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THE EFFECT OF CLASSROOM ENVIRONMENT ON SATISFACTION AND PERFORMANCE: TOWARDS IOT-SUSTAINABLE SPACES

Xinyue Hao[1] and Laura Florez-Perez[2]

ABSTRACT

The physical classroom environment includes the overall design and layout facilities that are provided in a classroom. Classroom facilities should be organised to maximise the satisfaction and performance of students. With the increased demand of well-equipped classrooms, upgrades in new high-technology need to be adopted to enable the optimisation of the students’ perceptions and behaviours. A number of studies have investigated the impact of classrooms in high schools. However, few studies have investigated the impact of the physical classroom environment in university settings. This paper examines the impact of the physical classroom environment on students’ satisfaction and performance in a university setting. A total of 173 responses from students were obtained regarding their perceptions of five physical classroom environment factors, namely, classroom layout, noise, temperature, lighting and colour. The questionnaire results showed that students have different demands for the physical classroom environment. Using the guidance of the person-environment fit theory, a smart IoT-enabled classroom has been proposed. The results of this study could be used by managers who make capital decisions on classroom construction upgrades and facility managers who aim to improve the satisfaction and performance of students in higher education institutions.

KEYWORDS

Process, design science, person-environment fit, internet of things (IoT).

INTRODUCTION

In recent decades, the progress reached in educational theories and paradigms in addition to the advancement of technological development, have served to create new possibilities for the transformation of learning environments in higher education institutions (HEI) (Baum, 2018). Such developments enable the optimisation of physical, technological, and social conditions of university classrooms (González-Zamar et al., 2020), since these spaces for learning must adapt to the needs of multiple students. Throughout the process

1 Postgraduate student, The Bartlett School of Sustainable Construction, University College London, 1-19 Torrington Place, London, UK, WC1E7HB, xinyue.hao.19@ucl.ac.uk, orcid.org/0000-0001-7136-9612

2 The Bartlett School of Sustainable Construction, University College London, 1-19 Torrington Place, London, UK, WC1E7HB, l.florez@ucl.ac.uk, orcid.org/0000-0002-9286-6949

of schooling, students spend the majority of their time inside the classroom where they study (Woolfolk and Margetts, 2007), so it is critical to ascertain the influence of physical classroom environments in HEI to guarantee that students obtain the maximum benefits from these spaces (Puteh et al., 2015).

Steels (1973) defined the word 'environment' as the surroundings and conditions which are occupied by humans; each element of which has a different impact on human perceptions and behaviours. It is the primary intention of a learning environment to assist and improve the physical aspects for its users, such as those which are auditory and visual (Kopec, 2018). The classroom environment as an intermediate for learning can be addressed separately as two components, namely physical factors and social factors (Ramli et al., 2014). The physical factors include the facilities which are provided in the classroom (lighting, colour, temperature, noise, classroom layout, amongst others), which collectively form the entire classroom (Earthman, 2002). In contrast, social factors refer to human subjective percpetions which are informed by physical factors (Tanner and Lackney, 2006).

In this context, the physical classroom is not understood as a simple volumetric container of human activities, but this concept goes beyond to an architectural and built environment object (González-Zamar et al., 2020). From a positive perspective, it is often supposed that students who are more satisfied with the physical classroom environment are more likely to get better study outcomes (Kamarulzaman et al., 2011). From a negative perspective, students who are disappointed with perceived physical classroom conditions, tend to become distracted from their studies (Badayai, 2012). Therefore, improving the quality of the physical environment within the classroom design is one of the major objectives in terms of building and developing the education system in HEI (Barrett et al. 2017).

Practical methods and tools for efficient (automated) data collection can act on students' requirements in a timely manner and provide effective communication and sharing of information (Teizer et al, 2017). Information and communication technologies are in particular beneficial to lean practices when they improve the flow of processes by identifying non-value adding options that can be eliminated. IoT systems can integrate internal and external information, feed this information into a platform and provide perceived information for decision-making. IoT systems can also enhance the interaction between facility managers and students to increase effectiveness. These are the aims of Lean Thinking (Huovila and Koskela, 1998) and in this empirical research the aim is to identify the impact of the physical classroom environment on motivational attributes of students in HEI. In doing so, it will explore whether the design of physical classrooms influences learning satisfaction and performance. The results of this research provide specific design suggestions that contribute to reducing absenteeism, increasing enthusiasm, and forming a good person-environment relationship that continuously satisfies the needs of students. Furthermore, the environmental factors for classroom design that enhance performance and satisfaction have been used to develop an IoT-enabled classroom that can boost the construction of smart spaces and buildings.

LITERATURE REVIEW

PERSON-ENVIRONMENT FIT THEORY

Lewin (1935) and Murray (1938) creatively proposed a theoretical standpoint that identifies both the physical environment and its connection with personal preferences of the individual as potent determinants of human behaviour. Lewin (1951) perfected the definition of the person-environment (P-E) fit model that has been widely adopted and continues to be used. It states that P-E fit refers to the research of behaviour as a consequence of the interaction between the individual and the surrounding physical environment. Chartrand (1965) proposed a core assumption that meaningful differences can be assessed between the individual and the environment and considers that matching individuals to physical environments will expand the likelihood of positive outcomes. The P-E model has been adopted to understand and predict performance in the workplace (Mackinnon, 1962; McDermid, 1965), and it has also been applied in the field of education (Pawlowska et al., 2014). The "E" refers to the physical classroom environment where students learn and expect to be comfortable and safe. The "P" focuses on the students' perceptions, behaviours, and performance that are formed in the environment "E" (Pawlowska et al., 2014).

PERSON-ENVIRONMENT FIT IN CLASSROOM

Fraser (2012) argued that the contemporary physical classroom environment can be either beneficial (encourages communication and increased performance) or detrimental (noisy and with poor privacy). Therefore, the question is how to make a physical classroom environment to play an active positive role? Although there are many physical classroom environment factors, the main ones are: noise, temperature, lighting, colour, and classroom layout (Lewinski, 2015). McCoy (2005) proposed that these five factors play a critical role in improving the happiness of users and constitute the second-largest financial overhead for the majority of organisations when it comes to physical spaces. Regardless of the investment, the allocation of these spatial factors continues to be uncontrolled for many organisations (Lewinski, 2015), so it is necessary to state the impact of these five factors before establishing formal guiding practices for building spaces (Zannin et al., 2012).

Noise and poor classroom acoustics can generate a negative environment for students (Shield and Dockrell, 2003). DiSarno et al., (2002) determined that noise undermines student's reading, writing, and comprehension skills as noise diminishes the level of focus on the task being performed. To respond to these concerns, many countries have introduced guidelines concerning appropriate noise levels to improve acoustic conditions (Shield and Dockrell, 2006). For instance, the ANSI standard S12.60 acoustical performance standard has noise guidelines for schools in the USA (ANSI, 2002), and the Department for Education and Skills (DfES) in the UK (DfES, 2003). The noise inside a classroom can be owing to several reasons such as external noise (adjoining classrooms and street), building services noise (heating, lighting, and ventilation systems), noise from teaching aids (computers), and noise from the students (Shield and Dockrell, 2004).

Temperature may also impact the classroom environment. An inappropriate temperature can have physiological problems on people and make them exert more effort and prone to making more mistakes (Halstead, 1974). Haverinen-Shaughnessy and Shaughnessy (2015) claimed that students who study in a classroom with an unsuitable temperature showed a decreasing trend in the achievement of high marks. The classroom climate should be cautiously managed not only to ensure comfort, but also to act as a positive environment in the learning process by increasing attention and concentration (Wargocki and Wyon, 2013). Although there is no ideal temperature for a classroom, Earthman (2002) proposed a comfort indoor temperature between is 23°C to 26°C.

The visual lighting environment also affects the capability of students in perceiving visual stimuli (Philips, 1997). Fenton and Penney (1985) found that children are more likely to engage and concentrate in classroom activities, and achieve good academic results with fluorescent light. Heschong and Knecht (2002) found significant positive correlations between learning satisfaction and lighting, that is, the better the use and artificial controls of fluorescent light and natural daylight, the greater the satisfaction of students.

Colour is a design element that induces physiological and psychological responses (Gaines and Curry, 2011). For the physiological factors, Engelbrecht (2003) proposed that colour affects children's blood pressure, eye strain, and even brain development. For psychological considerations, findings have shown a relationship between colour preferences and the participants' performance and satisfaction (Verghese, 2001). Torice and Logrippo (1989) noted colour characteristics in the classroom design since colours have different effects on social environment factors. It was found that active students prefer cool colours and passive students are more comfortable with warm colours.

Classroom layout and spatial arrangements with well-defined spaces positively impact the interactions between students and teachers and on-task behaviours (Budge, 2000). There are many forms of seating arrangements in a classroom such as U-shape, V-shape, Hollow square, Boardroom, Oval and Top tables, which share functional similarities (Burgess and Kaya, 2007). Fuhrer et al. (1999) determined that students in the U-Shape and V-Shape arrangements asked more questions than in the traditional classroom arrangement. Classrooms with traditional seating configurations improve the student's ability to concentrate on the lesson and focus on their work (Budge, 2000).

IoT and Smart Classroom

Internet of Things (IoT) devices have been widely applied to improve noise, lighting, and temperature conditions in diverse environments (Uzelac et al., 2015). The basic key features of IoT are sensing, communicating, networking, and producing new information. IoT can support organisations to advance the quality of learning and teaching by offering a more affluent learning experience, as well as real-time actionable insight into students' performance and satisfaction (Dawndasekare and Jayakody, 2017). It has the potential to create a smart learning environment in which students can customize environmental variables to their preferences. IoT applications (tablets, sensors, fitness bands, virtual reality headsets) are being used in education to track the performance of students (Asseo et al., 2016). Smart classrooms can measure and analyse the effect of different parameters in the physical environment like noise, CO2 level, temperature on students' attention (Gligoric et al., 2015) and decide in real time whether to the physical environment is enhanced to make the most of students' ability to focus on a task (Dawndasekare and Jayakody, 2017).

RESEARCH METHOD

This study assesses the influence of HEI classroom design on students' performance and satisfaction. Satisfaction refers to students' subjective feelings with the physical classroom environment. A physical classroom environment may be constituted by several dimensions such as noise, lighting, temperature, interior colour etc. that have a considerable positive or negative impact on behaviour, perceptions, attitudes and the performance of students (Ashkanasy et al., 2014). From a positive perspective, it is often supposed that students who are more satisfied with the physical classroom environment have better work outcomes (Kamarulzaman et al., 2011) and when emotionally engaged are actively eager to learn and work with higher grades (Mouratidis et al. (2009). From a negative standpoint, an inappropriate physical classroom environment will affect students' perceptions. Obviously, the subjective satisfaction level of students will have an impact on the objective grade. To explore the satisfaction and performance of students in HEI, data was drawn from a University in the UK. A survey questionnaire was conducted in order to solicit opinions and preferences from students on the factors that need to be considered for designing good quality classroom environments. The questionnaire was designed and a mix-method approach was used for analysis, where samples were drawn with the adoption of both random and purposive sampling. According to the research results, a smart classroom system based on IoT devices will be built to meet their specific needs.

DATA COLLECTION

A web-based questionnaire was sent to students since the goal was to learn about the opinions of students about classroom environments in HEI. According to the research hypotheses (see Table 1), the first part of questionnaire was designed to collect opinions on impact: "do you think that classroom noise/temperature/lighting/colour/ layout has an impact on your learning performance and satisfaction?", on a 5-point Likert scale in which: 1-strongly disagree and 5-strongly agree". In the second part, respondents were asked to answer open-ended questions: on what they think is the most: "influential noise source?"; "suitable temperature for university classroom?"; "suitable colour for the classroom?"; "favourite classroom layout?" and "comfortable light source?".

Table 1: Research Hypotheses

No.	Hypotheses
H1:	Classroom design influences learning performance and satisfaction
H1a:	Noise influences learning performance and satisfaction
H1b:	Temperature influences learning performance and satisfaction
H1c:	Lighting influences learning performance and satisfaction
H1d:	Colour influences learning performance and satisfaction
H1e:	Classroom layout influences learning performance and satisfaction

Participants

An email was sent to University students, requesting voluntary and anonymous participation responding to the questionnaire. About 283 emails were sent (randomly from the list of all students) and a total of 173 were returned with valid responses. The minimum age of respondents was 18 years of age. Of the total number of students, 45 were undergraduate, 100 postgraduate, 20 Ph.D., and 8 visiting (other) students.

Factor Analysis

Cronbach's coefficient alpha was used to measure internal consistency among the various factors. Cronbach's values were 0.765 (performance) and 0.791 (satisfaction), which were higher than the 0.50 threshold and indicate reliability at the 5% significance level. The collinearity diagnostic test was used to test the multi-collinearity among physical classroom factors. Prior to applying this method, the variance inflation factor (VIF) test was conducted. As for tolerance (=1/VIF), the less and closer that this value is to 1.0, the weaker collinearity relationship exists. All the tolerance values obtained were less than 1.0 and VIF values were less than 10. All data analysis was performed using IBM SPSS version 27.0.

RESULTS

Table 2 shows the survey results. The relationship between the independent variables (classroom design) and dependent variables (student satisfaction and performance) were examined by adopting Pearson correlation analysis.

Table 2: Pearson Correlation Analysis

Factors	N	T	L	CO	CL	CD	S	P
Noise (N)	1	.758	.715	.251	-.284	.785	.678	.723
Temperature (T)	.758	1	.711	.176	-.210	.871	.563	.475
Lighting (L)	.715	.711	1	.218	.170	.653	.325	.506
Colour (CO)	.251	.176	.218	1	.185	.567	.287	266
Classroom layout (CL)	-.28	-.210	.170	.185	1	.325	.752	692
Classroom design (CD)	.785	.871	.653	.567	.325	1	.610	.753
Satisfaction (S)	.678	.563	.325	.287	.752	.610	1	.785
Performance (P)	.723	.475	.506	.266	.692	.753	.785	1

For instance, the Pearson value for classroom design and students' satisfaction was 0.610 (p-value <0.001). This value suggests that there is a moderate positive correlation ([0.5, 0.8]) between students' satisfaction and classroom design. Similarly, the Pearson value for students' performance and classroom design was 0.753 (p-value <0.001), suggesting that there also exists a moderate positive relationship between these two variables ([0.5, 0.8]).

To investigate the influence of explanatory variables ("E" factors) on dependent variables ("P" factors), a regression analysis was conducted. The satisfaction model refers to the impact of "E" factors on satisfaction, and the performance model refers to the impact of "E" factors on performance. As shown in Table 3, the satisfaction model explained 58.2% of the variance in student satisfaction (dependent variable). Note that the model strength is 0.565 (p-value<0.05). Additionally, the results suggest that the better the physical design of the classroom, the higher satisfaction of students. The performance model explained 72.7% of the variance in students' performance and its strength is 0.725 (p-value<0.05). These results indicate that classroom design has a positive relationship with performance, that is, the better the physical design of the classroom, the better performance of students. Therefore, research hypotheses H1 were accepted.

Table 3: Classroom Design and Student's Satisfaction and Performance

Model	R	R^2	Adj. R^2	F	Sig.	B	T	Sig.
Satisfaction Model	.763	.582	.565	386.82	.00	.592	11.328	.000
Performance Model	.853	.727	.725	571.65	.00	.786	20.586	.000

Furthermore, a linear regression was employed to investigate the impact of classroom design on students' learning satisfaction and performance. Table 4 shows the results. Note that noise and classroom layout explain most of the variance (67.2% and 62.1% individually) in students' satisfaction. Similarly, noise and classroom layout explain most of the variance (71.5% and 68.5% individually) in students' performance.

Table 4: Classroom Design on Student's Satisfaction and Performance

Independent variables (Dependent variables)	R	R²	F-value	B	T
Noise (Satisfaction)	.819	.672	544.869	.685	13.248
Noise (Performance)	.845	.715	615.686	.752	18.156
Temperature (Satisfaction)	.716	.513	366.112	.603	12.597
Temperature (Performance)	.711	.506	347.861	.587	10.418
Lighting (Satisfaction)	.563	.318	175.498	.416	9.142
Lighting (Performance)	.702	.493	326.134	.565	10.113
Classroom layout (Satisfaction)	.788	.621	496.358	.638	14.956
Classroom layout (Performance)	.827	.685	579.625	.711	16.844
Colour (Satisfaction)	.514	.265	101.432	.395	7.354
Colour (Performance)	.492	.243	82.366	.316	8.743

Additionally, note that both noise and classroom layout have a positive relationship with performance and satisfaction. However, colour explains the least variance in performance (24.3%) and satisfaction (26.5%). From the results, it can also be concluded that the influence of temperature is greater than lighting. Specifically, temperature affects satisfaction (51.3%) slightly more than performance (50.6%), while lighting shows an opposite trend. From the results of regression analysis results, the research hypotheses H1a, H1b, H1c, H1d, and H1e were accepted. Accordingly, the conditions of the physical university classroom environment and its related characteristics can have a considerable impact on students' performance and satisfaction and the data support the possibility of a positive correlation of environmental factors on performance and satisfaction.

DISCUSSION

Quantitative research results show that the physical classroom environment has a particularly prominent impact on students' performance, followed by students' satisfaction. At a more micro level, every environmental factor will have an impact on students' performance and satisfaction. From the regression analysis, the influence rankings can be obtained for both performance and satisfaction: noise >layout>temperature>lighting>colour. Through the open questions, it was found that the demand for classroom environment shows a diversified trend. However, commonalities were found. For instance, the majority of students prefer natural daylight in the classroom and a temperature between 23°C to 25°C in the summer. Noise coming from outside the window affects students the most, yellow was found to be the students' favourite colour, and flexible seating arrangements such as V-shape and U-shape are enjoyed most by students.

To meet their diverse but common needs, an IoT-enabled smart classroom could be developed. IoT networks have a master control dashboard and have been used in various industries, including education (Meola, 2016). IoT campus developed by Abuarqoub et al. (2017) contains four applications (smart buildings, renewable and smart grid application, smart learning application and waster and water management). IoT-enabled services monitor environmental factors such as pressure, temperature, humidity. Sensors control the supply of hot water in radiators, turning them off and saving around 50-60% of energy for heating. The second advantage is that maintenance can be automated, with sensors attached to IoT devices that monitor status of equipment and when action is required maintenance staff can respond instantly. The third advantage is smart devices provide security. With Computer Vision (CV) algorithms, smart classroom can recognise entering students based on face recognition and give permission to pass. The fourth advantage is students' attendance can be done automatically through the use of biometric parameters. The fifth benefit is occupancy detection and tracking. IoT services can point out to students available study spaces. Lastly, the experience of users can be enhanced through intelligent equipment (sensi ng lights, automatic temperature adjustment). A wireless acoustic sensor network is presented by Segura et al. (2016), which evaluates the functional architecture of IoT prototype to produce noise maps. If the noise exceeds the standard, the system will automatically issue an alarm. A PIR Sensor is a motion-sensing device integrated with the controller to detect occupants in the room by sensing infrared fluctuations to trigger the lights from turning On/Off. PIR sensors are commonly used to detect human presence to monitor occupation and to save energy (Twumasi et al. 2017). IoT temperature controls allow for customisation from room to room, and temperature settings can be scheduled for certain times of day. Present scenes allow these environment adjustments to occur with just one click. Based on the above theoretical and practical research, an IoT-based automatic control system has been proposed for university classrooms (see Figure 1).

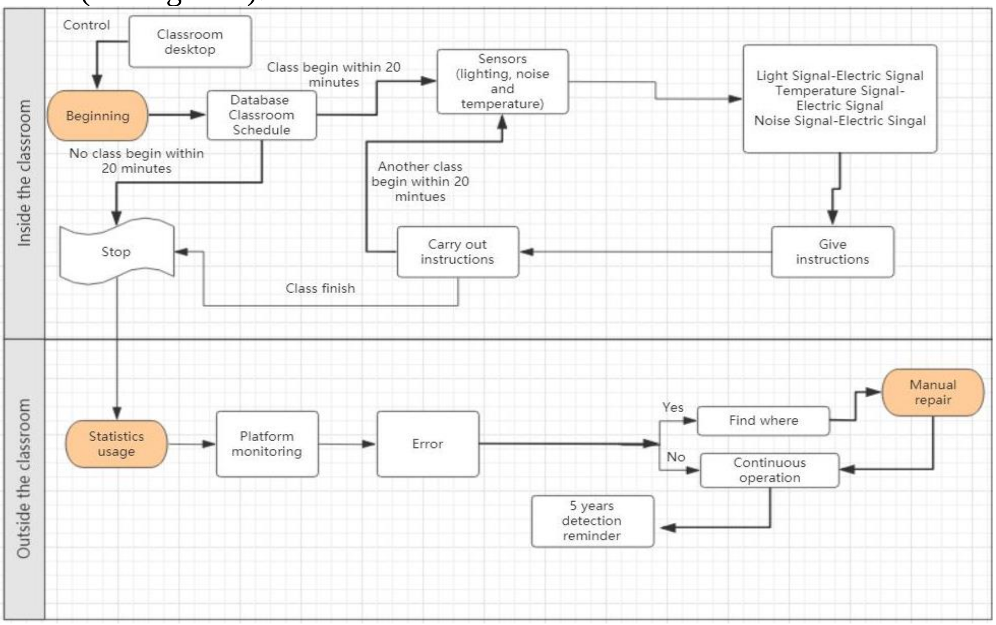

Figure 1: Classroom Automation Control System

For inside the classroom, lighting, noise and temperature sensors can be installed. Before sensors work, a database will check if a class will take place in the next 20 minutes, if so, sensors will be turned on. Otherwise, sensors will not operate. Lighting sensors will convert the light information into electrical signals. When natural light is insufficient (assuming that the curtains are closed), classroom lights will be turned on automatically. Additionally, when noise exceeds 60 dB, sensors will recognise and memorise the noise level. When temperature sensors determine the temperature is either too high or too low, the electric signal will automatically adjust the temperature of the air conditioner. The system will automatically operate the stated conditions after a class is finished. If another class will take place within 20 minutes from the previous class ending, sensors will continue to work. Otherwise, sensors will stop working. All the character strings will be transmitted to the platform system outside the classroom. If the operation is wrong, the alarm will be activated and the monitor platform will report the location where errors have occurred. It is expected that such a system can operate for 5 years, after which a large-scale maintenance needs to be scheduled. Note that the platform monitoring has permission to control all classroom sensors.

CONCLUSIONS

With the results from the person-environment analysis conducted in this study, a smart classroom based on IoT devices, flexible design, and higher quality building components has been proposed. This IoT-based smart classroom may ensure good working conditions for HEI environments that will satisfy the needs of its users. IoT devices integrating sensors, signal conversion, and intelligent processing mechanisms can efficiently ensure appropriate temperature and lighting conditions. When it comes to classroom layout, flexibility in the use of elements such as tables and chairs can be provided by allowing multiple configurations that promote collaboration between students and facilitate the interaction between students and teachers. Poor acoustics in classrooms have been recognised for years (Shield, 2011). For this reason, the DfES incorporated the Building Regulations for acoustic design for classrooms (DfES, 2003). School designs have to meet criteria for noise, reverberation and sound insulation. Specifically, acoustic insulation can be external and internal walls to meet the requirements (Shield and Richardson, 2018). Noise level in the classroom is monitored using several microphones. The data collected using IoT devices can be analysed and results presented in real-time. If a lecturer notices a higher noise than the standard, the current activity can be changed. This smart classroom system will decide in real-time whether acoustics are enhanced to make the most of student’s ability to focus. Results show that the colour of the university classroom has little influence on student’s performance and satisfaction, but the students prefer white and yellow. By improving the university classroom environment, the results of this study suggest that the performance and satisfaction of students may be enhanced. With such results and supported by IoT, the future of the classroom environment in which digital and physical objects can be connected by means of suitable information and communication technologies, a range of applications and services can be developed.

REFERENCES

Abuarqoub, A., Abusaimeh, H., Hammoudeh, M., Uliyan, D., Abu-Hashem, M. A., Murad, S., & Al-Fayez, F. (2017, July). A survey on internet of things enabled smart campus applications. In *Proceedings of the International Conference on Future Networks and Distributed Systems* (pp. 1-7).

Ashkanasy, N. M., Ayoko, O. B., & Jehn, K. A. (2014). Understanding the physical environment of work and employee behavior: An affective events perspective. *Journal of Organizational Behavior, 35*(8), 1169-1184.

Asseo, I., Johnson, M., Nilsson, B., Chalapathy, N., & Costello, T. J. (2016). The Internet of things: Riding the wave in higher education. *Educause review*, *51*, 11-33.

Backman, Y., Alerby, E., Bergmark, U., Gardelli, Å., Hertting, K., Kostenius, C., & Öhrling, K. (2012). Improving the school environment from a student perspective: Tensions and opportunities. *Education Inquiry, 3*(1), 19-35.

Badayai, A. R. A. (2012). A theoretical framework and analytical discussion on uncongenial physical workplace environment and job performance among workers in industrial sectors. *Procedia-Soc. and Behav. Sci., 42*, 486-495.

Barrett, P., Davies, F., Zhang, Y., and Barrett, L. (2017). The holistic impact of classroom spaces on learning in specific subjects. *Env. and Behave.*, *49*(4), 425-451.

Baum, E. J. (2018). Learning space design and classroom behavior. *Intl J. of Lear., Teach. and Educ. Res.*, *17*(9), 34-53.

Budge, D. (2000). Secret is in the seating. *Times educational supplement*, *4396*, 26-27.

Burgess, B., and Kaya, N. (2007). Gender differences in student attitude for seating layout in college classrooms. *College Stu. J.*, *41*(4), 940-947.

Chartrand, G. (1965). The existence of complete cycles in repeated line-graphs. *Bulletin of the American Mathematical Society*, *71*(4), 668-670.

Dawndasekare, D. M. S. P. K., & Jayakody, A. (2017). IoT Based Framework to Increase Student Success in the Classroom of Tertiary Education in Sri Lanka: The Smart Classroom. In *24th Annual technical conference of iet Sri Lanka network* (p. 57).

Department for Education and Skills (DfES) (2021). Every child matters https://www.gov.uk/government/organisations/department-for-education/everychild.

Earthman, G. I. (2002). School facility conditions and student academic achievement.

Engelbrecht, K. (2003). The impact of color on learning. NeoCON2003.

Fenton, D. M., and Penney, R. (1985). The effects of fluorescent and incandescent lighting on the repetitive behaviours of autistic and intellectually handicapped children. *Australia and New Zealand J. of Develop. Disab.*, *11*(3), 137-141.

Fraser, B. J. (2012). *Classroom env.* (Vol. 234). Routledge.

Gaines, K. S., and Curry, Z. D. (2011). The inclusive classroom: The effects of color on learning and behavior. *J. of Family & Consumer Sci.*, *29*, 1.

Gligoric, N., Uzelac, A., Krco, S., Kovacevic, I., & Nikodijevic, A. (2015). Smart classroom system for detecting level of interest a lecture creates in a classroom. *Journal of Ambient Intelligence and Smart Environments*, *7*(2), 271-284.

González-Zamar, M. D., Ortiz Jiménez, L., Sánchez Ayala, A., and Abad-Segura, E. (2020). The impact of the university classroom on managing the socio-educational well-being: A global study. *Intl J. of Env. Res. and Pub. Health*, *17*(3), 931.

Great Britain. School Buildings, & Design Unit. (2003). *Acoustic Design of Schools* (Vol. 93). Stationery Office.

Halstead, T. K. (1974). Proton NMR studies of lanthanum nickel hydride: Structure and diffusion. *J. of Solid State Chemistry*, *11*(2), 114-119.

Haverinen-Shaughnessy, U., and Shaughnessy, R. J. (2015). Effects of classroom ventilation rate and temperature on students' test scores. *PloS one*, *10*(8), e0136165.

Heschong, L., and Knecht, C. (2002). Daylighting Makes a Difference. *Educ. Facility Planner*, *37*(2), 5-14.

Kamarulzaman, N., Saleh, A. A., Hashim, S. Z., Hashim, H., & Abdul-Ghani, A. A. (2011). An overview of the influence of physical office environments towards employee. *Procedia Engineering*, *20*, 262-268.

Kopec, D. A. (2018). Environmental psychology for design.

Lewin, K. (1935). *Dynamic Theories of Personality*. New York: McGraw-Hill.

Lewin, K. (1951). *Field theory in social science*. New York: Harper.

Lewinski, P. (2015). Effects of classrooms' architecture on academic performance in view of telic versus paratelic motivation: a review. *Frontiers in Psych.*, *6*, 746.

MacKinnon, D. W. (1962). The nature and nurture of creative talent. *American Psych.*, *17*(7), 484.

Martínez-Otero, V., & Pérez, V. M. O. (1997). *Los adolescentes ante el estudio: causas y consecuencias del rendimiento académico* (Vol. 213). Editorial Fundamentos.

Marx, A., Fuhrer, U., and Hartig, T. (1999). Effects of classroom seating arrangements on children's question-asking. *Learning Environ. Res.*, *2*(3), 249-263.

McCoy, M., and Evans, W. (2005). Physical work environment. *Handbook of work stress*, 219-245.

McDermid, C. D. (1965). Some correlates of creativity in engineering personnel. *J. of App. Psych.*, *49*(1), 14.

Meola, A. (2016). How IoT in education is changing the way we learn. *Business Insider*.

Mouratidis, A., Vansteenkiste, M., Lens, W., & Auweele, Y. V. (2009). Beyond positive and negative affect: Achievement goals and discrete emotions in the elementary physical education classroom. *Psychology of Sport and Exercise*, *10*(3), 336-343.

Murray, H. (1938). *Explorations in Personality*. Boston, MA: Houghton Miffl.

Pawlowska, D. K., Westerman, J. W., Bergman, S. M., and Huelsman, T. J. (2014). Student personality, classroom environment, and student outcomes: A person–environment fit analysis. *Learning and Ind. Differences*, *36*, 180-193.

Phillips, R. (1997). Educational facility age and the academic achievement of upper elementary school students. *Unpublished PhD. Dissertation.* University of Georgia.

Puteh, M., Che Ahmad, C. N., Mohamed Noh, N., Adnan, M., and Ibrahim, M. H. (2015). The classroom physical environment and its relation to teaching and learning comfort level. *Intl. J. of Social Sci. and Humanity*, *5*(3), 237-240.

Ramli, N. H., Ahmad, S., Taib, M. Z. M., and Masri, M. (2014). Principals' perception on classroom physical environment. *Procedia-Social and Behav. Sci.*, *153*, 266-273.

Segura Garcia,J.,Perez Solano,J.,Cobos Serrano,M.,Navarro Camba,A., Felici Castell,S., Soriano Asensi,A., & Montes Suay,F. (2016). Spatial statistical analysis of urban noise data from a WASN gathered by an IoT system: Application to a small city. *Applied Sciences*, *6*(12), 380.

Shield, B. M. (2011). Acoustic design of schools-Where are we now. In *Proceedings of the Institute of Acoustics, Acoustics 2011 Conference* (Vol. 33, No. Pt 2, pp. 1-17).

Shield, B. M., and Dockrell, J. E. (2003). The effects of noise on children at school: A review. *Building Acoustics*, *10*(2), 97-116.

Shield, B., & Richardson, R. (2018). Regulation of school acoustic design in the UK: recent revision of Building and School Premises Regulations and their application.

Steele,F.I.(1973). Physical settings and organization development.Addison Wesley Publishing Company.

Tanner, C. K., and Lackney, J. A. (2006). Educational facilities planning: Leadership, architecture, and management. Allyn & Bacon.

Teizer, J., Wolf, M., Golovina, O., Perschewski, M., Markus Propach, M., Neges, M., & König, M. (2017). Internet of Things (IoT) for Integrating Environmental and Localization Data in Building Information Modeling (BIM). In *Proceedings of the* International Symposium on Automation and Robotics in Construction (pp. 603-609).

Torrice, A. F., and Logrippo, R. (1989). *In my Room: Designing for and with Children.* Fawcett.

Twumasi, C., Dotche, K. A., Banuenumah, W., & Sekyere, F. (2017). Energy saving system using a PIR sensor for classroom monitoring. In *2017 IEEE PES PowerAfrica* (pp. 347-351). IEEE.

Uzelac, A., Gligoric, N., and Krco, S. (2015). A comprehensive study of parameters in physical environment that impact students' focus during lecture using Internet of Things. *Computers in Human Behav.*, *53*, 427-434.

Verghese, P. (2001). Visual search and attention: A signal detection theory approach. *Neuron*, *31*(4), 523-535.

Wargocki, P., and Wyon, D. P. (2013). Providing better thermal and air quality conditions in school classrooms would be cost-effective. *Building & Env.*, *59*, 581-589.

Woolfolk, A., and Margetts, K. (2007). Education psychology. *Boston: Pearson Edition*.

Zannin, P. H. T., Passero, C. R. M., and Zwirtes, D. P. Z. (2012). Assessment of acoustic quality in classrooms based on measurements, perception and noise control. *Noise Control, Reduction and Cancellation Solutions in Eng*.