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The Influence of Light Colour Temperatures on Interior Design Student Performance in Classroom Studios

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Abstract The purpose of this research study was to examine how lighting conditions impact the perceived spatial quality, comfort, collaboration, motivation, distraction, and fatigue in a classroom studio. A survey was conducted with 124 students, and their responses were analyzed based on the overall spaciousness of the studio, the amount of natural light, and the brightness level. The results indicated that most respondents felt the studio was somewhat spacious in daylight with high colour temperatures, but cramped in low temperatures. Additionally, the majority of respondents preferred a very bright level of illumination. In terms of comfort and collaboration, students generally felt somewhat comfortable and collaborative, especially in the high colour temperature condition. The majority of respondents rarely felt distracted by external factors, particularly in the high colour temperature conditions. As for motivation and efficiency, most students felt somewhat motivated and efficient with high-colour temperature lighting, while the lowest number of respondents felt very motivated and efficient in the low colour temperature condition. Furthermore, the highest number of respondents reported feeling rarely fatigued in the high colour temperature condition. The findings suggest that lighting conditions significantly affect students' perceived comfort, collaboration, motivation, distraction, and fatigue. Therefore, educators and designers should take lighting conditions into consideration when creating a conducive and comfortable learning environment.

Keywords Interior Design Studio, Light Colour Temperatures, Spatial Quality, Social Adaptation

1. Introduction

The environment has been impacted by a variety of factors, and humans have been directly impacted by those settings [1]. People feel energised and joyful in well-designed surroundings, and vice versa. These components begin with the structure and design of the building and end with colour, light, exterior views, and furnishings. Sometimes, light has a considerably greater impact on the surroundings than any other factor. Understanding how light and the surroundings interact can help interior designers and architects create more effective spaces. All facets of human existence and health are significantly impacted by lighting conditions. They have an impact on our physical and mental health, and their dynamic alterations have a favourable impact on a number of facets of human well-being [2]. There have been many studies on how illumination affects human physiology, according to a study of the impacts of environmental

factors on health [3]. The built environment academic community's attention has shifted due to the importance of the subject [4] from the impacts of daylight and electric illumination on building performance and energy use to the consequences on health, well-being, and comfort.

Education spaces are places for the advancement of the physiological, psychological, emotional, and cultural aspects of a person, and it is anticipated that these buildings to effectively realise this advancement. When creating the necessary surroundings and circumstances, most educational structures offer the chance for proper development. They are also built with architectural design elements that allow for student engagement, encounter, revelation, investigations, thought, production, questioning, and socialisation. It has a positive impact on education in this way. Therefore, the architecture of learning environments plays a significant role. Nearly all educational administrators may not give the physical environment, student motivation, and effects on increasing success and performance enough consideration. In order to increase students' success, educational institutions frequently update their course curricula and strengthen their teams by hiring popular, well-known teachers. Educational institutions that have physical elements that are inappropriate for learning and instruction have a negative impact on students' success in their studies and their persistence in attending class [5]. As a result, it becomes very important to monitor the effects of physical environmental factors in learning environments on students' perceptions at regular intervals.

Light is also a crucial component of every individual's life and is crucial in establishing an effective and relaxing environment. To complete tasks safely and effectively in an educational setting, good lighting is essential. The importance of lighting has been extensively studied and is thought to be crucial for the performance of the occupant. Classroom lighting not only makes it easier for students to write and read when doing activities in the classroom, but it also assists these individuals in seeing the instructions on the board clearly [6]. Additionally, lighting contributes to the creation of an atmosphere that is visually appealing and improves the look of the indoor area [7]. Studies have demonstrated the impact of lighting on individual biological well-being, including blood pressure, pulse rate, and the rhythm of the circadian cycle. Some psychological behaviours, such as changes in mood, could be triggered by lighting. The prior study revealed the beneficial impacts of lighting conditions on the effective completion of tasks and productivity of individuals, in addition to biological and emotional effects [8]. Nevertheless, the majority of these observational studies [9] have concentrated on workplaces like offices, stores, and others. Even now, there is a lack of studies on the impact of illumination in learning environments. Learning how lighting and environment interact may be beneficial to enhance the quality of indoor environments thus improving students' success. Therefore, the following hypothesizes are correct for carrying out the study analysis:

Hypothesis 1: Daylight used in the lighting of design studios positively affects the "spatial quality" perception of students compared to high colour temperatures.

This theory is predicated on the concept that daylight, via its high colour temperature, can mimic natural lighting environments and offer a higher degree of contrast and brightness than other high colour temperatures. Students studying interior design should perceive spatial quality as being better as an outcome of the incorporation of daylight in design studio lighting.

Hypothesis 2: Low light colour temperatures used in the lighting of design studios positively affect the "social adaptation" perception of students.

The hypothesis is predicated on the idea that warm white and other low-light colour temperatures may produce a comfortable and personal ambience in the design workshop, and can encourage students' cooperation and interpersonal communication. The incorporation of low light colour temperatures in design studio lighting is anticipated to lead to a higher sense of social adaptation in students' interior design.

Hypothesis 3: High-light colour temperatures used in the lighting of design studios increase the "individual productivity" perception of students.

The hypothesis is founded on the idea that high light colour temperatures which include daylight, can make students more focused and attentive, which can result in greater degrees of personal productivity. The incorporation of high-light colour temperatures in the illumination of design studios is anticipated to lead to a higher sense of personal productivity among students of interior design.

1.1. Light Colour Temperatures Background

Over the past few years, there has been some research conducted on how different light color temperatures can affect human behavior and performance. Different light colour temperatures can influence individuals' physiological and psychological reactions, in accordance with the study carried out by Juan and Chen [10]. Warm white, a colour with a low colour temperature, has been related to relaxation, while daylight or cool white and spaciousness, a colour with a high colour temperature, are related to greater attentiveness and productivity. Furthermore, earlier studies have demonstrated that various light colour temperatures can have an impact on cognitive, emotional, and visual processes [8], [11], [12].

The study has additionally taken a look at how light colour temperatures affect educational achievement and learning. As per Lekan-Kehinde and Asojo [13] research findings from an academic performance by means of reading proficiency (accuracy, speed, and expression) in circumstances resembling those in daily life demonstrate that being subjected to higher correlated colour temperatures (CCT) light contributes to substantial improvements in children's performance of task-switching,

however, no effect has been observed on their continued focus. The learning atmosphere, according to Hansen *et al*. [14], is comprised of the physical setting (classrooms), the educational activities that happen to take place there throughout the course of school hours, and the conduct of the students that might or might not have an impact on those endeavours. Mott *et al*.'s [15] research indicates that lighting, both artificial and natural, has a significant impact on how well kids perform in school. Windows let in natural light and provide a view, while artificial light enhances kids' visual, cognitive, and behavioural abilities [16]. According to studies carried out by Govén *et al*. [17], blue lighting can improve focus and attentiveness in adolescents who look fatigued because of staying up late. It also helps sustain moods throughout the course of the day. Lighting has also been shown to be helpful in the growth of cognitive, behavioural, and visual abilities, particularly when it comes to visually following objects like books and materials.

Lighting is a key component of interior design because it influences the atmosphere and tone of the room [18]. The visual perception, psychological health, as well as performance of people in various settings can all be impacted by the use of various light colour temperatures [19]–[21]. Thus, the goal of this research study is to identify the preferred light colour temperatures among students studying interior design as well as how various light colour temperatures affect their ability to perceive space, adjust to social situations, and work independently in design studios. The results of the study could serve as a guide for architects and designers creating learning environments that would raise the bar for a space's ability to be both functionally useful and favourably received.

2. Conceptual Framework

The conceptual framework for this research study is shaped on the presumption that light colour temperature has a significant impact on how interior design affects student's spatial perception, social adaptation, and individual productivity in design studios. According to the framework, individual characteristics like age, gender, and prior lighting experience might have an impact on how these variables are affected by light colour temperature. Furthermore, the framework makes the assumption that the nature of the task carried out in the design studio might additionally have an impact on how light temperature affects spatial perception, social adaptation, and individual productivity.

2.1. Daylight and Spatial Quality

The effects of daylighting along with various classroom interior design elements on learning were examined in the study by Dahlan and Eissa [22] in a few classrooms on the campus of King Abdul-Aziz University located in Jeddah, Saudi Arabia. In spite of the presence of conventional descriptive learning factors, the findings indicated a relationship between daylight in classrooms and students' success in those environments. To determine whether there may be any potential impact on the performance of learners, additional factors such as acoustics, the quality of the indoor air, thermal comfort, and artificial light are investigated. Additionally, a study by Knoop *et al*. [23] discovered that many individuals opt for natural light over electrical illumination and that natural light fosters an increased feeling of satisfaction and health.

2.2. Low Light Colour Temperatures and Social Adaptation

According to Lin and Yoon [24] study that examined how electric light sources affected shoppers' behaviour. Warm lighting improved social behaviour and satisfaction among consumers, according to the findings. Similar findings have been identified in a research investigation by Bilgili *et al*. [25] that warm lighting in restaurants improved patrons' satisfaction and length of stay. According to Wansink and van Ittersum [26], when the illumination and music were softer, people consumed less food, gave it higher ratings, and spent the same amount of money.

2.3. High Light Colour Temperatures and Individual Productivity

Fostervold and Nersveen's [27] research study looked at the impact of light on the health and efficiency of employees in offices. In this regard, those who worked in environments with high colour temperatures (5000K) performed far more effectively in cognitive tasks while expressing felt more attentive than those who did so in low colour temperatures (3000K). In addition, the study by Figueiro *et al*. [28] discovered that people with Alzheimer's disease performed better cognitively when exposed to higher correlated colour temperature (CCT) light sources.

3. Design Methodology

The survey was conducted at Irbid University College and involved 124 students who were studying interior design. These students were selected as the target population for the study.

The survey questionnaire was designed to assess the impact of different light colour temperatures (low, daylight, and high) on students' spatial perception, social adaptation, and individual productivity in design studios. The questionnaire consisted of two sections. The first section collected demographic data, including information about gender, age, current year of study, and frequency of attending design studios per week. The second section focused on students' preferences for light colour temperatures and their perceptions of spatial quality, social

adaptation, and individual productivity.

The experimental environment for this study was the design studio, which has a floor space of roughly 80 m^2 and is housed at the Irbid University College in Jordon. All the physical environmental factors at this designated space for education were fixed and kept in check and it is considered as a dependent variable. High Light scenario was presented in Figure 1a and prior to the arrangement, the studio space's current conditions are shown in the figures below (Figure 1b).

Figure 1. High light scenario was presented in a and b images

3.1. Data Collection

The students were given an equal amount of time in each studio, and during this time, they were asked to complete the study questionnaire. The questionnaire provided rating scales for students to assess the quality of space, their level of social adaptation, and their individual productivity in the different light colour temperature conditions.

3.2. Data Analysis

The collected data from the study questionnaire were analyzed using SPSS 25 software. Descriptive statistics, such as means and standard deviations, were computed for each variable to provide an overview of the data. Correlation tests were performed to examine any statistically significant differences between the three light colour temperature conditions and the students' assessments of spatial quality, social adaptation, and individual productivity.

3.3. Limitations

It is important to note some limitations of the study. Firstly, the sample size was limited to 124 interior design students from a specific university, which may limit the generalizability of the findings to a larger population. Secondly, the study relied on self-reported data, which could be subject to biases or inaccuracies. Lastly, the study focused on the impact of light colour temperatures and did not consider other potential factors that could influence students' experiences in design studios.

3.4. Results

Table 1. Demographic details of respondents

		Frequency	Percent
Gender	Male	49	39.5
	Female	75	60.5
Age	18-24 years	107	86.3
	25-34 years	17	13.7
Current year of study	First Year	81	65.3
	Second Year	41	33.1
	Third Year	2	1.6
Frequency of attending design studios per week	1-2 times	74	59.7
	3-4 times	48	38.7
	5-6 times	2	1.6

Table 1 presents the demographic details of participants, firstly, the gender presentation shows the number of respondents who selected each option in the survey. Out of all the participants who responded to the survey, it was found that 39.5% of them identified themselves as male, while 60.5% identified themselves as female. This indicates that the female respondents are more actively participating in this research study and significantly they are involved in design studios. Secondly, the age ranges (18-24 years and 25-34 years) were chosen. The majority of respondents (107, or 86.3%) fell into the 18–24-year age range, while only 17 (13.7%) were between 25-34 years old. The current year of study (First Year, Second Year, and Third Year) shows the number of respondents who selected each option. The majority of respondents (81, or 65.3%) were in their first year of study, followed by 41 (33.1%) in their second year and only 2 (1.6%) in their third year. The frequency of attending design studios per week (1-2 times, 3-4 times, and 5-6 times) shows the number of respondents who selected each option. Most respondents (74, or 59.7%) attended design studios 1-2 times per week, followed by 48 (38.7%) who attended 3-4 times per week and only 2 (1.6%) attended 5-6 times per

week.

Table 2. Frequency analysis of the spatial quality with three different colour temperature

Spatial Quality	Daylight colour temperature	High colour temperature	Low colour temperature
Overall spaciousness of the classroom studio			
Very cramped	1	2	21
Somewhat cramped	20	8	52
Neutral	8	8	24
Somewhat spacious	81	64	23
Very spacious	14	42	4
Amount of natural light entering the classroom studio			
Very little natural light	4	8	38
Somewhat little natural light	7	9	50
Neutral	8	6	16
Somewhat ample natural light	68	71	17
Very ample natural light	37	30	3
Brightness level in the classroom studio			
Very dim	2	4	21
Somewhat dim	6	14	58
Neutral	14	6	24
Somewhat bright	46	69	14
Very bright	56	31	7

Table 2 represents the results of a survey conducted on the spatial quality, daylight colour temperature, and brightness level of a classroom studio. The survey responses were categorized based on the perceived overall spaciousness of the studio, the amount of natural light entering the studio, and the brightness level of the studio. The perceived overall spaciousness of the studio was categorized from very cramped to very spacious. Most of the respondents stated they obtained the Somewhat spacious in daylight at n=81, high colour temperature (n=64) and 52% had somewhat cramped in low temperature. Further, the table indicates the amount of natural light entering the studio, categorized from very little natural light to very ample natural light. As per the respondent's view, it is understood that somewhat ample natural light was obtained by n=68 in daylight, followed this, n=71 members obtained somewhat ample natural light in high colour temperature but the highest of n=50 in low colour temperature. The third column of the table shows the responses related to the brightness level in the studio, categorized from very dim to very bright. The highest of 56 members had expected high brightness levels in the classroom studio. Following that, there were 69 members who appeared somewhat bright, while 58 members seemed somewhat dim. In summary, the table presents the distribution of survey responses based on the perceived overall spaciousness, the amount of natural light, and the brightness level in the classroom studio.

Table 3. Frequency analysis of the social adaptation with three different colour temperatures

Social Adaptation	Daylight colour temperature	High colour temperature	Low colour temperature
Felt comfortable in the classroom studio			
Very uncomfortable	6	0	22
Somewhat uncomfortable	40	9	57
Neutral	19	6	23
Somewhat comfortable	51	73	18
Very comfortable	8	36	4
Easy to collaborate with your peers in the classroom studio			
Very difficult	1	2	37
Somewhat difficult	33	16	42
Neutral	26	7	22
Somewhat easy	59	70	19
Very easy	5	29	4
Feel distracted by external factors in the classroom studio			
Very often	5	2	21
Somewhat often	35	13	49
Neutral	19	8	30
Rarely	47	83	19
Very rarely	18	18	5

Table 3 presents the results of a survey conducted on the social adaptation of the respondents in the classroom studio. The survey responses were categorized based on the perceived level of comfort, ease of collaboration with peers, and level of distraction by external factors.

According to Table 3, the findings suggest that the respondents generally felt somewhat comfortable in the classroom studio under different lighting conditions, particularly in the high colour temperature condition where the highest number of respondents (n=73) felt somewhat

comfortable collaborating with their peers and 57 members had somewhat uncomfortable in the low colour temperature. The findings also suggest that collaboration was somewhat easy for most respondents, particularly in the high colour temperature condition where the highest number of respondents (n=70) felt somewhat easy collaborating with peers. Further, the highest of respondents (n=59) had somewhat easy in the daylight colour temperature, and 42 members had somewhat difficult in the low colour temperature.

In terms of distractions, the majority of respondents rarely felt distracted by external factors, particularly in the high colour temperature condition where the highest number of respondents (n=83) reported rarely feeling distracted. However, in the low colour temperature condition, a higher number of respondents (n=49) felt somewhat distracted by external factors. Overall, the findings suggest that the lighting condition in a classroom studio can have an impact on the level of comfort, collaboration, and distraction felt by students. A higher colour temperature condition may be more conducive to collaboration and less distracting, while a low colour temperature condition may result in more distractions. However, it is important to note that these findings may be subjective and can vary based on the context of the survey and the preferences of the respondents.

Table 4 indicates the frequency analysis of the social adaptation with three different colour temperatures. In the category of "Motivated to work in the classroom studio", the highest number of respondents (n=67) felt somewhat motivated in the high colour temperature condition, while the lowest number of respondents (n=4) felt very motivated in the low colour temperature condition. Similarly, in the category of "Efficiency when completing tasks in the classroom studio", the highest number of respondents (n=82) reported feeling somewhat efficient in the high colour temperature condition, while the lowest number of respondents (n=2) felt very efficient in the low colour temperature condition. These findings suggest that a high colour temperature condition may be more conducive to increasing motivation and efficiency among students when completing tasks in the classroom studio. On the other hand, a low colour temperature condition may be less motivating and less efficient for completing tasks. In terms of feeling fatigued or tired in the classroom studio, the highest number of respondents (n=81) reported feeling rarely fatigued in the high colour temperature condition, while the lowest number of respondents (n=4) felt very rarely fatigued in the low colour temperature condition. This suggests that a high colour temperature condition may make students feel less fatigued and more alert compared to a low colour temperature condition.

Table 4. Frequency analysis of the social adaptation with three different colour temperatures

Individual Productivity	**Daylight colour temperature**	**High colour temperature**	**Low colour temperature**
Motivated to work in the classroom studio			
Very unmotivated	18	2	24
Somewhat unmotivated	38	7	58
Neutral	19	7	23
Somewhat motivated	38	67	15
Very motivated	11	41	4
Efficiency when completing tasks in the classroom studio			
Very inefficient	9	2	40
Somewhat inefficient	50	5	44
Neutral	28	7	20
Somewhat efficient	35	82	18
Very efficient	2	28	2
Feel fatigued or tired in the classroom studio			
Very often	9	12	24
Somewhat often	50	19	53
Neutral	27	7	29
Rarely	30	81	14
Very rarely	8	5	4

Overall, the findings suggest that the lighting condition in a classroom studio can have a significant impact on the motivation, efficiency, and fatigue levels of students. A high colour temperature condition may result in students feeling more motivated, efficient, and less fatigued compared to a low colour temperature condition. However, it is important to note that individual preferences and context may influence the impact of lighting conditions on productivity and well-being.

Table 5. Correlation Analysis

		Individual Productivity		
		Daylight colour temperature	**High colour temperature**	**Low colour temperature**
Spatial Quality	Pearson Correlation	.319**	.371**	.911**
	Sig. (2-tailed)	.000	.000	.000
Social Adaptation	Pearson Correlation	.266**	.421**	.895**
	Sig. (2-tailed)	.003	.000	.000
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 5 displays the Pearson correlation coefficients for the variables of Individual Productivity, Spatial Quality, and Social Adaptation in relation to Daylight, High, and Low colour temperatures. Between the two variables, the Pearson correlation coefficient ranges from -1 to 1, with -1 denoting a perfect negative correlation, 0 denoting no correlation, and 1 denoting a perfect positive correlation. The significance level for the correlation coefficients in the table is 0.01, indicating that they are statically important. For all three colour temperatures, the correlation coefficient is significant and positive, with the lowest correlation (r =.911) being found for the Low colour temperature. This suggests that there is a significant relationship between individual productivity and the spatial quality of the classroom studio, with higher individual productivity being correlated with higher spatial quality. The correlation coefficient for these two variables is significant and positive for all three colour temperatures, with the Low colour temperature showing the highest correlation (r =.895).

4. Discussion

The presented findings are based on a survey conducted on the spatial quality, daylight colour temperature, and brightness level of a classroom studio. The survey responses were categorized based on the perceived overall spaciousness of the studio, the amount of natural light entering the studio, and the brightness level of the studio. According to the findings, most of the respondents stated they obtained somewhat spacious in daylight, in high colour temperature and somewhat cramped in low temperature. Moreover, the highest number of respondents had expected a very brightness level in the classroom studio, followed by somewhat bright and somewhat dim respectively. Based on the presented findings, it can be inferred that the respondents preferred a classroom studio with high colour temperature and brightness levels. These findings are consistent with previous research studies by Lekan-Kehinde and Asojo [13]. They have suggested that there is an improvement in academic performance by means of reading proficiency (accuracy, speed, and expression) which has been subjected to high colour light temperature. Additionally, this study has shown that good lighting circumstances have a positive impact on productivity and job completion, as well as emotional and biological effects [8].

The findings also suggest that the respondents generally felt somewhat comfortable in the classroom studio under different lighting conditions, particularly in the high colour temperature condition where the highest number of respondents felt somewhat comfortable collaborating with their peers. This finding was consistent with some previous study findings, for example, Fostervold and Nersveen [27] examined the effects of light in workplaces on workers' productivity and health. The study found that people who were working in conditions that had high colour temperatures (5000K) were reported being more attentive and were much more successful at cognitive activities than people who worked in surroundings that had lower colour temperatures (3000K). Additionally, a study by Figueiro *et al*. [28] found that higher correlated colour temperature (CCT) sources of light improved cognitive performance in individuals with Alzheimer's disease.

The majority of respondents rarely felt distracted by external factors, particularly in the high colour temperature condition where the highest number of respondents reported rarely feeling distracted. The findings by Pulay *et al*. [29] stated that in an office or lab environment, higher levels of correlated colour temperature (CCT) lighting affect the productivity of employees. Additionally, the results established a link between the CCT of the lighting systems and students' behaviour while on task in an elementary school setting, concluding that a greater number of male pupils physically shifted within the learning environment with higher the CCT of the lighting.

In terms of motivation and efficiency, the highest number of respondents felt somewhat motivated and efficient in the high colour temperature condition, while the lowest number of respondents felt very motivated and efficient in the low colour temperature condition. The finding was in line with the study of Kocaoğlu [30], the proper use of correlated colour temperature in an indoor space can benefit the inhabitants by boosting motivation, enhancing health, and supporting cognitive functions. The

presence of psychologically and visually comfortable conditions, which are both facilitated by the quantity and quality of light, affirms users' well-being and heightens their desire to work harder and generate better results [31]. The lighting conditions can be improved to increase the sense of space; support and motivate the learners' learning habits, and simultaneously make the learning setting a more pleasant and appealing place [32].

5. Conclusions

The results of this study posit that the lighting condition in a classroom studio can have a significant impact on students' comfort, collaboration, motivation, productivity, distraction, and fatigue levels. The majority of respondents expressed a preference for high colour temperatures and brightness levels, associating them with a sense of spaciousness and comfort. On the other hand, low colour temperatures and low illumination levels were linked to feelings of cramping, fatigue, and distraction. By examining demographic factors, such as age, gender, and educational background, it is understood how different groups of students may perceive and interact with the lighting environment.

Furthermore, the frequency analysis of spatial quality with three different colour temperatures provides valuable insights into the variations in perceived spaciousness under different lighting conditions. The results suggest that a higher colour temperature, accompanied by ample natural light, contributes to a greater sense of spaciousness in the classroom studio. In terms of social adaptation, the frequency analysis reveals how students' collaboration and ease of working with peers are influenced by the lighting conditions. It was found that a high colour temperature condition is associated with a higher level of comfort and ease in collaborating with peers, while a low colour temperature condition may lead to more difficulties and discomfort in social interactions.

Based on these comprehensive findings, it is recommended that educational spaces be designed with lighting systems that provide abundant natural light, high colour temperatures, and appropriate brightness levels. By creating a comfortable and efficient atmosphere for learning, students' motivation, teamwork, and productivity can be positively influenced. It is important to acknowledge that individuals' preferences and environmental factors may influence the impact of lighting conditions on students' experiences. Therefore, when developing lighting systems in classroom studios, it is crucial to consider the diverse preferences of students and regularly seek their feedback to ensure that the lighting continues to meet their needs and preferences.

In conclusion, this study emphasizes the significance of lighting in educational spaces and highlights the importance of considering various indicators, such as demographic details and frequency analyses of spatial quality and social adaptation. By incorporating these findings into the design and evaluation processes, educational institutions can create optimal lighting environments that promote students' well-being, engagement, and academic success.

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