number of teachers, number of enrollees, land area (sq.m.), number of buildings and number of trees was determined to support the analysis of the data collected. The respondents were the Top thirty (30) Grade V pupils from public city elementary school in the Bicol Region. The pen-and-paper test was administered using the standardized test question in Science V of forty (40) items. The examination was done in the room without ventilation at 9:00 O'clock to 11 O'clock in the morning. Outdoor and indoor air temperature was recorded. The temperature recorded in the seven Public Central City Elementary Schools ranged from 24^0C to 31^0C. The recorded temperature indicates that the air contains particulates or pollutants like CO2 resulting in high temperature. Future work is required to establish evidence based guidelines for average temperatures and CO2 levels in classrooms. Findings suggest that high ventilation rates and low temperatures are required to provide optimum health outcomes and learning conditions. Natural Ventilation is also recommended through planting more trees in school vicinity to provide fresher air.

KEYWORDS – Academic, Air, Performance, Temperature

1. INTRODUCTION

Based from A Strategic Approach to Climate Change in the Philippines stated by Sustainable Development Department East Asia & Pacific Region World Bank (April 16, 2010). The Philippines is highly exposed to hazards created by weather events, and climate change will exacerbate this through an increase in extreme weather events, changes in temperature, shifts in rainfall patterns, and sea level rise. The Philippines is highly exposed to extreme weather, and it is expected that climate variability could lead to an increase in the number, severity, and unpredictability of events. In the past 10 years the Philippines has experienced the highest recorded rainfall and the strongest typhoons. On average, some 20 typhoons hit the country annually (NDCC 2008). Weather-related disasters accounted for 98 percent of lives affected by all disasters and 78 percent of lives lost between 2000 and 2008 (EMDAT 2009). As a result of these factors, the Philippines ranked in the top 10 countries worldwide at risk for both climate change and disasters. Temperatures will rise. The observed change since 1990 is 0.2°C per decade, and the Intergovernmental Panel on Climate Change (IPCC) scenarios give a projected range for the future of 0.1–0.6°C per decade (World Bank 2009e). Much of Bicol Region is one of the most affected by rising temperatures.

Currently, the Intergovernmental Panel on Climate Change (IPCC) points out that global warming has led to a rise in temperatures around the world (Maliva, R , 2021) and is generating changes in climate patterns that have major public health implications (Díaz, J., 2018). Despite the fact that the study of temperature in the socio-labor context and general increase in temperatures have traditionally been ignored, it is increasingly common to find studies that are concerned with evaluating the thermal comfort of educational centers (Dias, M., et. al., 2011 and D'Ambrosio Alfano, F.R., et.al., 2013) because it is certain that environmental conditions affect productivity, performance and well-being (Simanic, B., et.al., 2019 and Vaquero-Álvarez, M., et.al.,2018) In this regard, most existing studies focus on assessing the indoor comfort of schools because pupils spend more time in school than in any other building, except the home (Zomorodian, Z.S.; Tahsildoost, M.; Hafezi, M., 2016). Recent study on Influence of Air Temperature on School Teachers' Mood and the Perception of Pupils' Behavior, it is observed that indoor temperature and the difference between this and the outdoor temperature has

a negative influence on the teachers' mood, which, in turn, negatively influence on perception of a pupils' behavior (Vilella,S. B., 2021). There is evidence suggesting that mental/cognitive performance and mental functions may be negatively affected by thermal stressors (Taylor, L., et.al, 2016). A major factor that contributes to mental performance and mental functions is thermal comfort (Law, T.-O., & Fay, R. 2009). Thermal comfort is defined as "that condition of mind, which expresses satisfaction with the thermal environment."

For this reason, the monitoring of urban air quality has been one of the primary objectives of the Environmental Management Bureau (EMB) Region V, as early as the 1990's. EBM defines air quality as a mixture of gasses vital for the existence of all living organisms. Disruption of the ecological balance is partially caused by industry, modernization and the use of fossil fuels, which contribute to air pollution. Air pollution affects not only the environment, human health and quality of life, but it also damages the whole ecological system. Harmful and toxic emissions spoil the air's natural components and contribute greatly to worsening air pollution. For this reason, close monitoring of air quality is identified as an essential action to minimize the undesirable effects of air pollution, and to restore the quality of air in the atmosphere.

Greenhouse gasses are trapping more heat in the Earth's atmosphere, which is causing average temperatures to rise all over the world. Temperatures have risen during the last 30 years, and 2001 to 2010 was the warmest decade ever recorded. As the Earth warms up, heat waves are becoming more common in some places, including the United States. Heat waves happen when a region experiences very high temperatures for several days and nights (EPA's Climate Change Indicators, 2016). Higher temperatures mean that heat waves are likely to happen more often and will last longer. Heat waves can be dangerous, causing illnesses such as heat cramps and heat stroke, or even death and school performance of children.

Warmer temperatures can also lead to a chain reaction of other changes around the world. Increasing air temperature plays an important role for human health, comfort and performance. Health, comfort and performance can be influenced by physiological, behavioral and psychological factors, while performance can additionally be influenced by the individual (skills, gender, circadian cycle, and emotional state) and social variables (Chatzidiakou, L. et.al. 2014). The human outcomes of primary interest in this research are cognitive performance of grade five (5) pupils in city schools in Bicol Region. Cognitive Performance is related to the ability of an individual to undertake different mentally and physically demanding tasks. Cognitive assessment in relation to school exposure is normally evaluated with standardized tests which can be pen-and-paper or computer based tests. Research focusing on the effect of indoor air temperature and performance considers two distinct aspects of human performance; accuracy and speed. This research study does not consider current debates about the proper measurement of academic performance, but considers educational achievement tests and neurobehavioral performance tests to be relatively objective metrics of learning or performance that, whatever their limitations, are more accurate than subjective assessments of performance.

Several studies were conducted in relation to temperature. Sharma and Panwar (1987) investigated various cognitive tasks across moderately cold ambient temperatures and found significant impairment of simple cognitive functions beginning at 59° F. They did not investigate moderately hot room temperatures, nor did they examine factors such as comfort and physiological arousal. Pilcher, Nadler, and Busch, (2002) performed a recent meta-analysis, which suggested that variables such as level of personal arousal, physical comfort, and type of cognitive task might impact performance under moderate to extreme temperature conditions.

The present study was therefore undertaken to investigate potential important effects of temperature on the cognitive performance of pupils in public city elementary schools in Bicol.

1.1. Objectives

1.1.1. General Objectives: To determine the effect air temperature to children's cognitive performance.
1.1.2 Specific Objectives: This study sought to answer the following:

1. Find out the air quality of Bicol Region from 2015 to 2018 and sources;
2. Find out the air temperature levels on the selected public city elementary schools in Bicol region
3. Compare the cognitive performance of pupils in public city elementary schools in Bicol exposed at different air temperature range.
4. Determine the significant differences on the cognitive performance of the pupils in the public city elementary schools in Bicol at the different air temperature range.

1.2. Hypothesis

1. The cognitive performance among city elementary school pupils exposed at different ranges is not significantly different.
2. The effect of air temperature on the cognitive performance of children are not significantly different.

2. METHODOLOGY

2.1 Study Area

This study was carried out in the Cities of Bicol region which is considered as high risk to climate hazards brought about by typhoon (super typhoons, typhoons, tropical storms and tropical depressions) and drought caused by El Niño, projected rainfall change and projected temperature increase (Rincón and Virtucio,2008).

2.2 Research Design This study used the descriptive research design. To determine the effect of temperature to the cognitive performance of the children pen-and-paper test was administered using the standardized test question in Science V of forty (40) items.

2.3 Procedure

Permission to conduct the research and use the standardized test question in Science V from the director of the Department of Education Region was requested and was approved. It is expected that the items in the test questions were already learned by Grade V pupils with the help of their science teachers. Dry run testing was conducted at Sagnay Central Elementary School, Nato Camarines Sur. Before administering the test to the respondents, the orientation and instruction to the children was conducted and an indoor and outdoor temperature was recorded using the atmospheric thermometer and aided with Google reports. Examination room was not ventilated. Electric fan and Air-condition were switched off. The examination was conducted from 9:00 'O'Clock to 11 'O Clock in the morning. To determine the air quality of Bicol Region data was collected from Environmental Management Bureau (EMB) Region V.

2.4 Respondent

Top thirty (30) Grade five pupils were selected from seven (7) City Central Elementary Public Schools in Bicol Region (Region V) namely: a) Iriga City Central Elementary School 1 (ICES) b) the Naga City Central Elementary School (NCES), c) Legazpi City Central Elementary School (LeCES), d) the Masbate City Central Elementary School (MCES), e) the Tabaco City Central Elementary School (TCES), f) the Sorsogon City Central Elementary School (SCES), g), the Ligao City Elementary School(LiCES).

2.5 Data Analysis

The researchers used computer aided statistical packages to analyze volumes of information collected using the above mentioned procedures. Specifically, Statistical Package for Social Sciences (SPSS) and Microsoft Excel were used for purposes of data analysis. All the completed test questions were first examined for completeness and consistency.

Figure 1. Map showing location sites of monitoring stations in the Bicol Region (Source: DENR-EMB V, Rawis, Legazpi City)

The analysis involved both simple descriptive methods and detailed statistics. Descriptive statistics including frequency counts, percentages and mean were used to summarize data on the effect of air temperature to cognitive performance of the Grade Five pupils. . Detailed data analysis t-Test and ANOVA were used at a statistical confidence level of 95%. The data were presented in tables, charts and graphs.

3. RESULTS AND FINDINGS

3.1 Air Quality of Bicol Region from 2013 to 2015 and sources

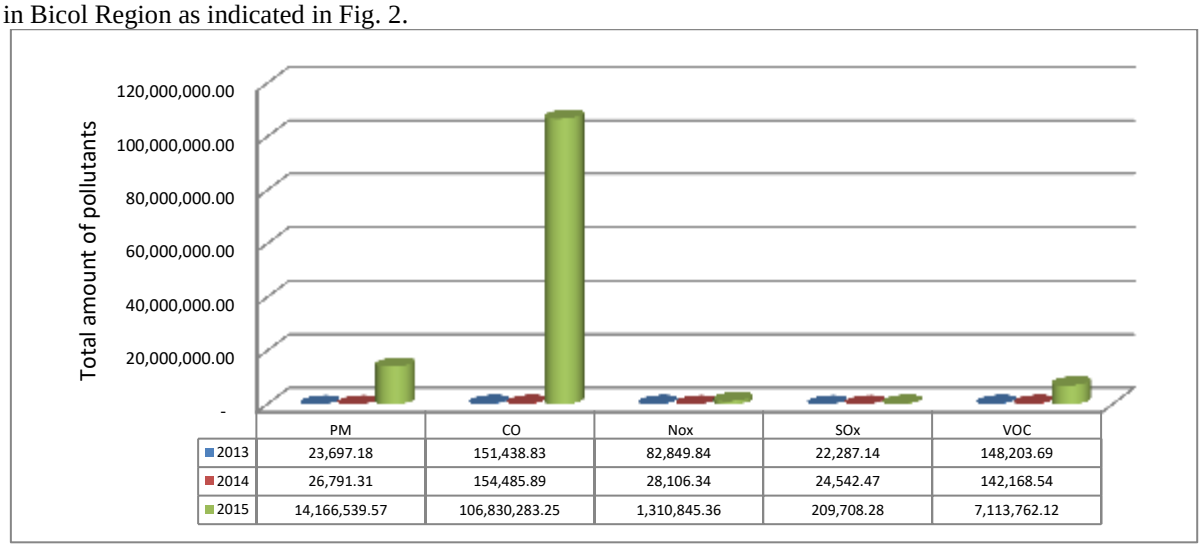
There are many factors and activities responsible for the increase of air pollution in the atmosphere. Two categories were found to be contributing factors to air pollution, namely: Anthropogenic sources and Natural sources. Natural sources refer to those that are naturally occurring air pollutants. A typical example is a volcanic activity, which releases Sulphur, chlorine and particulates in the atmosphere. The eruption of Mayon Volcano in the province of Albay last December 2009 and reaching the alert level 3 status in 2014 emitted a significant amount of Sulphur dioxide and toxic fumes in the atmosphere. Anthropogenic sources, on the other hand, refers to those sources of air pollution that are attributable to human activity. Example of anthropogenic sources is the burning of fossil fuel (e.g. coal) to produce electricity, which also emits Sulphur oxides, particulates, nitrogen oxides and carbon monoxide in the atmosphere. Anthropogenic sources of air pollution are further sub-categorized into 3 parts, namely: stationary source, mobile source and area source DENR-EMBV (2015).

3.2 Emission Inventory

EMB V (2015) conducted emission inventory for air quality once every three years as required under CAA 1999 or RA 8749. The data presented in the inventory are based on the inputs from the submitted Self-Monitoring Reports (SMR). Based on EMB record data the sources emission inventory is mostly based on the total number of households in Bicol Region. Extracted from the 2010 census of population and household, Region V has a total household of 5,411,521. Albay province has a total of 1,231,607 while Sorsogon has 739,688. Meanwhile, Camarines Sur registered as top in the list of highest number of households at 1,818,699 and the lowest is Catanduanes at 245,574 number of households. Camarines Norte and Masbate registered at 542,315 and 833,638 number of households respectively. Figure 2 shows the total emission of stationary, mobile and area sources in the Bicol Region.

In compliance with the provision of the Implementing Rules and Regulations of RA 8749 (Philippine Clean Air Act of 1999) under Section 2 Rule XIV Part V, the EMB V has been conducting emission inventory in the Bicol Region since year 2000 for the purpose of identifying sources and types of air pollutants and quantifying the amount emitted to evaluate its quality and make recommendations for effective implementation. The emission center is located in the cities of Legazpi, Iriga and Naga (Fig.1).

Purposely, emission inventory is to estimate the amount of air pollutants such as Carbon Monoxide (CO), Nitrogen Oxide (NOx), Sulphur Oxide (SOx), Volatile Organic Compounds (VOC), Particulate Matter (PM) from the different sources of air pollution. The Emission Inventory covers stationary, mobile and area sources in Bicol Region as indicated in Fig. 2.

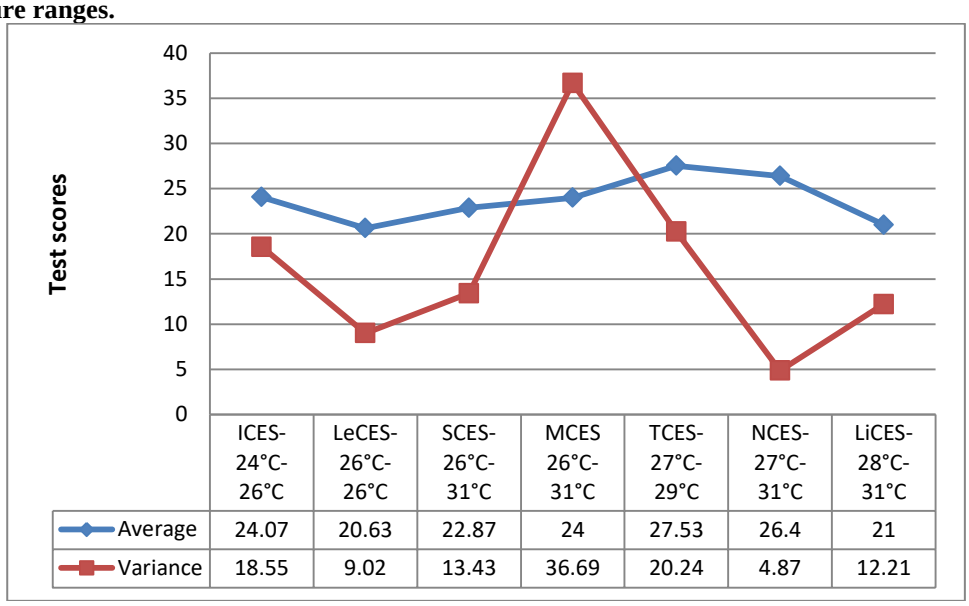


	PM	CO	Nox	SOx	VOC
2013	23,697.18	151,438.83	82,849.84	22,287.14	148,203.69
2014	26,791.31	154,485.89	28,106.34	24,542.47	142,168.54
2015	14,166,539.57	106,830,283.25	1,310,845.36	209,708.28	7,113,762.12

Figure 2. Total emission inventory of air pollutants for Region V from 2013-2015 in Tons/Year (Source: DENR-EMB V, Rawis, Legazpi City)

As shown in Fig. 2 the level of Carbon Monoxide (CO) pollutant is very high as compared to other pollutants which rises to 106,830,283.25 tons in 2015. This indicates that the Bicol Region is vulnerable to warming or to climate change which may affect not only the performance of children in school but most of all the Bicolanos' lives. Beyond the health damage, there is increasing evidence on the harmful consequences of exposure to air pollution on the human brain and cognitive performance (Zhang et al., 2018). An increasing number of studies show that exposure to air pollution harms pupils' performance. Numerous studies have linked local levels of air pollution on testing days (i.e. high levels of PM2.5) to lower performance of young adults in high-stakes examinations (Ebenstein et al., 2016; Roth, 2018; Graff Zivin et al., 2020). Prolonged exposure to high levels of air pollution has been associated with numerous respiratory problems (e.g. asthma), ultimately leading to school absences (Currie et al., 2009; Currie and Walker, 2011; Knittel et al., 2016), and declines in infant mortality (Chay and Greenstone, 2003; Currie and Neidell, 2005).

3.3 The cognitive performance of pupils in public city elementary schools in Bicol Region at different air temperature ranges.



	ICES-24°C-26°C	LeCES-26°C-26°C	SCES-26°C-31°C	MCES 26°C-31°C	TCES-27°C-29°C	NCES-27°C-31°C	LiCES-28°C-31°C
Average	24.07	20.63	22.87	24	27.53	26.4	21
Variance	18.55	9.02	13.43	36.69	20.24	4.87	12.21

Figure 3. The mean test score between city schools at different ranges of air temperature

According to Chatzidiakou, et.al (2014) that Based on the available evidence, engineering recommendations for healthy, comfortable school environments conducive to knowledge the recommended range of room temperature is 22 to 24^{0}C. Temperature in the range of 25 to 32^{0}C may have an impact on cognitive performance and comfort of the pupils/pupils. He further elaborated that there is evidence that lower temperatures in the range between 25^{0}C to 20^{0}C improve pupils' performance by 2% to 4% for every 1^{0}C reduction.

Looking at Fig.2 out of 40 test items to the Grade five pupils of Section 1 of City Elementary School, the mean score is less than 50%, especially under the temperature of 24^{0}C- 26^{0}C, 26^{0}C-26^{0}C, 26^{0}C-31^{0}C, 26^{0}C-31^{0}C, and 28^{0}C-31^{0}C. There is evidence that the temperature above 25^{0}C can affect the cognitive performance of the pupils.. Based on the observation during the conduct of the study the pupils are uncomfortable. Kahl, J. (2005) stated that room temperature affected subjective physical comfort; it had no impact on performance in mathematics, reading comprehension, or word recall. These results suggest that although performance has been found to correlate strongly with comfort (Griffiths & Boyce; Rohles, 1974), comfort is not a prerequisite for performance. Wyon, Fanger, Oleson, and Pederson (1975), similarly, concluded, “While participants tend to prefer warmer temperatures (66-73.4°F) than cooler temperatures, warmer temperatures may not improve task performance. Results from the current study also suggest that further research is needed to look at the effects of room temperature on performance with consideration on geographic location, time of year, and time of day.

Table 1

The Effect of Air Temperature among City Elementary School at Different Temperature Ranges.

Source of Variation	SS	df	MS	F	P-value	interpretation
Rows	2417.561	29	83.36418	31.84866	3.72	Significant
Columns	1183.628	5	236.7256	90.43923		
Total	3980.728	179				

The effect of air temperature among city elementary school pupils in the Bicol region was examined using Analysis of variance (ANOVA) (Table 1). In this result the p-value is 3.72, which is greater than the significance level of .05. Hence, the null hypothesis is rejected and concluded that the effect of air temperature among city elementary school pupils is significantly different. These results, similar to the research conducted by Bako Biro et al (2012) they investigated the effect of temperature on cognitive performance in the range from 25-23^{0}C. Performance tests represented different aspects of school work including language-based and numerical tests using computer-based tests. The analysis of cognitive performance of pupils suggested an improvement by about 6% to 8% when lowering the temperature from 25.3^{0}C. (s: 0.4) to 23.1^{0}C. (s: 0.8).

Some research finding documented that Thermal discomfort caused by elevated temperatures in classrooms has been shown to reduce the ability of pupils to perform typical school tasks [Wargocki, P., Wyon, D.P. (2007), Holmberg, I., Wyon D.P. (1967 Wyon, D.P., Andersen, I., Lundqvist, G. (1979. The heat stress caused by elevated outdoor temperatures has been shown to increase the number of pupils failing to pass exams [Goodman, J., et.al. 2018), Park J. 2016). Some studies have suggested that these negative thermal effects on performance are much greater for pupils who are less able [Porras-Salazar, J.A., et. al., 2018), Ryd, H., Wyon, D.P. 1970, Park J., 2016). Similarly, Former meta-analytic reviews Chatzidiakou, L., et.al. (2012), Mendell, M. J., et.al (2005), Angell, W. J., et.al (2003)offer a comprehensive picture of air quality and thermal conditions in school settings, emphasizing that reduced ventilation rates and elevated indoor temperatures in schools are common, frequently much worse than in office buildings.

As suggested by Milton Keynes (2007), that recommended temperature range in classroom settings lies between 20^{0}C. ±1 to 24.5^{0}C. ±2.5 depending on season. New York Commission on Ventilation, (1931) stated that the ideal classroom conditions conducive to learning are within a narrow band of temperature and relative humidity of 20–22 ◦C and 50%, respectively. In a metaanalysis of 18 studies (Wargocki, P.; Porras-Salazar, J.; Contreras, S., 2019) performance by learners on psychological tests could be expected to increase on average by 20% if classroom temperatures were lowered from 30 to 20 ◦C. Optimal performance was achieved at temperatures lower than 22 ◦C; however, these studies were all conducted in temperate climates, and hence, validation in other climates, such as tropical climates like Philippines, is needed. Since the present study uses the temperature above to the recommended temperature ranges, therefore the pupils may be uncomfortable with the situation which may be the cause of differences in test performance. One of the practical ways to combat rising temperature is to plant more trees in order to take more carbon out of the atmosphere. Based on the observation, some of the city elementary schools have a wider land area. However, there are only a few. Hence, researchers recommend that trees must be planted in the vacant area to provide natural ventilation in the schools.

Table 2

Comparison of effect air temperature to the cognitive performance of Grade Five pupils at different temperature range

Paired Variables	Variables	Mean	SD	T	df	p-value	Interpretation
ICES	24°C-26°C	24.067	1.28	-5.605	52	0.000337	SIGNIFICANT
TCES	27°C-29°C	27.53	1.49				
ICES	24°C-26°C	24.067	4.31	-2.641	43	0.00574	SIGNIFICANT
NCES	27°C-31°C	26.4	2.21				
ICES	24°C-26°C	24.067	4.31	0.0658	43	0.4737	SIGNIFICANT
MCES	26°C-31°C	3.435	3.44				
ICES	24°C-26°C	24.067	4.31	1.162	57	0.125	NOT SIGIFICANT
SCES	26°C-31°C	22.867	3.67				
ICES	24°C-26°C	24.067	4.31	1.208	29	0.118	NOT SIGIFICANT
MCES	26°C-31°C	3.435	3.44				
ICES	24°C-26°C	24.067	4.31	2.260	52	0.014	NOT SIGIFICANT
LiCES	28°C-31°C	22.867	3.67				
ICES	24°C-26°C	24.067	4.31	3.016	58	0.00188	NOT SIGIFICANT
LeCES	26°C-26°C	20.633	4.42				
MCES	26°C-31°C	24.00	3.44	1.20	29	0.11835	NOT SIGIFICANT
SCES	26°C-31°C	22.87	3.65				

Table 2 shows that ICES (24°C-26°C). is the city school with lower temperature during the conduct of the study. Hence, this is the baseline of comparison. T-test was used to determine the effect of air temperature on cognitive performance of the pupil in science. Top 30 grade five were selected and were asked to take the examination of 40 test items in Science VI. The temperature was recorded every ten minutes to get the ranges while pupils are taking tests for two (2) hours. Results indicates that comparing the lowest range of air temperature the 24°C-26°C (ICES) to 27°C-31°C (TCES), 27°C-31°C (NCES), and 26°C-31°C (MCES) shows that t value is -5.605, -2.64, 0.0658 and the P value is 0.000337, 0.00574, and .4737 respectively. Since t-value is less than to P value therefore there is a significant difference. The result implies that the air temperature affects the performance of children. Similarly, Chatzidiakou, L., et.al. (2012) also noted that higher temperature at school as stated affects the cognitive performance of children.

On the other hand, comparing the increase of 1-2^{0}C temperature results show no significant difference. Researchers have theorized that several factors may be able to account for the difference in task performance across ambient temperatures. Like the physical aspect of the building, the design of the buildings and the occupant density in the classroom. K. Wall, J. Dockrell, and N. Peacey (2008) stated School buildings are complex spaces to design as they need to perform well in all aspects of environmental conditions, including, but not limited to, air quality and acoustic levels, while needing to accommodate periods with very high occupant densities. The typical classroom has on average four times as many occupants per square meter as the typical office building.

The Environmental Protection Agency (EPA), (2003) explained that air in most indoor environments contains a variety of particles and gaseous contaminants. These contaminants are commonly referred to as indoor pollutants when they affect human health and performance. Indoor temperature and relative humidity can also affect health and performance directly, and can affect human performance indirectly by influencing the airborne level of molds and bacteria. Further, Miller, Sebastián J. and Vela, Mauricio A (2013) stated that air pollution also generates problems for children's cognitive performance and human capital formation. High concentrations of pollutants can affect children's learning process by exacerbating respiratory illnesses, fatigue, and absenteeism and attention problems.

EPA 2003, further proposes that Schools should be designed, built, and maintained in ways to minimize and control sources of pollution, provide adequate exhaust and outdoor air ventilation by natural and mechanical means, maintain proper temperature and humidity conditions, and be responsive to pupils and staff with particular sensitivities such as allergies or asthma. Failure to deal adequately with any of these issues may go unnoticed, but can and often does take its toll on health, comfort, and performance of teachers and pupils in school.

4. CONCLUSION AND RECOMMENDATIONS

This research focused primarily on air temperature in the classroom conditions that may influence cognitive performance. Included studies focused on cognitive performance of children aged 11 to 12 years old or Grade five (5) pupils attending in city schools in Bicol Region. Emerging evidence indicates a strong association between temperature and cognitive performance. While the relationships are not causal, more research in controlled laboratory conditions with a larger population including children is necessary, as the magnitude of the effects may differ between children of different age groups and adults. As well as improving thermal comfort of pupils, lowering the indoor temperatures in classrooms below 25^0C may also improve academic performance of pupils.

Overall evidence suggested limiting indoor and outdoor CO2 levels. Evidently DENR reported Bicol Region is at risk of the increase of Carbon Monoxide which may result in climate change or warming the environment. Although the level of CO2 in classrooms it's not the main focus of the present research, since the research was conducted from October to March a temperature that ranges from 24^0C to 31^0C can be correlated that the air contains particulates or pollutants like CO2 resulting in high temperature. Researchers propose a strong positive association between CO2 levels and risk of viral infections. It is also likely that low temperatures, low CO2 levels and corresponding increased ventilation rates will improve satisfaction of pupils with Indoor Air Quality (IAQ) and reduce children's sickness.

Future work is required to establish evidence based guidelines for average temperatures and CO2 levels in classrooms. These findings suggest that high ventilation rates and low temperatures required to provide optimum health outcomes and learning conditions may limit the potential for energy savings in school buildings. Natural Ventilation is also recommended through planting more trees in school vicinity to provide fresher air.

5. ACKNOWLEDGMENT

The researchers would like to thank all Grade V pupils of Public City Elementary School in Bicol Region who participated in realizing this study. A Special thanks to the director of Department of Education Region V, to all City School superintendents for allowing the researchers to undergo the conduct of research. A warmest thanks to all Grade V teachers for their support to the research team.

REFERENCES

1. Bakó-Biró, Z., Wargocki, P., Weschler, C. J., and Fanger, P. O., (2004) Effects of pollution from personal computers on perceived air quality, SBS symptoms and productivity in offices. Indoor Air, 14: 178-187
2. Currie, J., Hanushek, E. A., Kahn, E. M., Neidell, M., and Rivkin, S. G. (2009). Does pollution increase school absences? The Review of Economics and Statistics, 91(4):682–694.
3. Currie, J. and Walker, R. (2011). Traffic congestion and infant health: Evidence from e-zpass. American Economic Journal: Applied Economics, 3(1):65–90
4. Chatzidiakou, L., Mumovic D., and Summerfield, A. J. (2012), "What do we know about indoor air quality in school classrooms? A critical review of the literature," Intelligent Building International, no. October, pp. 37–41.
5. Chay, K. Y. and Greenstone, M. (2003). The impact of air pollution on infant mortality: evidence from geographic variation in pollution shocks induced by a recession. The quarterly journal of economics, 118(3):1121–1167.
6. Choudhary, M.P., (2013). Causes, Consequences and Control of Air Pollution. Conference: All India Seminar on Methodologies for Air Pollution Control At: Malviya National Institute of Technology, Jaipur, Rajasthan, India
7. Daisey JM, Angell WJ, Apte MG (2003). Indoor air quality, ventilation and health symptoms in schools: an analysis of existing information. Indoor Air.: 53-64. doi: 10.1034/j.1600-0668.2003.00153.x. PMID: 12608926.
8. (DENR-EMBV, 2013). Annual Report, Department of Environment and Natural Resources- Environmental Management Bureau V Regional Center Site, Rawis, Legazpi City
9. (DENR-EMBV, 2014). Annual Report, Department of Environment and Natural Resources- Environmental Management Bureau V Regional Center Site, Rawis, Legazpi City

10. Ebenstein, A., Lavy, V., and Roth, S. (2016). The long-run economic consequences of high-stakes examinations: Evidence from transitory variation in pollution. American Economic Journal: Applied Economics, 8(4):36–65.
11. EPA, 2003; Indoor Air Quality and student performance. www.epa.gov/iaq/schools.
12. Graff Zivin, J., Song, Y., Tang, Q., and Zhang, P. (2020). Temperature and high-stakes cognitive performance: evidence from the national college entrance examination in china. Journal of Environmental Economics and Management, 104:102365.
13. Griffiths, I.D. The thermal environment. In D.C. Canter (Ed.), Environmental Interaction: Psychological Approaches to Our Physical Surroundings. New York: International Universities Press, 1975.
14. Goodman, J., et.al. (2018). Heat and Learning, Cambridge, MA, 2018.
15. Holmberg, I., Wyon D.P. (1967). The dependence of performance in school on classroom temperature. Educational and Psycho- logical Interactions, Malmo, Sweden.
16. Kahl, J. (2005). Room Temperature and Task Effects on Arousal, Comfort and Performance. UW-L Journal of Undergraduate Research VIII.
17. Knittel, C. R., Miller, D. L., and Sanders, N. J. (2016). Caution, drivers! Children present: Traffic, pollution, and infant health. Review of Economics and Statistics, 98(2):350–366.
18. Mendel,Mark J. and Heath, Garvin A. "Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature. Published in Indoor Air Journal, vol. 15, pp. 27-32.
19. Miller, Sebastián J. and Vela, Mauricio A (2013). The Effects of Air Pollution on Educational Outcomes: Evidence from Chile. Inter-American Development Bank
20. Mohai, P., Kweon, B.-S., Lee, S., and Ard, K. 2011. "Air pollution around schools is linked to poorer student health and academic performance". Health Affairs , 30(5):852–862.
21. New York Commission on Ventilation, (1931). School Ventilation and Practices; Teachers College, Columbia: New York, NY, USA, 1931. Available online: https://escholarship.org/uc/item/5sw56439#page=17 (accessed on 3 May 2021)
22. Park J. (2016). Temperature, Test Scores, and Educational Attainment, Boston, MA.
23. Pilcher, J. J., Nadler, E., & Busch, C. (2002). Effects of hot and cold temperature on performance: A meta-analytic review. Ergonomics, 45(10), 682–698. https://doi.org/10.1080/00140130210158419
24. Porras-Salazar, J.A et.al. (2018). Reducing classroom temperature in a tropical climate improved the thermal comfort and the performance of elementary school pupils, Indoor Air.) 1–13. doi:10.1111/ina.12501
25. Roth, S. (2018). The effect of indoor air pollution on cognitive performance: Evidence from the uk.
26. Ryd, H., Wyon, D.P. (1970). Methods of Evaluating Human Stress due to Climate D6-1970, Stockholm, Sweden, 1970Sharma VM, Panwar MR (1987). Variations in mental performance under moderate cold stress. Int J Biometeorol. 1987 Mar;31(1):85-91. doi: 10.1007/BF02192842. PMID: 3583448. ,
27. Taylor, L., Watkins, S. L., Marshall, H., Dascombe, B. J., & Foster, J. 2016. The Impact of Different Environmental Conditions on Cognitive Function: A Focused Review. Frontiers in physiology, 6, 372. doi:10.3389/fphys.2015.00372
28. Wargocki, P.; Porras-Salazar, J.; Contreras, S. The relationship between classroom temperature and children's performance in school. Build. Environ. 2019, 157, 1–5. [CrossRef]
29. Wyon, D. P., Fanger, P. O., Olesen, B.W., & Pederson, C. J. K. (1975). The mental performance of subjects clothed for comfort at two different air temperatures. Ergonomics, 21, 231-233.
30. Wyon, D.P., Andersen, I., Lundqvist, G. (1979).The effects of moderate heat stress on mental performance, Scand. J. Work Environ. Heal. 5 352–361. doi:10.5271/sjweh.2646.
31. Wargocki, P., Wyon, D.P. (2007). The Effects of Moderately Raised Classroom Temperatures and Classroom Ventilation Rate on the Performance of Schoolwork by Children, HVAC&R Res. 13 (2007) 193–220. doi:10.1080/10789669.2007.10390951.
32. Zhang, X., Chen, X., and Zhang, X. (2018). The impact of exposure to air pollution on cognitive performance. Proceedings of the National Academy of Sciences, 115(37):9193–9197.