The Effect of Artificial Classroom Illumination on Students' Academic Achievement in Public Boarding Secondary Schools in Nairobi County of Kenya

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Abstract

Light is a key factor in instruction. Classroom illumination is intended to create an excellently lit environment that is conducive to instruction. A conducive instructional setting creates a stimulus where students have a feeling of well-being which soothes them to concentrate and perform well in their learning tasks. Even though there has been a mammoth advancement in lighting technology, artificial classroom illumination in many secondary schools is below the requisite threshold. The goal of this research was to investigate the effects of artificial classroom illumination on instruction which in return influence public boarding secondary school students' academic performance. A descriptive survey research design was used in this study. The study was guided by the Walberg's theory of education productivity. The target population of this study comprised 29 public boarding secondary schools, 29 principals, 1,120 teachers and 2,015 students of Nairobi County public boarding secondary schools. The study sample comprised of 20 principals, 200 teachers, and 435 form three students. The sample was selected by the use of purposive, stratified and random sampling techniques. Questionnaires and interview schedules were used to collect data for the study. A pilot study was conducted in the neighboring Kiambu County. A Cronbach alpha of 0.822 was obtained which was considered appropriate for the study. The collected data was analyzed using descriptive and inferential statistics. The findings were presented in graphs tables and narrations. The study established that in Nairobi County, public boarding secondary schools, artificial classroom illumination negatively impacted on instruction and students' academic achievement. The artificial illumination of the classroom made it difficult for the students to see clearly what was written on the chalk/whiteboard, letters displayed on the computer screen and diagrams on the classroom projector screen. The study recommended that all secondary classroom to be installed with adequate classroom illumination so as to eliminate undesirable illumination effects on instruction and academic achievement.

Keywords: Artificial classroom illumination, instruction, students' academic performance

INTRODUCTION

Illuminating a classroom is a key facet of acquiring knowledge and instruction and it is an important determinant of students' learning achievement. Light is essential to our lives because it helps us to operate ideally in every environment. It is a powerful source of energy that orchestrates our endogenous daily trend setter with our surroundings and is a means for improving mental recital (Keis *et al*., 2014). Light is an emblem of security, wealth and modernity (ALAN, 2013). Generally speaking, human life and activities especially the process of acquiring knowledge and skills is centered on light. A study by Mott *et al*. (2012) observes that light directly affects all aspects of human

life. The study pointed out that light is a powerful aid of visual performance, a regulator of a variety of body processes like sleep and attentiveness, an essential component for cognition and mood, a stimulator for the creation of essential hormones such as cortisol and melatonin, and is indispensable in a healthy relaxation-working pattern. The study suggested that light is next to food and water in a human beings' requirements and is the most desirable environmental component in the regulation of physical disposition. The study also revealed that diffuse light affects biorhythms, pulse, brain activity, blood pressure, and respiratory rate. The study reported that the eyes have "photoreceptor cells" known as cones and rods which control visual results. Further, the study underscored that, the moment light shines on the cones and rods, an intricate chemical response happens which creates electrical whims in the nerves which link photoreceptor cells to the visual cortex at the rear of the brain which interprets the electrical whims as vision. A study conducted by Zumtobel (2017) indicate that the rods switch on at night and enable people to see grey shades and cones switch on during the day to enable us to see sharpness, details and colour. The study revealed that classroom lighting has a central role in a students' learning process. This suggests that classroom lighting should be adequately designed so that it can positively influence students' academic achievement.

The most important objective of lighting design in a classroom is to provide a well illuminated and intuitive learning space that enable students to be comfortable and perform their learning tasks well (Etayo *et al*., 2007). Most of the learning is by seeing and one can only see in the presence of light. A study by BRANZ (2007) reported that although natural classroom lighting is the best for a learning environment, during overcast days (when additional lighting is needed) or at night, artificial lighting is needed to provide light in the classroom for learning purposes. The study bemoaned that many of the classrooms being constructed today lack sufficient natural lighting because they are overcrowded and obstruct each other from receiving natural light leading to the use of artificial lighting which is less sufficient as compared with natural lighting intensity from the sun. From BRANZ (2007) sentiments, it is clear that the use of artificial classroom lighting is paramount and inevitable. This artificial classroom lighting in most cases is not sufficient for a learning environment and therefore cause a number of lighting-related problems and illness.

Lighting is a central consideration in the design and functioning of schools (Mousavi *et al*., 2011). A study by Samani and Samani (2012) reported that the light received in the eye has significant visual and non-visual biological effect on the body, controls eye health and eases eye wellness and efficiency. The study suggested that appropriate classroom lighting should be comfortable to all students. The study recommended that most places in the school should be well lit and remarkable. The presence of light causes reflectance and the colour on the main surfaces. Reflectance and colour make the classroom an attractive, stimulating and comfortable environment for both the learners and the teachers (Loe *et al*., 1999).

During the 1940s and 1950s, the development of economic fluorescent lamps led to the rapid installation of artificial lighting in the classrooms, compared to the use of natural light obtained through windows (Yucan, 2014). Electric lighting often delivers illumination levels between 215lux to 1,600 lux as compared to 2700 lux to 100,000 lux delivered by natural light between twilight and noon (Bullina, 2016). A study by Wishaw (2017) reported that artificial lighting is a unique human race innovation and has greatly enhanced the value of human existence. The study, however, noted that undesirable effects are emanating from getting exposed to artificial light. The study reported that blue light can cause diabetes, circadian rhythm disruption, obesity,

cancer, heart disease, and sleep disturbances. The study concluded that blue-rich light also affects the regulation of numerous hormones and the ability of the human body to resist infections. A study by Nuhfer (2007) warned that artificial lighting may cause havoc with human vision if it is not well designed and installed. The study reported that artificial lighting that is rich in yellowish wavelengths produces glare on a white paper which leads to eye strain. According to Mirrahimi *et al*. (2012), artificial lighting causes strain, fatigue and circadian dysfunctions among students. A study by Buckley (2014) indicated that insufficient classroom lighting can cause a number of barriers to learning such as inadequate colour rendering, glare, and flickering. The study concluded that such barriers can cause headaches, fatigue, boredom, and lack of engagement. Energy Focus (2015) warned that poorly designed artificial lighting emits ultraviolet radiation that damages the eye tissues causing clouding of the lens (cataract formation) which leads to visual impairment or blindness. Various human physiological processes such as electric impulses of the brain, melatonin production, core temperature, heart rate variability and blood pressure are influenced by the intensity and colour of artificial light (Sleegers *et al*., 2012). Mott *et al*. (2012) supported Sleegers *et al*. (2012) that when human beings are exposed to light, they experience physiological changes. Light sends visual messages to the minds of learners that affect their mood and encouragement levels (Samani & Samani, 2012). This shows that artificial lighting affects learners in a number of ways which need to be investigated.

The quality and intensity of artificial classroom lighting determine the degree of comfort in a learning space (Gilavand *et al*., 2016). A study by Loe *et al*. (1999) reported that visual well-being is necessary, and it is mandatory to regulate lighting in the general area to avoid eye strain and headaches. The study warned that dysplasia can occur in the task area due to a view of the sky, direct sunlight and reflection from a shiny reading material such as a computer screen. Therefore, such glaring sources should be eliminated. Higgins *et al*. (2004) argued that the visual milieu affects students' mental attitude, academic performance and their capability to perceive visual stimuli. A study by Samani and Samani (2012), revealed that discomfort caused by poor lighting or fading of light cause skipping of words or lines during reading, and bloodshot or red eyes after reading. The study further indicated that better installed artificial classroom lighting creates a good learning environment that speeds recognition of things, eliminates eye strain and increases visual stability.

Fluorescent lamps are the most commonly used light fitting in classroom artificial lighting. However, most experts now recommend controlled natural light complemented by appropriate artificial lighting because they create the best lighting conditions for instruction (Blazer, 2012). A research conducted by Walton *et al*. (2008) disclosed that teachers preferred a combination of different lighting types, each for a particular learning task. A study conducted by Suleman *et al*. (2014) established that a good classroom environment has a positive impact on the test scores among secondary school students. A study by Buckley (2014) indicated that artificial classroom lighting settings have an effect on an individual's behavior, disposition, and inspiration. The study reported that the quality of artificial classroom lighting can have a positive or a negative effect on students' academic achievement. The study contended that since technology advances are quicker than the built environment, artificial classroom lighting should be planned for tractability. The study concluded that provisions should be made to eliminate reflections, glare and visual discomfort when using visual display surfaces. According to Gilavand *et al*. (2016), the aim of classroom lighting is to provide a good and conducive learning environment where students' energy is spent on the learning process rather than straining to see. A study by Samani and Samani (2012)

reported that quality artificial classroom lighting enhances students' visual, comfort and interpersonal relations. The study also reported that when students clearly see the task they learn well and attain high academic test scores. The study advised that if students' visual discomfort is eliminated, their level of concentration increases which enhances their academic performance. The study concluded that when students are able to see clearly what they read, they cooperative and communicate well. Ibanez *et al*. (2017) retorted that it is possible to attain adequate lighting for visual task, but the visibility of a task depends on factors such as the internal surfaces on which the light is illuminated, the light source color characteristics, the window type, and the brightness level. A study by Mott *et al*. (2012) reported that lighting affects many echelons of human aspects such as vision, perception, mood, and daily rhythm. The study revealed that visual impairments induce behavioral problems, reduced level of concentration and hinder learning motivation. The study finally pointed out that accuracy, attention and reading speed are aided by cool white-focused fluorescent lighting, while students' teamwork is facilitated by warm white light. There is a gap in this literature because there is no substantial research that has been done on the effect of artificial classroom illumination on secondary school students 'academic achievement in Africa particularly in Nairobi County. This study therefore will endeavor to breach that gap.

Problem statement

Many researchers have confirmed that adequate classroom illumination improves student's concentration and academic achievement. However, even though there has been a successful advancement in illumination technology, artificial classroom illumination in many public boarding secondary school classrooms are below the required threshold (between 500 lux and 1000 lux). Many of the secondary school classrooms have unnecessarily inefficient classroom illumination that has been attested to cause discomfort, learning related problems and many challenges that curtail their learning processes. Many students who learn using inadequate artificial classroom illumination feel sick, uncomfortable, and therefore loose concentration in learning which leads to many health problems such as eye strain, musculoskeletal injuries and decreased attention span.

In Kenya, limited studies have been conducted to establish how artificial classroom illumination affect students' academic performance in secondary schools. The Kenya Ministry of Education Science and Technology policy only mentions that that poor lighting can lead to eye problems and classroom lighting should be sufficient (Ministry of Education Science and Technology, 2008). It does not specify the standards to be met in artificial classroom lighting installation. It is this situation that the researcher was impelled to investigates the effect of artificial classroom illumination effect on students' achievement.

Purpose of the study

The purpose of this study was to assess the effects of artificial classroom illumination on public boarding secondary school students' academic achievement in Nairobi County of Kenya. In this study, the effect of artificial classroom illumination was investigated because students use artificial lighting during the evening preps, private studies and morning preps.

Objectives

The specific objectives of this study are:

i. To investigate the effect of artificial classroom illumination of instruction.
ii. To establish how the instructional effects caused by artificial classroom illumination effects affect students' academic achievement.

Hypothesis*:*

This study tested the following hypothesis;

H_{01}: There is no significant relationship between the effects of artificial classroom on academic achievement.

THEORETICAL FRAMEWORK

This study adopted the Walberg's theory of education productivity (Walberg, 1981) which advances that individual student's psychological characteristics and immediate psychological environment impacts on the student's ability/prior achievement, motivation and level of development (Kuterbach 2013). The theory of educational productivity examines variables that include traits that are intrinsic to the learner, instructional factors, and environmental factors (*Ibid*). One variation of the Carroll model is Walbrg's (1981) theory of educational achievement. The model consists of nine factors designed to affect the cognitive, as well as effective, outcomes of learners. The nine factors include (a) ability or prior achievement, (b) age, (c) motivation (d) self-concept, (e) quantity of instruction, (f) quality of instructional experience, (g) classroom or school environment, (h) peer group environment and (i) Mass media (Rugutt & Chemosit, 2005). This theory suggests that the student's psychological characteristics and their immediate psychological environment influence their educational outcomes (cognitive, skills, and attitudes). This is considered as educational process goals as well as achievement goals to increase educational productivity. This theory informs the study that artificial classroom lighting affects students' psychological characteristics and their immediate psychological environs which influences their academic performance. The improvement of artificial classroom lighting will improve students' psychological environment and this will improve students' reading concentration and academic performance. This theory informs the study that adequate classroom illumination creates a conducive instructional environment which in return boosts students' academic performance.

Conceptual framework

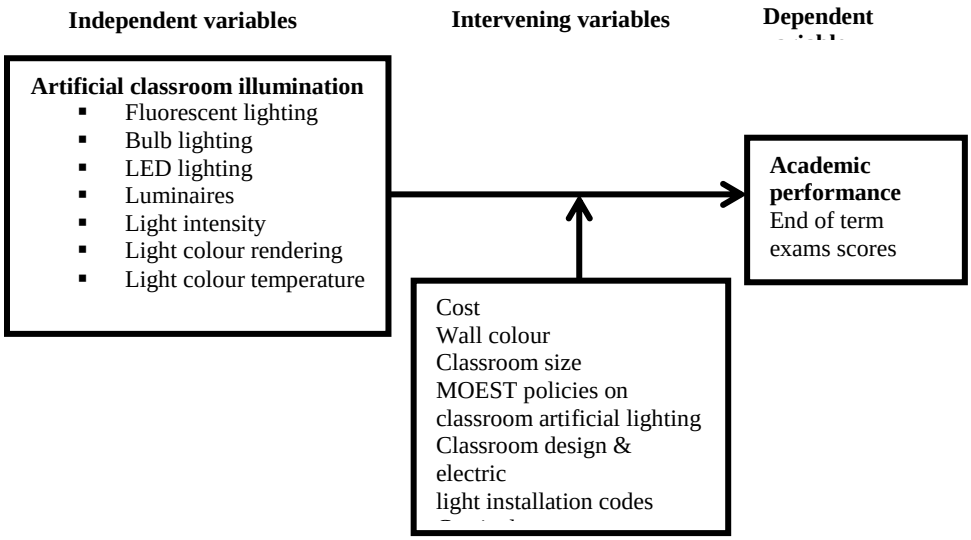

Figure 1: Relationships between artificial classroom illumination and academic achievement

METHODOLOGY

This study adopted a descriptive survey research design. The study was informed by a pragmatic philosophy which states that the significance of carrying out research is to provide practical solutions to the problem at hand and this can be amicably achieved by using both qualitative and quantitative information (i.e. the adoption of mixed ways analysis methodology). This study was conducted in Nairobi County public boarding secondary schools in Kenya.

The target population of this study comprised 29 public boarding secondary schools, 29 principals, 1,120 teachers, and 2,015 students of Nairobi County public boarding secondary schools. Purposive and stratified sampling techniques were used to select the 20 public boarding secondary schools, while simple random sampling was applied to select 20 principals, 200 teachers and 435 form three students.

Questionnaires and interview schedules methods were used to collect data that was analyzed using both descriptive and inferential statistics. The questionnaires were used to collect information from the teachers and students. The questionnaires solicited information on the state of artificial classroom lighting installation, artificial classroom lighting challenges on instruction and academic achievement. The interview schedule was used to gather information from the principals of the secondary schools under the study. The interview solicited information about the states of artificial classroom lighting installation in the schools and the principals' perceptions on the effect of artificial classroom lighting on instruction and academic achievement.

RESULTS AND DISCUSSION

In this section, respondents gave their perceptions on the effect of artificial classroom illumination on instruction. The responses were ranked on a four-point Likert scale with disagree (1), tend to disagree (2), tend to agree (3), and agree (4). Tables1 and 2 give a depiction of their responses. The researcher administered a questionnaire which captured the respondents' perception on how artificial classroom affect instruction. The researcher also captured the students end of term examination scores. The research coded the respondents' responses and students' end of term examination scores, entered the data into SPSS computer program and analyzed it. Table 1 shows the results of the analysis.

Artificial Classroom Illumination Effects on Instruction

Table 1: Teachers' Perception of Artificial Classroom Illumination Effects on Instruction

	Total		Responses			
	(N)		*Disagree (D)*		*Agree(A)*	
Item	**F**	**%**	**f**	**%**	**f**	**%**
Learners not able to see clearly diagrams on classroom projector screen when electric light is on	195	100	47	23	148	76
Learners not able to read letters displayed on computer screen	195	100	57	29	138	71
Learners were not able to see small writing on the chalk / white board	195	100	37	19	158	81
Learners appeared sleepy when learning using artificial classroom lighting	195	100	29	15	166	85

Source: Author, 2019

Table 1 reveals that majority 148 (76%) of the teachers agreed with only 47 (23%) disagreeing that the students could not clearly see diagrams on the classroom projector screen when artificial classroom lighting was on. Many teachers 138 (71%) agreed while only 57(29%) disagreed that the students were not able to read letters displayed on the computer screen when artificial classroom lighting was on. Many teachers 158 (81%) agreed while on only 37(19%) disagreed that the students were not able to read small letters displayed on the chalk/whiteboard when artificial classroom lighting was on. Many teachers 166 (85%) agreed while only 29(15%) disagreed that some students looked asleep when they were learning artificial classroom lighting were on. This could be due to lack of proper policy guidelines on artificial classroom lighting installation standards. Also most of the school administrators are more concerned about power saving and reduction of electricity bills at the expense of good quality lighting of instructional environment. This study indicates that artificial classroom lighting in Nairobi County public boarding secondary schools made the students not to be able to read small letters displayed on the chalk/whiteboard, see clearly diagrams on the classroom projector screen, and read letters displayed on the computer screen. This is in agreement with Buckley (2014) and Wall (2016) who state that inadequate artificial classroom lighting hinders instruction delivery. A Study by Oribo and Okemwa (2020) noted that inadequate artificial classroom lighting poses an instructional challenge in Secondary schools because it makes it difficult for teachers to integrate ICT in teaching. To improve instruction, there is a need to install adequate artificial classroom lighting in public boarding secondary schools. This assertion is in agreement with the findings of many researchers who found out that adequate artificial classroom lighting greatly contributes towards effective administration of instructional methods. A study by BRANZ (2007) revealed that adequate artificial classroom lighting creates a conducive and suitable instructional environment. Suleman and Hussein (2014) advise that appropriate illumination settings should be put in place to facilitate effective instruction delivery.

The impact of instructional effects caused by artificial classroom illumination on students' academic achievement

Table 2: Instruction effects on students' academic performance

Effects	N	Student end of the term mean score	SD	Variance
Students 'difficulty to see clearly what is displayed on the projector screen	104	48.00	7.83	61.37
Light flickered	93	47.00	7.99	63.86
Students' difficult to see clearly writing on chalk/whiteboard	105	46.00	7.57	57.24
Some sections of the classroom slightly darker than others	107	45.00	7.34	53.87
Total	**409**			

Source: Author, 2019

Table 2 illustrates that learners who stated that there were difficulties in seeing clearly what is displayed on the projector screen scored a mean of 48.00 in end of term examination, those who indicated that some lighting flickered scored a mean of 47.00 in end of term examination, those who had difficulties in reading letters on the white / chalk board scored a mean of 46.00 in end of term exams and those who said that some sections of the classroom were darker than others scored a mean of 45.00 in end of term examination. All students whose instruction was affected by artificial classroom illumination scored below average at the end of term examination. This is because the

artificial classroom illumination was not adequate. Also, the government has not emphasized the need for installing adequately artificial lighting in the classrooms. Instead, the government is currently concentrating on lighting schools which had not be electrified and there is lack of awareness of the negative impact of inadequate artificial classroom lighting on students' academic achievement. This study indicates that illumination effect on instruction made the students to score below average in their academic performance. This is in agreement with some studies which indicate that the quality of artificial classroom lighting influences students' academic performance. A study by OCC (2020) reported that lighting is a leading aspect in the brain's capacity to focus on learning. The study revealed that learners in bright lit environment achieve better grades as compared with those in dimly lit classrooms. The study concludes that insufficient lighting diminishes the cognitive efficiency of the human brain. Alternatively, some literature in this study indicate that sufficient artificial classroom lighting has a positive effect on students 'academic performance. Aloyo (2015) conducted a study on the relationship between physical environment and academic achievement in Nairobi City of Kenya public secondary schools. The study revealed that the type of classroom lighting is a key predictor of academic achievement. A study by Mott et al. (2012) which investigated the effects of artificial lighting characteristics on maximum learning found out that focused light lead to high academic achievement. Ismail and Abdullah (2018) reinforce that lighting in a learning environment shapes students' learning behavior. Keis *et al*. (2014) points out that light is a powerful source of energy that orchestrates an individual's endogenous daily trend setter with his or her surroundings and is a means for improving mental recital. Sleegers *et al*. (2012) and Aloyo (2015) in one voice attest that quality artificial classroom lighting has a positive effect on academic achievement.

This study did not dwell on the effect of lighting colour correlated temperature and light colour index. This was because the research was not able to get equipment which measure lighting colour correlated temperature and light colour index. However, some studies indicate that light temperature and correlated index influence students' academic performance. A study by Mott *et al*. (2012) revealed that lighting of colour correlate temperature between 4000 K and 17000 K boosts students' alertness and academic achievement. The study revealed that girls perform well in warm white lighting environs whereas boys perform well in mental activities in cool white lighting. The study concluded that colour rendering, correlated color temperature, and luminous efficacy lighting diode enhance visibility creating a conducive learning environment.

Results of Hypothesis Test

Table 3: Ranking of the Effects of Artificial Classroom Lighting on Instruction

Effects	N	Mean	SD
Students had difficulty to see clearly writings on white / chalk board	409	1.80	0.51
Some classroom sections were slightly darker than others	409	1.25	0.44
Light sometimes flickered	409	1.20	0.40
Students not able to see clearly diagrams on classroom projector screen when electric light is on	409	1.15	0.38
Students not able to read letters displayed on computer screen	409	1.14	0.36
Some students look sleepy when learning using artificial classroom lighting	409	1.12	0.32

(Source: Author, 2019)

As indicated in table 3 above, artificial classroom illumination aspects relating to learners' "difficulty to see clearly what is written on the white / chalk" board ($\bar{x}$ =1.80, SD = 0.51) were the most dominant effects of artificial classroom lighting on instruction.

The artificial classroom lighting factors relating to "some classroom sections are slightly darker than others" ($\bar{x}$ =1.25, SD = 0.44) was a more predominant artificial classroom lighting effect of on students' instruction. The artificial classroom lighting factors relating to "flight sometimes flickers" ($\bar{x}$ =1.20, SD = 0.40) were the predominant effect of artificial classroom lighting on students' instruction. The artificial classroom lighting factors relating to "students not able to see clearly diagrams on classroom projector screen when electric light is on" ($\bar{x}$ =1.15, SD = 0.38) were the least predominant effect of artificial classroom lighting on students' instruction. The artificial classroom lighting factors relating to "students not able to read letters displayed on computer screen" ($\bar{x}$ =1.14, SD = 0.36) were the least predominant effect of artificial classroom lighting on students' instruction. The artificial classroom lighting factors relating to "Some students look sleepy when learning using artificial classroom lighting" ($\bar{x}$ =1.12, SD = 0.32) were the most least predominant effect of artificial classroom lighting on students' instruction.

Table 4: The Chi-Square Source Table of the Results of the Level of Relationship between Artificial Classroom Illumination and Instruction

df	Item	Observed	Expected	O-E	(() – E)^2	$\frac{(O-E)^2}{E}$
1	Learners not able to see clearly diagrams on the classroom projector screen when electric light is on	272	246	26	676	2.748
2	Students had difficulty to see writing on chalk / white board	305	246	59	3481	14.150
3	Students appearing sleepy in classroom	160	246	-85	7396	30.065
4	Students not able to see clearly diagrams on classroom projector screen when electric light is on	272	246	26	676	2.748
5	Students not able to read letters displayed on computer screen	305	246	59	3481	14.150
Total						**63.861**

Source: Author, 2019

Decision: The decision rejected that claim since 63.861 > 0.21. From the test results, there was sufficient evidence to reject that claim that there is no significant relationship between artificial classroom illumination and instruction. Therefore, there is a significant effect of artificial classroom lighting illumination on instruction. Figure 2 shows that the observed graph is very much below the expected. The gap between the two graphs shows how the results of the Chi-squares test for goodness-of-fit-test is not a good fit.

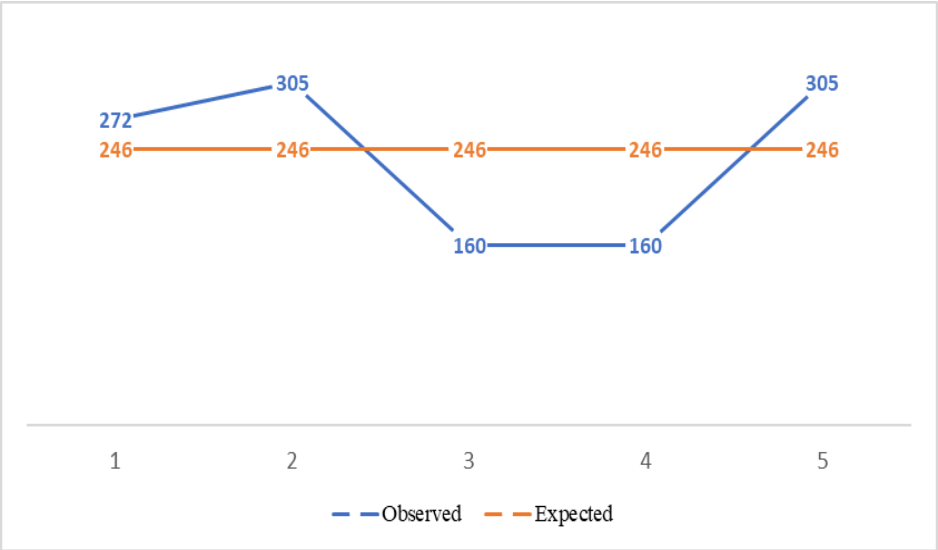

Figure 2: Results of the Goodness-of-fit for artificial classroom lighting on instruction

NOT GOOD FIT

Results from the interview schedule

Secondary school principals who were the key managers of the schools were interview. The interview solicited information about the states of artificial classroom lighting installation in the schools and the principals' perceptions on the effect of artificial classroom lighting on instruction and academic achievement. In response to the state of artificial classroom lighting, the principals said that the artificial classroom lighting was not the best but they were more concerned about high costs installation and electricity bills. The principals also noted that artificial classroom lighting posed a challenge to instruction and students' academic achievement.

Findings

The study established that;

1. Artificial classroom illumination in public boarding secondary schools in Nairobi County made it hard for the students to see clearly diagrams on the classroom projector screen, letters displayed on the computer screen and what was written on the chalk/whiteboard.
2. Artificial classroom illumination negatively impacted on instruction and students' academic achievement in Nairobi County of Kenya public boarding secondary schools.
3. There was a significant relationship between artificial classroom illumination and the quality of instruction.

CONCLUSION

From the study findings, it was concluded that:

Artificial classroom illumination in Nairobi County public secondary schools negatively affected students' instruction that ultimately negatively affected students' academic achievement. Artificial classroom illumination in Nairobi County public boarding secondary schools hampered instructional activities such as seeing clearing what was written on chalk/whiteboard, projections on the projector screen and displays on the computer screen.

RECOMMENDATIONS

The current study evaluated the effect of artificial classroom illumination on students' academic achievement and found out that artificial classroom illumination in Nairobi County of Kenya negatively impacted on students' instruction. The study, therefore, recommends that artificial classroom illumination classroom should be adequately designed so that it can positively influence students' academic achievement. This will create a conducive instructional environment that will boost students' academic achievement.

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