



The Influence of Weather on Students' Academic Performance in Kashim Ibrahim College of Education, Maiduguri, Nigeria

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Authors' contributions

This study was a collaborative work carried out by three authors. Author AKM designed the study collected data, performed statistical analysis and drafted the manuscript. Authors MAJ and HAM participated in data collection, statistical analysis and managed literature searches. All authors read and approved final manuscript.

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ABSTRACT

This study investigated the influence of ambient temperature on academic performance of a cohort of 259 students of Kashim Ibrahim College of Education, Maiduguri over a three year period i.e. from the year of their matriculation to completion. The students were randomly selected from four departments of the college. The achievements of these students (GPA) at the end of each semester examination that roughly coincided with hot and cool seasons were collected beginning from their matriculation year in 2010 through 2013 (graduation year). Additionally questionnaire instrument was used to gauge the perceptions of the students' performance in the two seasons at the end of the final year. Student's t – test statistic was used to compare the performance of students in the two semesters. Results generally showed significant differences between the two seasons in terms

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of students' performance in the first and third years ($p < 0.001$) while no significant differences could be established in the second year ($p > 0.001$). Disaggregated data on the basis of departments however showed significant difference only with respect to the two science courses (Agriculture and Integrated Science) while the two humanities courses (Social Studies and English Language) showed no significant difference ($p > 0.001$). Although most students preferred academic activities during cool season, chi squared test of the association between sex, place of origin and duration of stay in Maiduguri and performance did not show any significant difference ($p > 0.05$). It was recommended that academic activities be staggered to emphasise early morning and evening activities during hot weather to improve teaching and learning. Other measures recommended include decongestion of classrooms, provision of adequate ventilation, the use of white colour paint in school buildings and improvement in electricity supply to schools.

Keywords: Academic performance; students; temperature; weather.

1. INTRODUCTION

The totality of man's actions, despite the levels of control exerted by modern technology is greatly influenced by the physical environment. The interaction of the elements within the physical environment governs his economic activities such as transportation, crop cultivation, fishing, lumbering etc. This is especially true for the developing countries where technological advancement is still quite low to control the physical environment. Because of the overbearing influence of climate in particular on peoples' livelihoods (which has a marked seasonality), the level of influence may vary between and across seasons of the year. It is in an effort to overcome such influences that man has devised the means to survive harsh weather conditions. In cold regions for instance, houses may be insulated, furnaces provided and roofs become very steep to avoid snow collection while in hot environments adjustments may range from simple technologies such as thatched roofs to modern ones such as the provision of appliances like air conditioners in homes and public places. Notwithstanding these adjustments, weather influences on man's activities has constituted an interesting field of investigation by geographers [1]. have stressed that human comfort and health are affected more by climate than any other element of the physical environment. Climatic elements that affect physiological function of the human body include radiation (sunshine), temperature, relative humidity and atmospheric pressure. Human comfort and health are influenced mostly by temperature and humidity variations [2,3]. Yan has established significant relationships between weather and human mortality in Hong Kong [4]. Deaths from all causes except cancer were significantly higher in winter and specifically, significant negative association was observed between minimum temperature and cloud cover with mortality.

Man is constantly exposed to the influence of atmospheric changes whether indoors or outdoors which have profound impact on the physiological functioning of his body. The term 'thermal stressor' has thus been used to describe the way human body (with a constant temperature of 37°C) adjusts to changes in atmospheric temperature which often leads to stress [5]. This effect was observed in different settings. Extreme temperatures, whether hot or cold have implications for both teaching and learning outcomes [6,7]. A research by Dunn and Dunn cited in Pytel [8] indicated severe cold or hot room temperatures affect pupils' learning because the brain will be constantly reminding the body to respond appropriately until the required temperature is achieved; these reminders are likely to affect learning and learning outcomes. This is because learning and memory require attention and so thermal stress on the individual may result in poor memory [5]. A related experiment by Pilman has established that temperature at 64°F and 80°F has significant negative effect on memory while temperature at 72°F showed no such effects [9]. This indicates that the latter temperature is ideal for learning since variances of temperature from 72oF either way indicated reduction in ability to remember certain tasks. The United States Environmental Protection Agency (EPA) also maintains that within school settings poor management of indoor temperature and humidity have adverse effects on not only learners' performances but also those of teachers [10]. Though, unlike the earlier researches cited, no specific temperature range was suggested for optimum school task performance, even moderate changes in room temperature was noted to have effect on students' mental task performance such as addition, multiplication and sentence comprehension. Based on these effects EPA suggested that extreme temperatures be avoided to enhance teaching and learning in schools. At

its Annual Conference in 2007 the National Union of Teachers in the UK prescribes that maximum indoor temperatures should not exceed 26°C for optimum learning of pupils [7]. The NUT emphasized government approved performance standards for new schools in the UK. At least two of the following will have to be met in the design of new schools:

- i. The total number of hours during which classroom temperatures exceed 28°C should not be more than 120
- ii. On average internal temperature should not exceed 5°C above the external temperature
- iii. Internal temperature when the space is fully occupied should not exceed more than 32°C

Variations in temperature have been shown to differentially affect memory. Higher temperatures of 32°C and 38°C were shown to lead to slower task acquisition and retention in rats compared with a temperature of 25°C while no significant negative effect was observed when temperature was lowered to 7°C and 15°C [5]. The implication of this experiment on humans is yet to be fully understood but the fact that most researches conducted on small animals are later extended to humans is instructive. Studies have indicated the effect of temperature on not only classroom tasks but also in office settings. Research on the impact of temperature on office work indicated that productivity was measured to be highest at 22°C with about nine percent reduction in productivity when temperature increased to 30°C [11]. In Pakistan, the physical environment, including temperature, acoustics, lighting etc. and have been shown to significantly affect students' performance [12].

While these studies indicated the importance of temperature on cognitive tasks, they are largely confined to the advanced world where weather effects on individuals can be effectively overcome. Little attention is paid to developing countries where school facilities are often poor, with high student population despite the harsh weather conditions. More importantly, the experiments did not consider temperatures beyond 40°C which is common in Maiduguri in the months of April, May and June. To what extent do seasonal differences in temperature affect students' achievement? What is the relationship between period of residency in Maiduguri and performance according to seasons? How does temperature affect school

performance according to gender? Therefore this study examined the effect of high temperature on the performance of learners with respect to Maiduguri, Northeastern Nigeria.

2. THE STUDY AREA

Maiduguri the study area has a hot and dry climate that falls within Koppen's Bsh classification. It is semi-arid and hot throughout the year with a mean monthly temperature of 25°C. Minimum daily temperature of 15°C is usually recorded in December while maximum daily temperature of 45°C is recorded in May. Thus the coolest month is December while May, the month in which onset of rains is recorded is the hottest (Fig. 1). Rainfall lasts between four to five months with a single peak usually recorded in August. Average rainfall recorded was estimated at 613 mm [13]. The climate of Maiduguri is characterized by a long dry season with high evaporation rate from October to May and a short wet season for the remaining part of the year. Even though two seasons (wet and dry) are distinctly recognised, natives of the city identify four seasons. These are rainy season, (June to September), Harvest season (September to November), Harmattan or Cool dry season (December to February) and hot dry season (March to May) [14]. These seasons are influenced by two types of winds i.e. Northeast trade winds originating from the Sahara and Southwest monsoons. The Northeast trade winds are dry, dusty and cold while the southwest monsoons or the rain bearing/moisture laden winds originate from the Atlantic Ocean. The arrival of this latter wind marks the beginning of the rainy season.

3. MATERIALS AND METHODS

This study involved a longitudinal survey carried out to examine the effect of high environmental temperatures on academic achievement of students in Kashim Ibrahim College of Education, Maiduguri between 2010/2011 and 2012/2013 session. Since the minimum number of years for the award of Nigeria Certificate in Education (NCE) awarded by the college is three years, performance in semester examinations of a cohort of students enrolled in 2010/2011 session was studied through to their year of graduation in 2013 taking into account the season under which the examinations were conducted. Other relevant data generated were students' sex, marital status, age, and place of origin and duration of stay in Maiduguri. Throughout the study period,

first semester lectures were conducted in the months of December through March and examinations held in March/April (hot dry season) representing a period of high temperature, less humidity, with little or no cloud cover locally referred to as *be* by locals in the study area. Second semester lectures were held from May – July and examinations held in August (rainy season) or *nengəli* during which lower temperatures, high humidity, cloud cover and maximum rainfall for the year are recorded (see Fig. 1). In this study, the month of May (during which first semester examinations were held) was taken as a surrogate for high temperature while August (during which second semesters were held) was used as a surrogate month for low temperature.

Sampling procedure used in this study was the stratified random sampling technique. A sample of four academic departments was randomly chosen from a total of 21. One department each was randomly selected from each of the four schools of Vocational Education, Sciences, Arts and Social Sciences, and Languages (Table 1). In each department sampled, 80 students that enrolled in 2010 session were randomly selected from the departmental register and their performances monitored throughout the duration of studies. Additionally, self completed questionnaires were issued to the sampled students in the sixth semester i.e. their final semester in the college to measure their

perception of weather/performance relationship. In all, out of the target population of 320 students only 259 students returned the questionnaires and whose records of performance were used. This represents about 22 percent of the total of 1185 students matriculated in that session.

Although two schools i.e. Education and Basic Studies structurally exist in addition to the above named schools in the college, these were excluded in the sampling of departments because all students take education as a compulsory course and therefore belong to the School of Education (education is compulsory to all matriculated students) while those in the School of Basic Studies were not matriculated to warrant their selection.

For analysis of data generated through the above procedure, performance of each student in a department was summarized by semester using the course credit system to determine the grade points earned. Each end of semester examination was also categorized into either hot or cool as described above. The Grade Point Average (GPA) for each student which summarizes their performance in a semester was stored into computer by department using SPSS version 16.0 software. These were later collated for all the sampled departments and statistical tools such as tables, charts, percentages and student's t - test were used to analyze the data. Probability level was set at

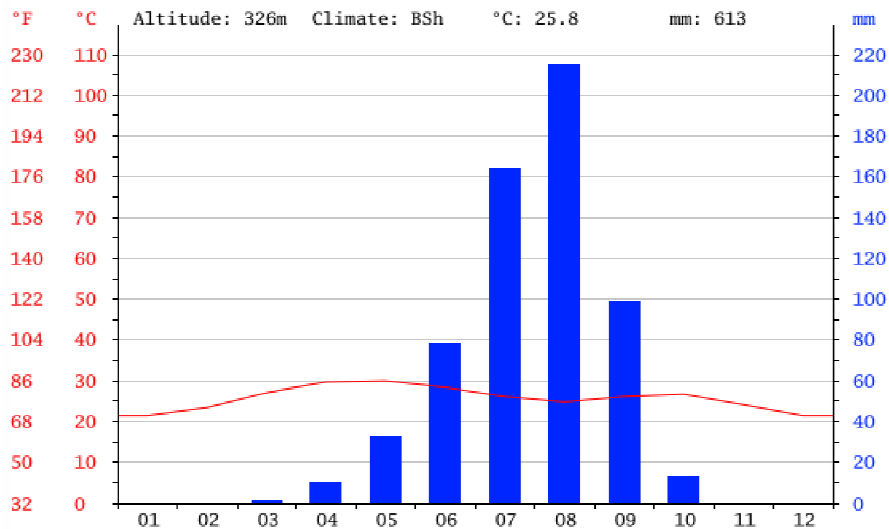


Fig. 1. Average Temperature and Rainfall Pattern of Maiduguri

Source: <http://en.climate-data.org/location/545/>

$p < 0.05$. Since a minimum of six and maximum of ten semesters is required for graduation for the NCE programme, sampled students that were repeated during the course of their study were considered to be part of the analysis while those that have been withdrawn were excluded from the list.

4. RESULTS

4.1 Socioeconomic Characteristics of Respondents

The socioeconomic characteristics of the respondents are shown on Table 2. There were slightly more female respondents in the sample (53.5%) than male (46.5%).

The reason for such a higher number of female students may lie in the fact that teaching as a profession (especially at the primary school level) is most appealing to women in Borno State. Since KICOE is a teacher training institution located in the urban centre, many women take such an advantage seriously. Besides, the attitude of men who prefer their wives to be in the teaching profession than others could also explain this higher number of female in the sample. Many men, Muslims in particular frown at their wives taking up appointments in the clerical, secretarial and administrative cadres since these are perceived to be 'dirty' work because women and girls may become exposed to temptations of other men. A significant percentage of respondents (80.7%) in the sample were native to Borno State because KICOE is a state owned institution. Of these, nearly 70% are from the southern part of the state, a region that has had early missionary contact and which has have given it an early lead in secular education within the state. Weather is also relatively cooler in the southern region compared to the north and central zones. Slightly more than a third of the respondents have stayed in Maiduguri for less than five years. Perhaps these are respondents that only came to Maiduguri for studies. About 33% have however stayed for 20 years or more.

4.2 Respondents' Mean Score and Relationship with Environmental Temperature

Respondents' mean score in the three year period (six semesters) is shown in Table 3. The mean score for the six semesters generally suggest a declining performance with the fifth semester having the least performance.

Performances were also marginally higher in the second semester with a mean CGPA difference of 0.06, 0.02 and 0.04 in the first, second and third years of study. The higher performance in the second semester relative to the first is particularly noteworthy as lectures and examinations in the college were held during the stressful period of March – May when temperatures are generally much higher. A t- test performed on the difference in performance between first and semester showed significant difference in the three year period ($p < 0.001$). It was further observed that the difference was equally significant in two out of the three years of study i.e. first year ($p < 0.001$) and third year ($p < 0.001$). However, it was interesting that the difference between the two semesters in the second year was not significant ($p > 0.05$). This suggests generally better performances of students in the second semester which is also corroborated by the respondents' claim in the questionnaire administration that their performances are better in the second semester (71%) than first.

Disaggregated data on the relationship between temperature and performance of respondents by course of study also yielded interesting results. The difference was observed with respect to the two science courses of integrated science and agriculture while few of such differences were observed in the case of arts and humanities courses (Table 3a). Thus, while significant variation exists in integrated science in the first, second and third years ($p \leq 0.01$), the variation in respect of agricultural education was observed to be significant only in the first and third years ($p < 0.05$). On the other hand, there was no significant variation with respect to English Language ($P > 0.05$) and social studies (except in the third year).

4.3 Perceived Effect of High Temperature on Performance

Maiduguri is generally a hot city (see Fig. 1). This was confirmed by respondents as the city was perceived to be very hot by 54 percent of the respondents and hot by 42 percent. Thus, apart from the official record of school performance and its relationship with season, respondents were also asked to state whether or not high environmental temperature affected their scores in examinations in the college. The responses were that 74.1 percent perceived there was effect of high temperature on performance in examinations while only 21.9 percent perceived

high environmental temperature had no effect on school achievement. The effect of high environmental temperature on students was disaggregated on the basis of respondents' sex, duration of stay in Maiduguri and place of origin and presented on Tables 4, 5 and 6. These variables were used in order to examine more closely the extent temperature exerts on the performance of different sub-groups. A slightly higher percentage of males (78.3%) than females (76.3%) perceived high environmental temperatures affected their grades. Since temperature could affect people differently, information on place of origin of respondents i.e. whether from Borno State (indigenes/locals), respondents from other northern states and those from southern Nigeria were also collected. Data revealed no large differences in responses on the basis of place of origin. Specifically, 79%, 65.5% and 75% of locals, respondents from other northern states and those from southern Nigeria respectively reported temperature affected their performance. Similarly, high temperature was perceived to affect students irrespective of their duration of stay in Maiduguri the study area. There was a high response rate affirming the effect of temperature on school performance. The highest affirmative response was however from respondents who have stayed in the town between 5 – 9 years (90.0%) and least response was for those who stayed for less than five years (73.6%). Chi square test performed on all the variables revealed no significant differences between respondents' sex,

place of origin and time spent in Maiduguri and their performance ($p > 0.05$).

Table 1. Number of departments and students sampled

School	Department sampled	No. of students
Languages	English	61
Arts and Social Sciences	Social Studies	80
Sciences	Integrated Science	65
Vocational Education	Agricultural Education	53
Total	4	259

Source: Field Data, 2014

5. DISCUSSION

Literature on the effect of high environmental temperature on various aspects of human endeavour is generally perceived as one that is a strong determinant and often of negative consequence, seriously affecting man's actions. In this study, high environmental temperature usually recorded during end of first semester examinations (without controlling for other factors) was observed to have influence on academic performance of students as the performances were significantly less than those of second semester. It is instructive to note that examinations and indeed many other academic tasks took place in the college at temperatures

Table 2. Demographic characteristics of respondents

Variable	Frequency	Percent
Sex		
Male	120	46.3
Female	139	53.7
Place of origin		
Borno	209	80.7
Other Northern States	27	10.4
Southern Nigeria	23	8.9
Borno state students		
Borno North	12	5.7
Borno Central	52	24.9
Borno South	145	69.4
Total duration of stay in Maiduguri		
<5 years	93	35.9
5 – 9 years	11	4.2
10 – 14 years	21	8.1
15 – 19 years	48	18.5
20 years and over	86	33.2

Source: Field Data, 2014

Table 3. Mean performance score of respondents

Level of study	Year 1 (2010)		Year 2 (2011)		Year 3 (2013)	
	1 st	2 nd	1 st	2 nd	1 st	2 nd
Semester						
Mean CGPA	2.12	2.18	2.14	2.16	1.94	1.98
P value	0.000	-	0.85	-	0.000	-
df	258	-	258	-	258	-

Source: Field Data, 2014

Table 3a. Effect of temperature on students performance by department

Department	Year 1 (2010)	Year 2 (2011)	Year 3 (2013)
English			
t	0.15	0.52	0.85
df	60	60	60
p	0.544	0.60	0.40
Social studies			
t	5.91	0.38	3.40
df	79	79	79
p	0.56	0.71	0.0001
Integrated science			
t	3.5	6.9	5.52
df	64	64	64
p	0.01	0.0000	0.000
Agriculture			
t	2.71	1.29	2.22
df	52	52	52
p	0.01	0.21	0.032

Source: Field Data, 2014

Table 4. Perceived relationship between sex and performance

Sex of respondents	Yes		No		Total	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Male	94	78.3	26	21.6	120	100
Female	106	76.3	33	23.7	139	100
Total	200	77.2	59	22.8	259	100

Source: Field data, 2014 $\chi^2 = 0.158$, $p = 0.69$ **Table 5. Perceived relationship between place of origin and performance**

Place of origin of respondents	Yes		No		Total	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Borno	166	79.0	44	21.0	210	100
Other Northern States	19	65.5	10	34.5	29	100
Southern Nigeria	15	75.0	5	25.0	20	100
Total	200	77.2	59	22.8	259	100

Source: Field data, 2014, $\chi^2 = 2.78$, $p = 0.25$

between 35°C and 40°C from mid-first semester to examination period in May when maximum temperatures of 45°C were common. In the United Kingdom 26°C has been recommended as the maximum indoor temperature beyond which teaching and learning should not take place [7] (National Union of Teachers, 2010). It was also observed that temperature between 69

– 74 °F is the ideal learning temperature in Iowa, United States [15]. Since indoor temperatures were higher due to overcrowding of students and poor classroom condition especially arising from lack of air conditioners and fans in our study site, it is reasonable to expect that such high temperatures would impact on the proper physiological functioning of the body including

Table 6. Relationship between duration of stay and performance

Duration of stay	Yes		No		Total	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
5 years	69	73.4	25	26.6	94	100
5 – 9 years	10	90.9	1	9.1	11	100
10 – 14 years	20	87.0	3	13.0	23	100
15 – 19 years	38	77.6	11	22.4	49	100
20 years and over	63	76.8	19	23.2	82	100
Total	200	77.2	59	22.8	259	100

Source: Field data, 2014, $\chi^2 = 3.20$, $p = 0.53$

memory. Indeed environmental temperature has been seen to influence body temperature [5]. Although this study is not experimental, it is significant that the findings were determined through both official record of performance (performance between two semesters with contrasting temperature characteristics) and also through individual perception via the use of a questionnaire. While the link between indoor temperature (thermal quality) and school achievement has been emphasized [7] this study departs from that of Toyinbo [16] conducted in Finland where mean air temperature was shown to have significant positive correlation with perceived air quality but not with learning outcomes. Learning outcomes were observed not to significantly differ among the groups of students in schools studied that possessed the required indoor temperature and those whose indoor temperature was higher. Even though the effect of high temperature on performance outcome of learners in this study was determined in two different ways, it is important that the two methods used both suggest significantly lower performances. Findings from a study [17] suggest an increase in test scores of 12 – 13 points with every decrease in classroom temperature of 1°C within the observed temperature range of 20 – 25°C. Nevertheless, there however appears to be among respondents, a perceived differential effect based on course of study - the effect being more on students from science related courses than the humanities. Furthermore, it is instructive to note that the perceived effect of high environmental temperature appeared to uniformly affect respondents irrespective of their background characteristics especially as they relate to sex, place of origin within Nigeria and duration of stay in Maiduguri. This was confirmed statistically since no significant differences could be established between the performance of respondents displaying these background characteristics and perceived effect of high environmental temperatures. It must be realized however that direct causal relationship between

temperature and school performance is difficult to establish and was only inferred in this study.

6. CONCLUSION

From the forgoing discussion it was established in this study that there is a relationship existing between seasonal temperature variations in Maiduguri and school achievement of students in Kashim Ibrahim College. Conditions of poor infrastructure such as inadequate fans and lack of air conditioners in lecture rooms coupled with overcrowding in classrooms may have contributed to poor level of performance among students. The relationship between seasonal variation and school achievement is strongest among science students and least for students in the arts and humanities disciplines. However, further studies, perhaps of the experimental type are required to establish the strength of the relationship on a larger scale.

Based on the findings, the paper therefore recommends that there is the need for a more conducive learning environment to enable the students learn more and perform better in their final examination. The school should also equip all the classrooms and lecture theaters and halls with air conditions. The erratic and epileptic nature of electricity in the city should be curtailed by providing standby generators during harsh weather conditions between March and June by the school. The need to decongest classrooms by pegging maximum classroom size limits will reduce the adverse effects of weather on students.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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