P-ISSN: 2709-6254 | Journal of Development and Social Sciences | April-June 2023, Vol.4, No. 2
O-ISSN:2709-6262 | http://dx.doi.org/10.47205/jdss.2023(4-II)73 | [836-852]

JDSS Journal of Development and Social Sciences
www.jdss.org.pk

RESEARCH PAPER

Effects of Micro-Environmental Factors on Students' Learning in Classroom at College Level in Pakistan

[1]Umer Farooq* [2]Dr. Muhammad Javed [3]Dr. Hina Afreen

1. Lecturer Department of Education, The Islamia University of Bahawalpur, Punjab, Pakistan
2. Chairman Department of Language Education, The Islamia University of Bahawalpur, Punjab, Pakistan
3. Assistant Professor Department of Computer Science, Faculty of Computing The Islamia University of Bahawalpur, Punjab, Pakistan

***Corresponding Author** umerfarooq@iub.edu.pk

ABSTRACT

The research aimed to determine the effects of Micro-Environmental Factors (MEFs) on students' learning. Students' learning was measured in controlled and uncontrolled MEFs within classroom. Researcher explored the effects of MEFs on students' learning and find out the relationship between them. For this study, the experimental research design was used. In the first step, The Classroom Environmental Monitoring System (CEMS) was developed using (COTS) sensors to measure MEFs like temperature, CO2, humidity, and luminosity. In second step a test was conducted to evaluate students' learning. Data were collected by experiment in twelve (12) government and eighteen (18) private colleges of division Bahawalpur. Data analysis was performed in python using Logit, Probit Regression models, and Artificial Neural Network (ANN). The result of this study reveals that MEFs have impact on the students' learning and both the variables are correlated. Henceforth, monitoring the MEFs during teaching learning process ultimately enhanced the learning of students.

Keywords: COTS, IoT, Indoor Air Quality, MEFs, PAH,VOC

Introduction

Education is a vital and productive activity, which provides an opportunity for the development of cognitive, affective, and practical domains and source of training for the comprehensive growth of individuals. It is a way to make individuals aware of their targets in life. It also enables them to achieve the aims of life. It is a tool used for spiritual development and establishing a healthy society concerning human needs within the context of Islamic apprehension. Education is an effective method used for developing the behavior and abilities of a person under Islamic teaching, so education helps in the overall development of the individual and society (Edgar et al., 2021).

Every country on earth needs a well-established educational system, and Pakistan is no exception. Any nation or person's development and prosperity can be greatly aided by a strong and efficient educational system (Wang, 2012). Humans continue to learn, both consciously and unconsciously, both individually and collectively, as long as they are a part of society (Reeve & Woollard, 2015). Therefore, participating in one's education is essential if one wants to improve their social and economic development. Humans are naturally shaped by the environment in which they are raised. Learning, which occurs through experience and active participation, is the end outcome (Jickling & Wals, 2019). This outcome includes the growth or improvement of knowledge-based abilities, as well as thinking, responsiveness, values, ethics, ideal morality, and feelings, as well as an improvement in the ability to act and react in a variety of circumstances. Effective learning also promotes growth, innovation, and a drive for knowledge and excellence. Because of this, the students become more diversified in a variety of areas, and as a result, they contribute significantly to the development of the nation (Hénard & Roseveare, 2012).

The scholars have made an effort to uncover the various circumstances surrounding academic accomplishment, which leads to success in life. Psychologists sought to identify the only causes of these differences in the students (Adepoju et al., 2011)).

Pupils spend a lot of time in college classrooms for learning activities. That is an important location for the students where they put their efforts into being experts in multiple skills, which leads them towards success in this global society (Edgar et al., 2021). It is the place of developing a student's abilities in different domains so that they can contribute to global progress.

According to Kumpulainen et al. (2017) the ideal learning conditions for individuals to acquire new information are organized by a support system called the learning environment. According to a learner's needs, it complements their learning process and their educational needs. Infrastructure, technologies, and various groups that encourage learning can all be considered components of the learning environment. All of these have their respective and specified role in the upbringing and development of the student (Pardo & Siemens, 2014).

Comfortable environments reduce students' exposure to protect against harmful constituents and diseases and enable and facilitate efficient and easy development of abilities (Sarbu et al., 2015). Pupils need to provide healthy environmental conditions, particularly those from backward areas. It not only facilitation for improved learning but also provides an opportunity to minimize the educational disparities among different groups of students.

Experts from psychology and education identified that attitude, behavior, and cognitive development can be accelerated by providing learners with a certain environment (Liang et al., 2012). Further, it can be noted that the behaviors of pupils can be stimulated and affected because of different environmental aspects within the campus (Choi et al., 2012). Significant parameters are Physical environment, Non-Physical Environment, climate, and emotional setup in the classroom setting.

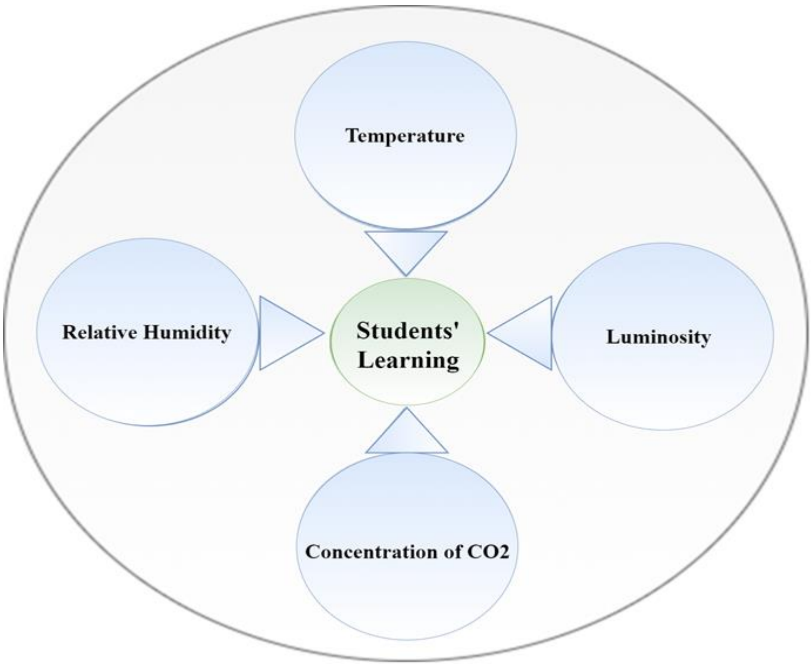

Figure 1. Impact of micro-environmental factors on students' learning.

Different indoor and unseen micro-environmental factors are crucial for a healthy classroom environment. Parameter of the environment cannot be ignored while discussing Students' performance in the institutions (Ferguson et al., 2020)

The notable components of the atmosphere that directly affect the overall health of climate are achieving the best standard of ventilation naturally or mechanically, heating conditions, and luminosity (Korsavi et al., 2021).

Different micro-environmental factors vital to consider during the teaching-learning process are temperature, humidity, light, and the level of CO_2 in the air. It is highly desirable to monitor these classroom environment factors and determine the students' learning status. As Rousseau said, "you gave me a child, I will make him as whatever you want." The quotation shows the importance of the environment for a child and that the environment makes the child good or bad.

Literature Review

Developing new knowledge, abilities, values, and desires is known as learning. There are various types of information involved. You can't look for all the facts at once. It is more on the basis of prior knowledge. Learning causes learners' attitudes and behaviours to change permanently (Anvekar et al., 2014). Environmentalists define "institute readiness" as the age or developmental stage at which youngsters are capable of responding correctly to both the institute's and the classroom's environments (e.g., rules and regulations, curriculum activities, positive behaviour in group settings, and directions and instructions from teachers and other adults in the institute) (Satterly,1987).

Vygotsky (1978) said "properly organized learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning". He saw learning as a jack of development. Learning is a source of progress in development and communal collaboration is vital for learning. So, learning is a social and individual activity, according to this definition.

Piaget (1964) describes "learning is subordinated to development and not vice versa". He described development as the dynamic creation of knowledge and learning as the passive foundation of the association. He explored the concept of knowledge creation and stated that learning happens after cognitive development.

The majority of modern theorists concurred that not all learning results in immediately noticeable change. Bandura (1977) recognized that learning can occur even if learners don't exhibit any evident behavioral changes. In addition to all of this, psychologists concurred that learning can be simple, complex, or organized. Fernandez et al. (2018) explored that a child's environment plays a critical role in determining how they learn. Human behavior, learning, and development are regarded as responses to the environment. Parents, schools, and learners are motivated by this perspective to make the assumption that children learn and develop new skills in response to their environment. The public is paying more and more attention to indoor environmental quality (IEQ) as a result of climate change and the green construction movement. IEQ factors have a direct impact on how comfortable, healthy, productive, and satisfied residents are(Horr et al., 2016). Although children and young people may be particularly at risk, adult university students make up a sizable prospective cohort whose institutional setting should be investigated (Zhong et al., 2019).

Suleman et al. (2014) revealed that classroom environments judged to have higher levels of coherence, contentment, goal direction, organization, and less friction were consistently linked to accomplishment in cognitive and affective learning outcomes.

Recent surveys found no formaldehyde concentrations above the WHO IAQ standard. Some countries have found classrooms with high concentrations of various chemical air pollutants coming from indoor sources, such as benzene, volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs). The generalization of findings to the entire Region is not possible due to the dearth of data for many low-income and lower-middle-income nations. High CO2 levels in a closed learning environment divert students' attention and make them queasy in classrooms (Chatzidiakou et al., 2015). A classroom study with a controlled environment found that students' learning status improved on different tests in a room with a good level of ventilation and decreased levels of CO2 (Haverinen-Shaughnessy & Shaughnessy, 2015).

Jaber et al. (2017) revealed that an important factor contributing to increased air stuffiness within a closed environment is the status of CO2 in that particular climate. Kapalo et al. (2018) identified that high reading of CO2 above 1500ppm is connected to a decrease in performance results at several intellectual tests. It has been determined that mechanical ventilation is the most effective approach to lower air pollution and save money on electricity. Mechanical ventilation can be carefully controlled to keep CO2 levels in classrooms under 1000 ppm (Stabile et al., 2017).

Earthman (2004) established that air quality, heating, and temperature are key factors in students' ability to learn. Phillips et al. (2007) noted that lighting is one of a classroom's most important physical characteristics. Reduction in learning was found in the winter season with a decrease in temperature below 19° C. It was also noted that the poor, misty air in classrooms was related to increased signs of headache and frustration among students (Budiawan et al., 2021). Generally, relative humidity must range from 30% to 50% (Zhang et al., 2020). A single, compact device that can run for up to a year on a single set of batteries may measure relative humidity and temperature (Hänninen & Haverinen-Shaugnessy, 2015).

In addition to enhancing image vision, light applies powerful and significant effects, including regulating attitude and learning tasks (Lexuan Zhong et al., 2019). In this study, we found that the direct effects of light on learning and mood use discrete output streams. This is because the factional basis facilitated the effects of light on learning (Fernandez et al., 2018)

A student's attention during the lesson can be influenced by sound and light (Farhadian et al., 2017). Fluorescent light bulbs are most commonly used in colleges. These emit a buzzing effect that can divert attention and make studying difficult for students who prefer natural light (Haverinen-Shaughnessy & Shaughnessy, 2015). Ventilation, IAQ, acoustic and thermal conditions, and illumination are examples of IEQ elements that have a direct impact on occupant comfort, health, productivity, and satisfaction (Dedesko & Siegel, 2015).

Material and Methods

Conceptual Framework

The proposed study identifies different microenvironment factors in the class room that effect on students' learning. The microenvironment factors identified in the classroom environment include temperature, humidity, luminosity and carbon dioxide. The proposed study also aims to find the relationship between MEFs and students' learning. A conceptual framework is proposed to represents the MEFs and its effect on the learning of students in the classroom, shown in the Figure 2.

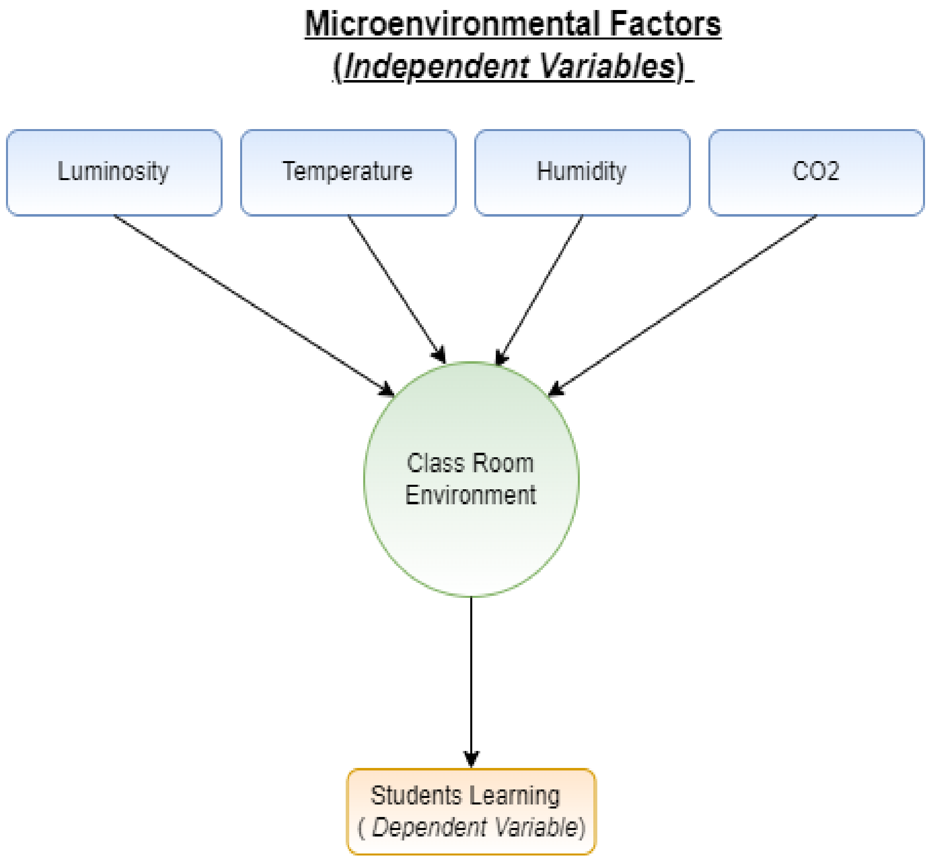

Figure 2. Conceptual framework of the proposed study

This study is conducted to determine micro environmental factors' effects on students' classroom learning. For this proposed study experimental research design is used. The teaching-learning process was executed in a controlled and uncontrolled classroom environment. In both categories of classrooms, Classroom Environment Monitoring System (CEMS) measured the micro-environmental factors during a teaching-learning process in the classroom. After that, a test was conducted to measure students' classroom learning status. Then the students' learning status in the classrooms is compared to find the relationship between micro-environmental factors and students' learning.

CEMS consists of sensors to measure CO2 concentration, temperature, humidity, and luminosity level within the classroom. These sensors were connected and installed to the Arduino UNO micro controller. All the sensors detected the values of factors within the classrooms and then sent those values for different factors to Arduino UNO. Then Arduino UNO sent all the values to the computer system for further processing. In this way MEFs were measured using CEMS during teaching process.

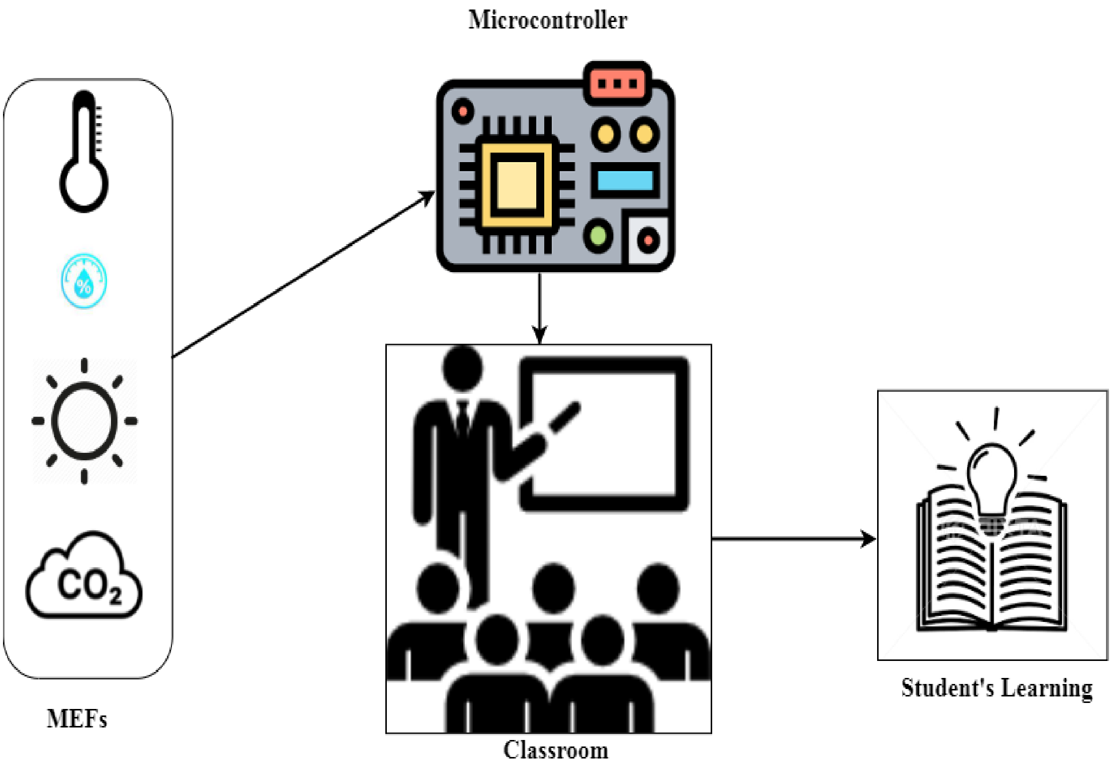

Figure 3. Schematic description of proposed approach

There are two parts of this experimental research, in first part CEMS read out the MEFs in the classroom during teaching learning process in progress within the classrooms. At the end of each session, a test was conducted to assess students' learning status. This process was repeated in twelve (12) government colleges and eighteen (18) private colleges of division Bahawalpur. Different micro-environmental factors such as temperature, CO2, humidity, and luminosity contribute to the environment's health. First of all researcher recorded the reading of these factors within the classroom. There were two categories of classroom environment.

Controlled Classrooms

Means those classrooms where the readings of different micro-environmental factors were within standard range. Such environment was considered as controlled environment for learning.

Un-Controlled Classrooms

Means those classrooms where the readings of different micro-environmental factors are out of standard range, such environment was considered as uncontrolled environment.

Sampling

Researcher used Convenience sampling technique. In Convenience sampling technique researcher selected twelve (12) colleges from government sector and eighteen (18) colleges from private sectors shown in Table . Experiments were repeated to enhance the validity of results.

Table 1
Sampling of Data

Division BWP	Bahawalnagar		Bahawalpur		Rahim Yar Khan		Total
	Male	Female	Male	Female	Male	Female	

Govt. Colleges	1	1	3	3	2	2	12
Private College	2	2	4	4	3	3	18

Development of Research Tool

Keeping in view the study's objectives, Classroom Environment Monitoring System (CEMS) was developed using COTS sensors and a microcontroller and then deployed in the classroom from where the researcher collected the data regarding the MEFs. It is a cost-effective system to measure the micro-environmental factors and it was more feasible to install in the institutes belonging to developing countries like Pakistan. For developing research tools experts from the field of computers were consulted.

To measure learning ability, a concept test was used. That test was conducted using clicker's technology and physically where an online facility is unavailable. Clickers' technology offers an opportunity to conduct the test immediately after the teaching-learning session.

CEMS Experimental Setup

The CEMS comprises a set of cost-effective sensors to gauge real-time environmental factors in a classroom setup. The sensing components of CEMS contain sensors off, power supply PCB board, breadboard, and microcontroller. For reading and recording data this complete set up of four modules with breadboard working was installed in the classroom where learning was in progress in specific instructional processes as shown in Figure 4.

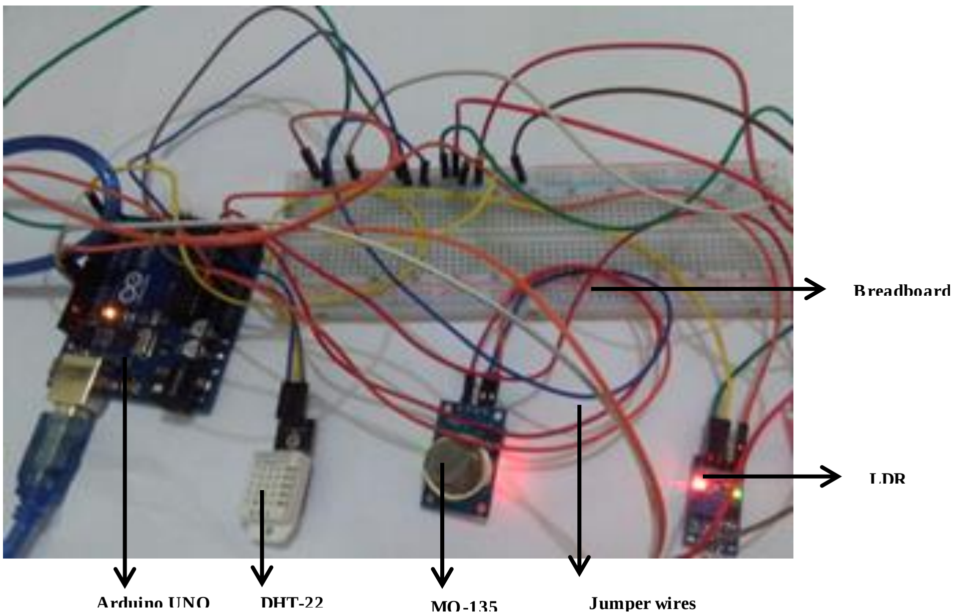

Figure 4. Experimental setup of CEMS

Results and Discussion

The experiment was performed randomly in multiple classrooms of different colleges in the division of Bahawalpur. The CEMS system was placed within the classroom with active sensors and connectivity with the laptop to receive values from the Arduino UNO. The teaching-learning process was carried out within the classroom, recording the micro-environmental factors using CEMS. At the end of the session, a test was conducted to evaluate students' learning in that particular session. The results obtained from the Arduino UNO and the test were compared and explored the relationship between different micro-environmental factors and students' learning within the classroom setup (Devaux et al., 2014). We have computed a model summary of the Logistic regression model that is given in following Table 2.

Table 2
Results of Logistic Regression Model

Features	Coefficient	Standard err	z	P>|z|	[0.025	0.975]
Intercept	-12.3352	4.762	-2.590	0.010	-21.668	-3.002
Temperature	-0.5165	0.103	-5.028	0.000	-0.315	- 0.718
Humidity	0.1326	0.048	2.785	0.005	0.039	0.226
CO2	-0.0317	0.005	-5.885	0.000	-0.042	-0.021
LI	0.0077	0.003	2.772	0.006	0.002	0.013

We have computed a model summary of the Logistic regression model given in. In the logistic regression model, the value of the test statistic is -5.028 for temperature which has a minimum p-value of 0.000 that indicates that temperature is significant for student performance. And the estimated value of the parameter for temperature is -0.5165 which shows that when in this situation temperature increases the performance of student's decreases. The relationship between temperatures and performance is inversely proportional. The value of test statistics for humidity is 2.785 and has a minimum p-value i.e. 0.000 which shows that humidity is also highly significant for students' performance. And the estimated value of the parameter is 0.1326 shows that humidity increases from dry situation to humid situation, and the performance of students also increases. The value of test statistics for CO2 is -5.885 and has a minimum p-value of 0.000, indicating that carbon dioxide is also a highly significant factor in students' performance. And the estimated value for the CO2 is -0.0377 which shows the negative relationship between performance and CO2. If CO2 increases, then there is a decrease in students' performance. The value of test statistics for luminosity is 2.772 and has a minimum p-value of 0.000 which depicts that luminosity is highly significant for students' performance. And the estimated value for the parameter luminosity is 0.0077 shows the students' performance increased if the luminosity level increased within the classroom. The relationship between luminosity and performance is positive. We have computed the significance of all independent variables and drawn the tornado diagram which indicates that carbon dioxide and temperature are more significant variables in the gauged dataset. While humidity and light intensity also contribute significantly.

Probit Regression Model

We have implemented the Probit regression model in python and computed model performance in terms of R-squared, Mean Absolute Error (MAE), and Mean Square Error (MSR). The summary of the Probit regression model is shown in Table 3.

Table 3
Results of the Probit Regression Model

Features	Coefficient	Standard error	z	P>|z|	[0.025	0.975]
Intercept	-6.2428	1.742	-3.584	0.000	-9.656	-2.829
Temperature	-0.2346	0.037	-6.291	0.000	-0.161	-0.308
Humidity	0.0641	0.17	3.734	0.000	0.030	0.098
CO2	-0.0143	0.0002	-7.352	0.000	-0.018	-0.010
LI	0.0044	0.001	4.447	0.000	0.002	0.013

In the Probit Regression model, the value of the test statistic is -6.291 for temperature, which has a minimum p-value of 0.000, indicating that temperature is highly significant for student performance. And the estimated value of the parameter for temperature is -0.2346 which shows that when temperature increases the performance of students decreases.

The relationship between temperature and performance is inversely proportional. The value of test statistics for humidity is 3.734 and has a minimum p-value i.e. 0.000 which shows that humidity is also highly significant for students' performance. And the estimated value of the parameter is 0.0641 shows that humidity increases from dry to humid conditions, and the implementation of students also increases.

The value of test statistics for CO_2 is -7.352 with a minimum p-value of 0.000, indicating that carbon dioxide is also a highly significant factor for students' performance. And the estimated value for the CO_2 is -0.0143 which shows the negative relationship between performance and CO_2. If CO_2 increases, then there is a decrease in students' performance. The value of test statistics for luminosity is 4.447 and has a minimum p-value of 0.000 which depicts that luminosity is highly significant for students' performance. And the estimated value for the parameter luminosity is 0.0044 shows that students' performance increased if the luminosity level increased within the classroom. The relationship between luminosity and performance is directly proportional.

To show the relationship between independent and dependent variables, we have also drawn the pair plot in Figure 5.

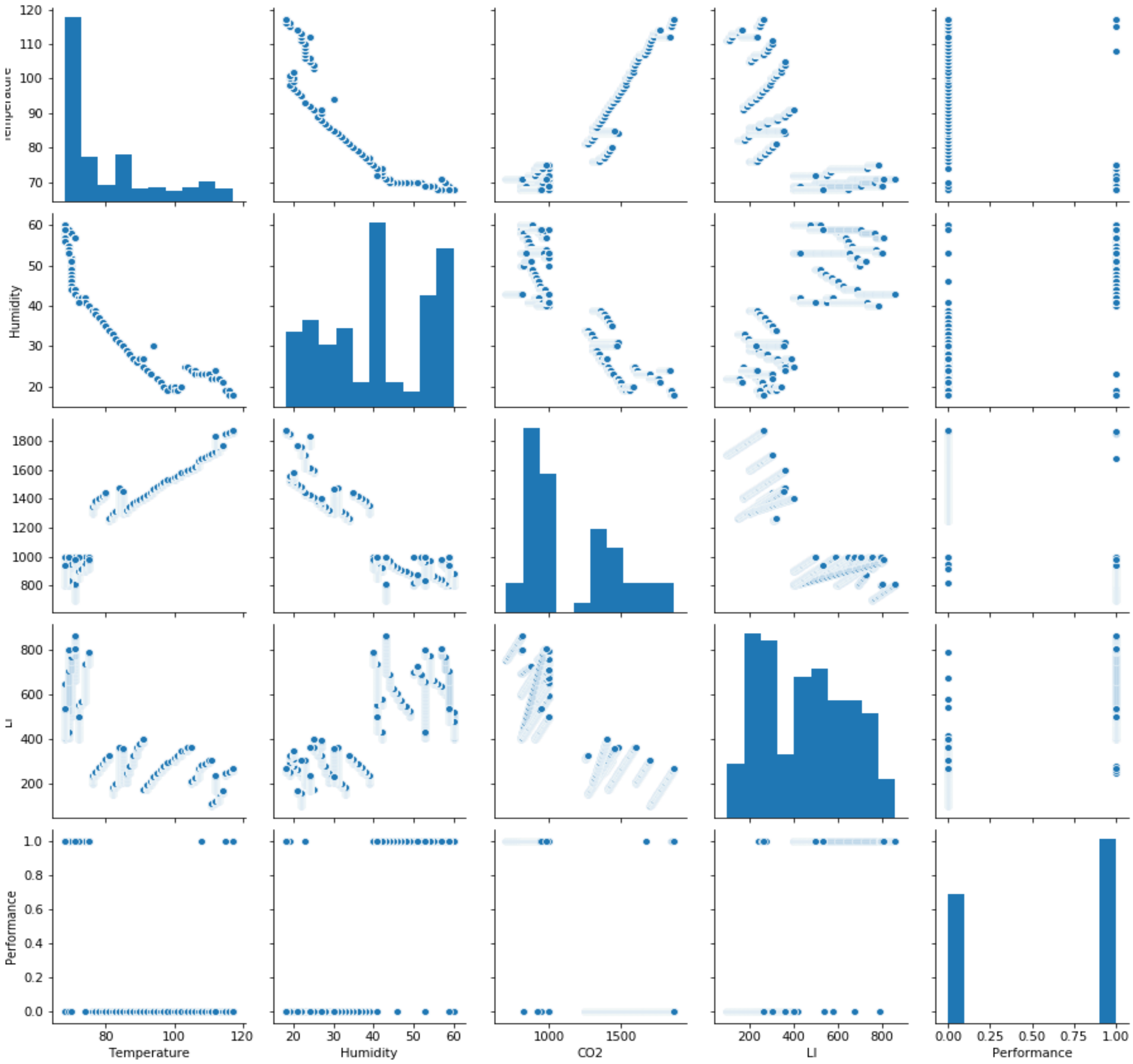

Figure 5. Pair plot between independent variables and dependent variable

The pair plot consists of two primary types of figures such as histogram and scatterplot. The distribution of a single variable is shown diagonally using a histogram while the scatter plots show the relationship between two variables as shown in Figure 5. For example, a scatter plot of humidity versus temperature is shown as the leftmost plot in the second row in Figure 5.

ANN Regression Model

ANN regression model is employed to predict the relationship between features, including a dependent variable and independent variables. There are four neurons at the input layer, 10 neurons at the middle layer, and 1 neuron at the last layer for the output variable. At the first epoch, the loss is 0.1256, which decreases as the number of epochs increases. The loss reaches 0.0025 at the 50th epoch which is a good indication of the performance of the proposed model as shown in Figure 6.

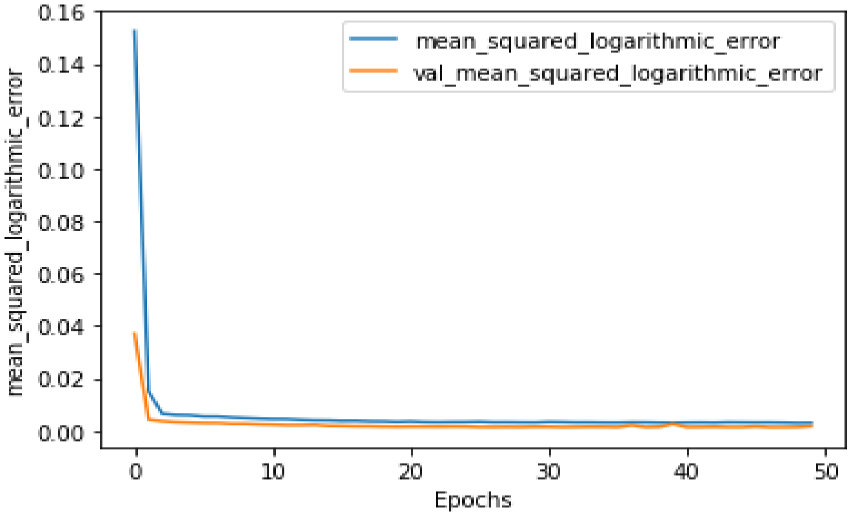

Figure 6. Mean squared logarithmic error

We have computed the mean squared logarithmic error that is 0.1240 at the first epoch and it is decreasing as the number of epochs decreases. After the 50th epoch, the mean squared logarithmic error reaches 0.0025. it indicates that the ANN regression model's overall performance is satisfactory. We also drew a graph of the accuracy curve that indicates the accuracy reaches 97%, as shown in Figure 7.

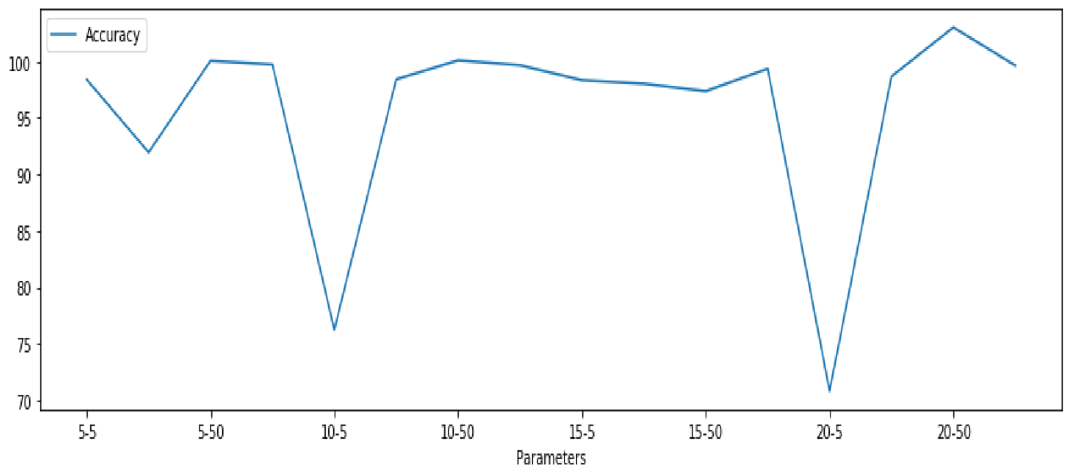

Figure 7. Accuracy Curve of ANN Regression Model.

In the below-mentioned Table 4, the value of R^2 described the fitness of the model used. It is clear from the Table 4, that all the models are a good fit for the conducted experiment. The logistic regression model value of R^2 is 0.9125, for the OLS Regression model value determined is 0.9230, for the Probit Regression model value is 0.9448 and the ANN value of R^2 is 0.9397. Among all models, the model which outperforms the experiment is the Probit Regression model as the value of R^2 is close to 1 i.e. 0.9448. This shows the level of fitness for the Probit Regression model.

Table 4
Models performance in terms of R-Square

Regression Models	R^2
Logistic	0.9125
Probit	0.9448
ANN	0.9397

Error! Reference source not found. illustrates the data distribution of the input data set concerning its density distribution. We have drawn a quantile-quantile plot (Q-Q plot) to describe either measured dataset following the normal distribution. Data is assumed to be normally distributed in our case because most of the points follow the reference line of about 45° approximately as shown in

Figure 8.

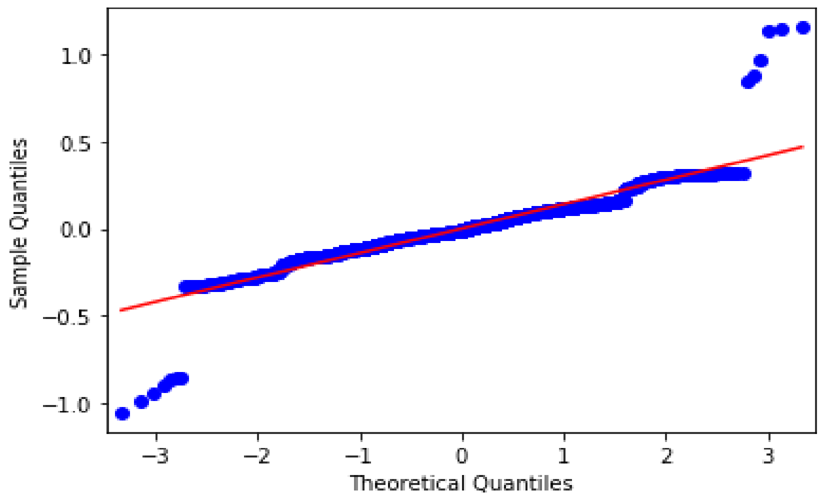

Figure 8. Representation of Data Distribution

Findings

The current study investigated the effects of different MEFs on students' learning at the college level in Pakistan. This section contains a comprehensive description of the topic of the thesis, findings explored during the study, and a discussion regarding each study objective. Conclusion and recommendations are also given below:

Effect of temperature on students' learning

In the Probit Regression model, the value of the test statistic is -5.889 for temperature, which has a minimum p-value of 0.000, indicating that temperature is highly significant for student performance. And the estimated value of the parameter for temperature is 0.2294 which shows that when temperature increases within the threshold range, i.e. 24-26 c the performance also improves.

Effect of humidity on students' learning

The relationship between temperatures is positive. The value of test statistics for humidity is 3.400 and has a minimum p-value i.e. 0.000 which shows that humidity is also highly significant for students' performance. And the estimated value of the parameter is 0.0598 shows that humidity increases from dry situation to humid situation, and the performance of students also increases. CO_2

Effect of CO2 on students' learning

The value of test statistics for CO2 is -7.269 with a minimum p-value of 0.000, indicating that carbon dioxide is also a highly significant factor for students' performance. And the estimated value for the CO2 is -0.0145 which shows the negative relationship between performance and CO2. If CO2 increases, then there is a decrease in students' performance.

Effect of luminosity on students' learning

The value of test statistics for luminosity is 4.113 and has a minimum p-value of 0.000 which depicts that luminosity is highly significant for students' performance.

And the estimated value for the parameter luminosity is 0.0041 shows that students' performance increased if the luminosity level increased within the classroom. The relationship between luminosity and performance is positive.

ANN regression model

ANN regression model is employed to predict the relationship between features, including a dependent variable and independent variables. There are four neurons at the input layer, 10 neurons at the middle layer, and 1 neuron at the last layer for the output variable. At the first epoch, the loss is 0.1256, which decreases as the number of epochs increases. The loss reaches 0.0025 at the 50^{th} epoch which is a good indication of the performance of the proposed model

ANN regression model is employed to predict the relationship between features, including a dependent variable and independent variables. There are four neurons at the input layer, 10 neurons at the middle layer, and 1 neuron at the last layer for the output variable. At the first epoch, the loss is 0.1256, which decreases as the number of epochs increases. The loss reaches 0.0025 at the 50^{th} epoch which is a good indication of the performance of the proposed model as shown in Figure 6.

Correlation between Microenvironment Factors

To find the relationship between a dichotomous variable and independent variables, we draw a heat map in python as shown in **Error! Reference source not found.**9. We have used the *heatmap ()* method of the seaborn package to draw a heat map. It is a graphical representation to visualize the dataset using the different schemes of light and dark colors according to the interdependency of factors. A grid of colored squared is represented along the x-axis and y-axis which reports a numeric count accompanied by color. The darker color represents a larger associated count to the corresponding cell range.

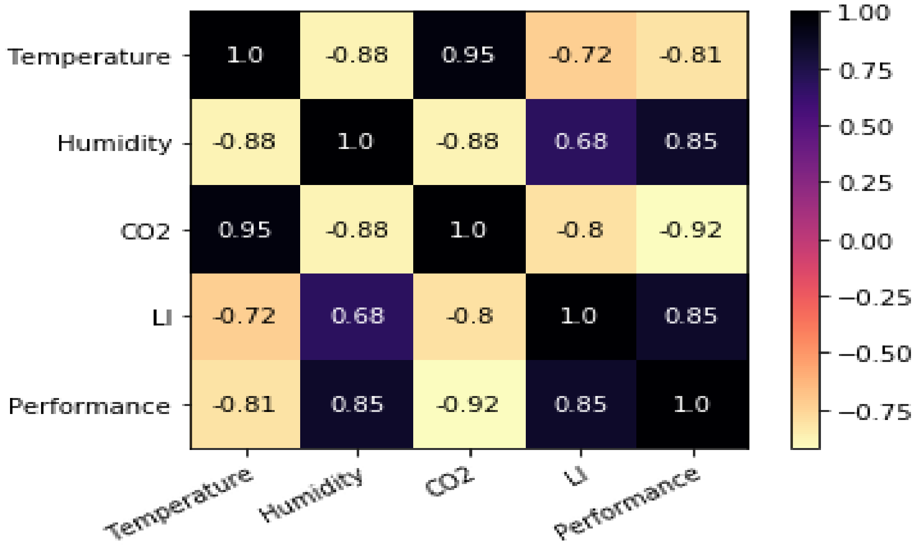

Figure 9. Heat map of collected data

Examining the cell color variations makes it easy to predict the pattern residing among the dataset. The diagonal squares cells values equal 1 indicate the strong correlation between dependent and independent (Rajagopalan et al., 2021).

The values of correlation between variables range from -1 to +1. The values near zero depict that there is no significant relationship between variables. In our case, there is no such value exists that indicates that variables in our dataset are correlated

In a parallel project, Mudassir and Norsuhaily (2015) investigated how the learning environment in a subset of secondary schools in Kuala Terengganu affected students' academic performance. Different MEFs are crucial for making the environment conducive to learning. According to the finding of the research, it is concluded that multiple MEFs affect on learning ability of students. And factors are not visible enough to view with the naked eye. But those factors affect the learning process.

Based on findings it can be concluded that the different MEFs within the classrooms affect students' performance. These factors are hidden and often ignored by many of the institute administrators. But all these factors contribute significantly towards the learning of students. In many countries of the world weather conditions for various seasons reach their peak level, thus the environment is heavily affected by these weather conditions, which further influence the indoor classroom environment. It is vital to keep a deep eye on the classroom's environmental conditions to boost students' learning status. We can maximize students' learning by minimizing hurdles during teaching-learning. And the learning environment is a vital part of it.

Education experts have found multiple factors affecting students' perception of learning and its climate (Earthman & Lemasters, 2009). Kelting national statistics revealed that over 43% of the U.S. colleges had reported problems with the indoor quality of air(Kelting & Montoya, 2011. Indoor quality of air composed of ventilation, and CO ratings in colleges that have issued concerns for health problems related to respiratory problems like asthma. (Daisey et al., 2003). More specifically, early studies found that temperature control

During the experiment, it was noted that temperature and level of CO_2 highly affect students' ability to learn. Other factors significantly affect humidity and luminosity in the classroom. Any change in the MEFs beyond the optimal range affects students' learning ability. So monitoring these factors in a real-time system is necessary to uplift learning in the classroom. Researchers identified cost-effective sensors and IoT devices for measuring MEFs in the classrooms.

Conclusion

Based on the discussion, it is concluded that different MEFs are not visible but affect students during their instructional process. Those factors cause the students' decreased performance. The slightest awareness is there about these factors, particularly in the world's developing countries like Pakistan. Some countries of the world are now focusing on developing such infrastructure of institutional buildings with an atmosphere more conducive to student learning.

Educational achievements are vital in every walk of life. And for the development of all faculties of a child, is needed the time to improve the instructional process by minimizing the hurdles in learning students.

Monitoring the status of the classroom environment is crucial to maximizing students' learning and making them skillful individual in their future life.

Recommendations

The researcher explored that different MEFs effects on the learning of students during teaching learning process. Monitoring of MEFs factors within the classroom is vital to consider. Some elements may not be visible with naked eye but contribute significantly in making classroom environment healthy for learning process.

To maximize the learning process of students, as all other physical and non-physical factors are essential to keep a check and control on those elements, MEFs are also crucial to consider and control. It is the need of hour to maximize the awareness about these factors among institute administrators, planning and, decision making authorities. Researcher recommends the use of cost-effective sensors that can be deployed in the classroom to monitor MEFs within the school during teaching learning activities within the classrooms. Monitoring these factors enabled administrators and teachers to control these hidden factors that significantly effecting students' learning within the classroom. In future study, Mobile application can also be developed to generate an alert for teachers / administrators about the situation where MEFs crossed their threshold limit during learning process of students. Considering and controlling these MEFs will provide an environment conducive to learning and a source of maximizing students' learning in the educational institutions.

References

Adepoju, T. L., & Oluchukwu, E. E. (2011). A study of secondary school students' academic performance at the senior school certificate examinations and implications for educational planning and policy in Nigeria. *African Research Review*, *5*(6), 314-333. https://doi.org/10.4314/afrrev.v5i6.26

Anvekar, S. R., Joshi, G. K., Subrahmanyam, V., & Sandhya Anvekar, D. (2014). The Need and Importance of On-Demand E-Learning for Customized Management Skills Enhancement. *Researchgate.Net*, *19*(1), 31–38. https://doi.org/10.9790/0837-191103138

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review*, *84*(2), 191.

Budiawan, W., & Tsuzuki, K. (2021). Thermal comfort and sleep quality of indonesian students living in japan during summer and winter. *Buildings*, *11*(8), 326.

Chatzidiakou, L., Mumovic, D., & Summerfield, A. (2015). Is CO2 a good proxy for indoor air quality in classrooms? Part 1: The interrelationships between thermal conditions, CO2 levels, ventilation rates, and selected indoor pollutants. *Building Services Engineering Research and Technology*, *36*(2), 129–161. https://doi.org/10.1177/0143624414566244

Choi, S., Guerin, D., Kim, H.-Y., Brigham, J. K., & Bauer, T. (2014). Indoor Environmental Quality of Classrooms and Student Outcomes: A Path Analysis Approach. In *Journal of Learning Spaces 2*(2), 1-14

Daisy Sahni, A., Indar Jit, B., Gupta, C. N. M., Gupta, D. M., & Harjeet, E. (2003). Branches of the splenic artery and splenic arterial segments. *Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists*, *16*(5), 371-377.

Dedesko, S., & Siegel, J. A. (2015). Moisture parameters and fungal communities associated with gypsum drywall in buildings. In *Microbiome* (Vol. 3). https://doi.org/10.1186/S40168-015-0137-Y

Devaux, A., Kromann, P., & Ortiz, O. (2014). Potatoes for sustainable global food security. *Potato Research*, *57*(3), 185-199.

Earthman, G. (2004). *Prioritization of 31 criteria for school building adequacy*. American civil liberties union foundation of Maryland

Earthman, G. I., & Lemasters, L. K. (2009). Teacher attitudes about classroom conditions. *Journal of Educational Administration*, *47*(3), 323-335.

Edgar, F., Blaker, N. M., & Everett, A. M. (2021). Gender and job performance: linking the high performance work system with the ability–motivation–opportunity framework. *Personnel Review*, *50*(1), 47–63. https://doi.org/10.1108/PR-10-2019-0577/

Farhadian, N., & Chalak, A. (2017). Associations between Iranian University-Level EFL Learners' Perceptions of Their Language Learning Environment and Their Motivation and Self-regulation. *Journal of Advances in English Language Teaching*, *5*(5), 62.

Feng, X. (2017). *Multi-modal and deep learning for robust speech recognition* (Doctoral dissertation, Massachusetts Institute of Technology).

Ferguson, L., Taylor, J., Davies, M., Shrubsole, C., Symonds, P., & Dimitroulopoulou, S. (2020). Exposure to indoor air pollution across socio-economic groups in high-income countries: A scoping review of the literature and a modelling methodology. *Environment international*, *143*, 105748.

Fernandez, D. C., Fogerson, P. M., Ospri, L. L., Thomsen, M. B., Layne, R. M., Severin, D., ... & Hattar, S. (2018). Light affects mood and learning through distinct retina-brain pathways. *Cell*, *175*(1), 71-84.

Fisk, W. J., Lei-Gomez, Q., & Mendell, M. J. (2006). Meta-Analyses of the Associations of Respiratory Health Effectswith Dampness and Mold in Homes. *Indoor air*, *17*(LBNL-59363).

Hänninen, O., & Haverinen-Shaugnessy, U. (2015). *School environment: policies and current status*. Copenhagen: WHO Regional Office for Europe, 2015.

Haverinen-Shaughnessy, U., & Shaughnessy, R. J. (2015). Effects of classroom ventilation rate and temperature on students' test scores. *PLoS ONE*, *10*(8). https://doi.org/10.1371/JOURNAL.PONE.0136165

Hénard, F., & Roseveare, D. (2012). Fostering quality teaching in higher education: Policies and practices. *An IMHE Guide for Higher Education Institutions*, 1(1), 7-11.

Horr, Y., Arif, M., Kaushik, A., Mazroei, A., Katafygiotou, M., & Elsarrag, E. (2016). Occupant productivity and office indoor environment quality: A review of the literature. *Building and environment*, *105*, 369-389.

Jaber, A. R., Dejan, M., & Marcella, U. (2017). The effect of indoor temperature and CO2 levels on cognitive performance of adult females in a university building in Saudi Arabia. *Energy Procedia*, *122*, 451-456.

Jickling, B., & Wals, A. E. (2019). Globalization and environmental education: Looking beyond sustainable development. In *Curriculum and Environmental Education* (pp. 221-241). Routledge.

Kapalo, P., Domnita, F., Bacotiu, C., & Podolak, M. (2018). The influence of occupants' body mass on carbon dioxide mass flow rate inside a university classroom–case study. *International Journal of Environmental Health Research*, *28*(4), 432–447. https://doi.org/10.1080/09603123.2018.1483010

Kelting, S., & Montoya, M. (2011). Green building policy and school performance. In *International Conference on Sustainable Design and Construction Proceedings:* Kansas City, MO.

Korsavi, S. S., Montazami, A., & Mumovic, D. (2021). Perceived indoor air quality in naturally ventilated primary schools in the UK: Impact of environmental variables and thermal sensation. *Indoor Air*, *31*(2), 480–501. https://doi.org/10.1111/ina.12740

Kumpulainen, K., & Rajala, A. (2017). Dialogic teaching and students' discursive identity negotiation in the learning of science. *Learning and Instruction*, *48*, 23-31.

Kweon, B. S., Ellis, C. D., Lee, J., & Jacobs, K. (2017). The link between school environments and student academic performance. *Urban forestry & urban greening*, *23*, 35-43.

Liang, C., Hsu, Y., Huang, Y., & Chen, S. C. (2012). How learning environments can stimulate student imagination. *Turkish Online Journal of Educational Technology*, *11*(4), 432–441.

Mudassir Ibrahim, U., & Norsuhaily, A. B. (2015). The impact of parents' occupation on academic performance of secondary school students in Kuala Terengganu. *Multilingual academic Journal of Education and Social Sciences*, *3*(1), 112-120.

Pardo, A., & Siemens, G. (2014). Ethical and privacy principles for learning analytics. *British Journal of Educational Technology*, *45*(3), 438–450. https://doi.org/10.1111/BJET.12152

Phillips, J. M., Coltrin, M. E., Crawford, M. H., Fischer, A. J., Krames, M. R., Mueller-Mach, R., Mueller, G. O., Ohno, Y., Rohwer, L. E. S., Simmons, J. A., & Tsao, J. Y. (2007). Research challenges to ultra-efficient inorganic solid-state lighting. In *Laser and Photonics Reviews* (Vol. 1, Issue 4). https://doi.org/10.1002/LPOR.200710019

Piaget, J. (1964). Cognitive Development in Children: Development and Learning. *Journal of Research in Science Teaching, 2,* 176-186.

Rajagopalan, K. N., Chen, X., Weinberg, D. N., Chen, H., Majewski, J., Allis, C. D., & Lu, C. (2021). Depletion of H3K36me2 recapitulates epigenomic and phenotypic changes induced by the H3. 3K36M oncohistone mutation. *Proceedings of the National Academy of Sciences*, *118*(9), e2021795118.

Reeve, J., & Woollard, V. (2015). Learning, Education, and Public Programs in Museums and Galleries. *The International Handbooks of Museum Studies*, 551–575. https://doi.org/10.1002/9781118829059.WBIHMS989

Sarbu, I., & Pacurar, C. (2015). Experimental and numerical research to assess indoor environment quality and schoolwork performance in university classrooms. *Building and Environment*, *93*, 141-154.

Satterly, D. (1987). Assessment: Weighed in the balances and found wanting. *European Journal of Psychology of Education*, *2*, 101-107.

Stabile, L., Dell'Isola, M., Russi, A., Massimo, A., & Buonanno, G. (2017). The effect of natural ventilation strategy on indoor air quality in schools. *Science of the Total Environment*, *595*, 894-902.

Suleman, Q., & Hussain, I. (2014). Effects of classroom physical environment on the academic achievement scores of secondary school students in Kohat Division, Pakistan. *International Journal of Learning & Development*, *4*(1), 71-82.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes. Cambridge,* MA: Harvard University Press.

Wang, Y. (2012). Education in a changing world*: Flexibility, skills, and employability*. World Bank.

Zhang, X., Liang, J., Wang, B., Lv, Y., & Xie, J. (2020). Indoor air design parameters of air conditioners for mold-prevention and antibacterial in island residential buildings. *International Journal of Environmental Research and Public Health*, *17*(19), 7316.

Zhong, L., Yuan, J., & Fleck, B. (2019). Indoor environmental quality evaluation of lecture classrooms in an institutional building in a cold climate. *Sustainability*, *11*(23), 6591.

Zhong, Lexuan, Yuan, J., & Fleck, B. (2019). Indoor environmental quality evaluation of lecture classrooms in an institutional building in a cold climate. In *Sustainability (Switzerland)* (Vol. 11, Issue 23). https://doi.org/10.3390/su11236591