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# How Does The Interior Design of Learning Spaces Impact The Students` Health, Behavior, and Performance?

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**Abstract:** The importance of research: human beings are greatly affected by their surroundings, especially in learning spaces. Lighting, colors, seating arrangement, and other factors all have a physical and psychological impact on students, which is reflected in their behavior, and performance.

**Research problem:** Although there have been previous studies that have linked a student's behavior to the interior design elements of the learning space, there is no extensive, combined study that can guide the design of university educational spaces to achieve the highest possible efficiency for the students.

**Research Objective:** Set criteria to assess the learning space; this standard states whether or not a learning space can provide an appropriate learning environment that can help students physically and psychologically.

**Research methodology:** (theoretical approach) relied on a review of previous theoretical and practical studies to gather sufficient information to determine the criteria for evaluating each element of the educational space and how it impacts students, this is shown by presenting definitions of human behavior and how it is influenced by the built environment, and then used to illustrate how the interior architectural design of the educational space impact students, reaching the ideal status for each element in the final table. (analytical approach) in which a questionnaire was conducted for students as a field study and then analyzed for results.

Results showed that many existing educational spaces have problems with interior design elements. Some of these problems, such as lighting, ventilation, and temperature, can be avoided from the beginning by orienting educational spaces correctly and thus obtaining adequate natural lighting, ventilation, and temperature without having to rely on industrial means. Noise can also be reduced if a suitable location away from the noise is chosen, as well as careful selection of finishing materials of sound insulation material. Table 8 shows additional means of isolation that can be used in existing spaces. On the other hand, the color of the white wall, which many studies have confirmed harms the space users of students and teachers but is still used, is a problem that is easily avoidable but still recurring. It is preferable to use cold or warm colors instead, as shown in Table 8. The significance of this research is in assisting in the creation of a suitable educational space that meets the needs of students while avoiding all of the problems mentioned above in many educational settings.

**Keywords:** Learning Environment, Students Behavior, Classroom Setting.

## I. INTRODUCTION

Understanding the mutual relationship between people and their surroundings is a major concern of behavioral sciences because human behaviors, attitudes, and values are important in creating enabling environments for people's diverse needs.

As a result, architects bear a great deal of responsibility for designing buildings that can communicate with their users and meet their needs. [1].

One of the most important aspects of the educational process is the interaction between students and their environment. This behavior is a reflection of environmental effects. The university environment is one of the most significant influences on students' behavior, achievement, and study habits. A student who finds what helps him commit in his university setting, whether from psychological or physical comfort in the place where he receives science and spends the majority of his time, was found to be psychologically and socially compatible and motivated to achieve. While the opposite happens when the university environment is poor and full of frustration and threats [44].

The definitions of human behavior and how it is influenced by the built environment, as well as environmental psychology, will be presented to demonstrate the extent to which the interior architectural design of educational spaces in universities affects student behavior and performance by presenting design considerations of the educational space and discussing its psychological, physical, and behavioral impact on students. To develop a mechanism for evaluating educational spaces in terms of:

1) Its positive and negative impact on their behavior, interaction, and academic performance.

2) Know the optimal alternatives for each interior design element in the educational space to provide the optimal environment for students to reach their maximum potential.

## II. HUMAN BEHAVIOR

### A. concept of human behavior

Human behaviour is defined as "the glandular and motor responses of the organism's muscles or glands in its body. It, therefore, consists of the multiple activities that any person performs in his daily life so that he can meet his basic needs".

Human behavior is even innate or learned behavior. Innate behavior is a behavior that a person has from birth without the need to learn, or train, while learned behavior needs learning and training in different skills, like reading [45]. Another classification in terms of relationships is individual behavior, group behavior, and social behavior. Individual behavior means the interaction of the individual with his environment which reflects his personality and demonstrates the impact of his traditions, culture, and experience. On the other hand,

group behavior results from the interaction between group members who have a common thing, to act or express themselves in a particular way. Thus, the main driving force of it is the culture of this society, which gives the individual a sense of belonging. When individuals or groups conduct various activities in the environment it is called social behavior [45].

### B. General effects of human behavior

#### Basic needs that constitute human behavior

Needs can be defined as “An organism's urgent desire for something that it lacks and cannot live without, causing it to experience constant muscular and psychological stress until it responds to this desire” [46]. One of the most appropriate frameworks for analyzing humanitarian needs is Maslow's theory of humanitarian needs, which states that basic needs at the lower level must be satisfied first, and then the other needs at higher levels. These needs as shown in “Fig. 1” are physiological, the need to feel safe, the need for belonging and forming relationships (social needs), the need for a sense of appreciation and respect (self-esteem), and the need for self-realization [48].

### Motives affecting human behavior

Motives can be defined as the force behind behavior. Motivation is the alarm or the excitement that drives a human's desire to satisfy his need, whether it is primary physiological or secondary needs acquired [46]. Motives affecting human behavior are explained in “Fig. 2,” below.

#### Human nature

Human nature is influenced by human habits, traditions, and values. It is also affected by the surrounding environment and appears clearly by noticing that one's behavior varies depending on the environment and cultural and social factors. Therefore, factors that affect human behavior are physiological characteristics and physical abilities, Personality, society to which an individual belongs, cultural background, and Physical environment [45].

### C. Behavioral domains of human interaction with the environment

Some studies have identified human interaction with the surrounding environment within three behavioral domains through Knowing and feeling something and then acting in its direction by a particular act, which the apparent and underlying patterns of behavior, and these domains are: [48]

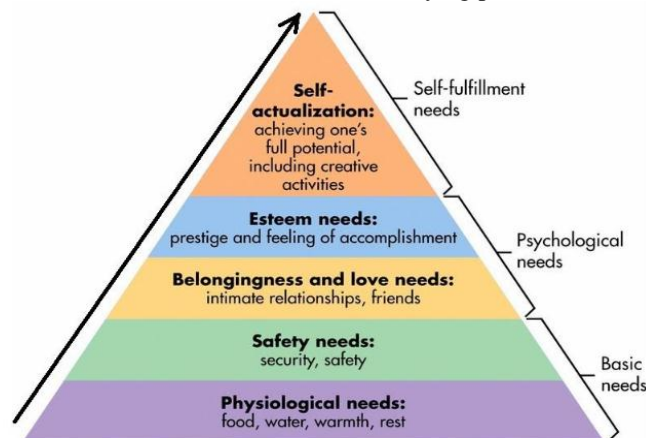


Figure 1: Maslow's theory of the inclusion of humanitarian needs [48].

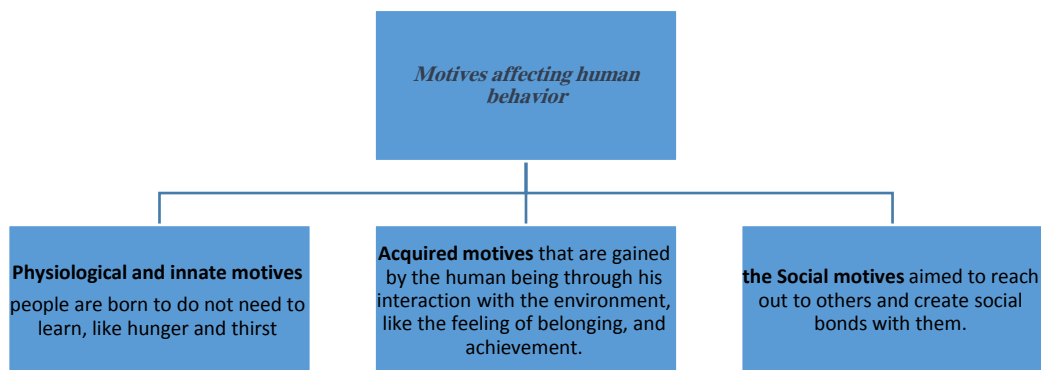


Figure 2 - Motives affecting human behavior [54].

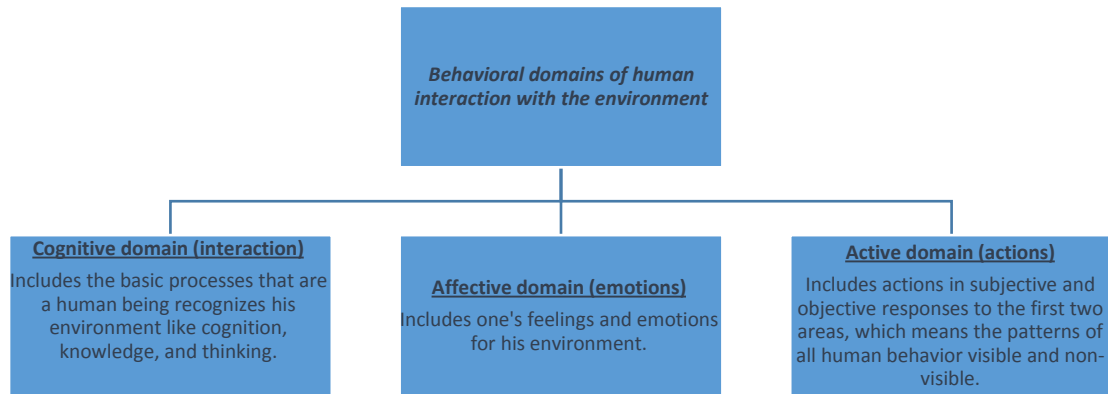


Figure 3-Behavioral domains of human interaction with the environment [48].

#### D. Research approaches the study of human behavior in the environment

In behavioral sciences, a key goal is to comprehend how people and their environment interact, which has raised many questions. Many studies have attempted to explain this relationship, and many theories have evolved, one of the most well-known and also most appropriate for the study of this paper is environmental psychology. Environmental psychology studies space and its relationship to human behavior, individual understanding of spaces, individual expectations and activities in the space, and the impact of spaces on those expectations and experiences. It is interested in studying human behavior in the environment, as well as the relationship of human behavior to environmental factors such as light, air, and temperature, as well as spatial, temporal, and audiovisual dimensions, such as studying the impact of space dimensions on individuals' behavior toward others in the environment [47]. To conclude, Lang defined environmental psychology as "the psychological study of behavior that is also related to the physical environment of everyday life" [2].

#### III. Learning environments effect on students

The learning environment is the physical space set aside for learning and teaching, and it is an essential factor in ensuring effectiveness and improving learning outcomes. A good learning environment can encourage intellectual activities, idea generation, friendship, cooperation, as well as learning, growth, and personal development. Numerous studies have found a link between the learning environment and student achievement, satisfaction, comfort, health, and enjoyment. As a result, the learning environment in the classroom should be well designed for students to learn comfortably, actively collect learning information, and gain appropriate experiences [3].

#### A. University learning space interior design standards and their impact on students:

It includes all aspects of the learning space's interior design. When designing an educational space, many factors must be considered as "Fig. 4," shows. The following are the design

elements for university educational spaces, explaining how each one affects student behavior, health, and performance:

##### A.1. Size of the learning space

Class size is an educational tool that describes the average number of students in each educational space [4]. The average amount of educational space per person is 1.5 to 2 square meters. The number of students should be appropriate for the space size in terms of vision, sound, ventilation, and other factors that are going to be discussed in detail later. The detailed dimensions and arrangement should also be appropriate for the space's size [47].

To sum up, smaller classes are better than larger ones for many reasons, but a small class isn't necessarily mean a small size or area, it usually means a small number of students, or to be the more specific appropriate number of students according to the activity they do like architecture

Another important element is ceiling height; it influences the sense of intimacy and protection, determining the degree of comfort or distress and contraction. Studies showed that there is a correlation between the small size of the educational space and the generation of positive behavior, satisfaction, and self-fulfillment, and supports the use of design methods that encourage the formation of small educational groups, through their suitability for educational activities [47]. (Table 1) shows a comparison between small and large classes and their effect on students.

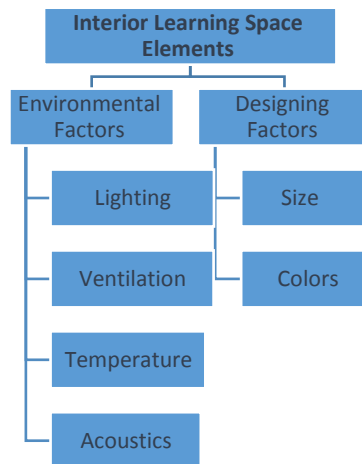
Study, for example, the class size, the teacher and his interaction with students. In the end, the goal is positive attitudes, perceptions, and human relationships among students themselves and them and their teachers, with improved students 'performance and learning behavior.

##### A.2 Color

Colors are one of the most important elements of the physical learning environment, not only as a decoration but also have a significant impact on mood and behavior [11]. Color also affects emotions and physiology, causing mood swings and performance. In addition, color has physical, psychological, and social impacts on human life [12].

**Table 1 : comparison between small and large classes and their effect on students.**

Small class sizes	Large class sizes
<p><u>(advantages)</u></p> <ul style="list-style-type: none"> <li>Smaller classes help students develop positive attitudes, perceptions, and interpersonal relationships. They can perform better as group members and leaders; they also learn basic skills more effectively, and quickly. They can think more creatively and divergently, and as a result, they can achieve higher attendance and lower rates of absence. Students in small classes have closer relationships, develop a better understanding, and identify with their classmates and their teachers [5], [6].</li> <li>Teachers in small classes are more likely to give students individual attention, effectively control and manage the classroom, and build stronger relationships with students. Similarly, students in small classes are more likely to be engaged in classroom activities and to interact with teachers and peers [7], [8], [9].</li> <li>Students in small classes exhibit less disruptive behavior than students in large classes. Smaller classes improved students' performance and learning behavior while also resulting in fewer classroom disruptions and discipline issues, as class size has a significant impact on students' cognitive skills in the classroom [4], [7].</li> </ul> <p><u>(disadvantages)</u></p> <ul style="list-style-type: none"> <li>Reduced class size creates a resource issue because it requires more teachers and classrooms, implying that more education funding is required [7].</li> </ul>	<p><u>(disadvantages)</u></p> <ul style="list-style-type: none"> <li>In overcrowded classrooms, respiratory diseases and other infectious illnesses are easily transmitted. An overcrowded environment reduces the quality of air that people breathe by limiting the availability of oxygen, which harms people's health [5].</li> <li>Overcrowding harmed both classroom activities and instructional techniques, according to students and teachers in overcrowded classes. Students learn at various rates and in various ways. In a large class, the teacher could not devote the time that students might require for extra assistance [4], [5].</li> <li>The most common behavioral attitude associated with large classes is excessive noise [4], [10].</li> <li>High density has a direct behavioral impact on students due to a lack of privacy, which hinders their ability and desires to learn. A high student density can increase aggression, hostility, movement, and distraction, resulting in lower academic achievement [7].</li> </ul>

**Figure 4. Interior learning space elements that effect students in universities [source: researcher]**

### *Psychological and physiological responses to color*

Color evokes both physiological and emotional psychological responses. Physiological studies have revealed changes in blood pressure, eye strain, and brain development. It could also stimulate the autonomic nervous system, as bright warm colors do, or slow it down, as soft cool colors do. When exposed to red, for example, the heart beats faster, blood pressure rises, and the sense of smell becomes more acute. In contrast, blue causes a slower pulse rate and a lower body temperature. Color-related psychological responses include changes in mood and attention. It may also affect productivity and accuracy, which affect academic performance. When color is transmitted through the eyes, the brain releases a hormone that affects mood, mental clarity, and energy level [11].

### *Color and educational spaces*

Colors act as decipherable codes for the brain, assisting in organizing the images for visual perception. When selecting colors for educational settings, functional factors take precedence over aesthetics. Color overstimulation causes sensory overload. Colorless interiors, on the other hand, can be stressful and unproductive. In other words, an under stimulating environment can be just as harmful as an overstimulating one. The chromatic project should serve two functions: providing visual comfort, promoting belonging, and aiding learning. The feeling of belonging conveys the comfort and peace required for learning [13]. The findings in determining the best color combinations for learning environments are inconclusive. And so, the information in (table 2) is meant to provide a functional guideline with an explanation of the colors' different effects on students in the classroom.

**Table 2. Colors and its effect on students in the learning environments**

Classification	Common examples	Its psychological effect on students	Its effect on their learning skills and tasks
Cool Colors	Green Blue Purple	<p><i>Positive effects</i></p> <ul style="list-style-type: none"> <li>Encourage internalization and relaxation [13].</li> <li>Enhance a more peaceful environment [14].</li> <li>Linked with openness and freedom [15].</li> <li>Green is the most restful for the eye [11].</li> <li>Blue can help calm and assist students who are hyperactive [11].</li> </ul>	<ul style="list-style-type: none"> <li>Can activate a promotion focus to encourage people to achieve positive outcomes, thus enhancing creative tasks especially blue [15], [16].</li> <li>Cool colored spaces had a more positive effect on the "individual productivities" and "social adaptation" than warm colors [16].</li> <li>Classrooms painted light blue, yellow, yellow-green, and orange increased IQ levels while stimulating alertness and creativity in children [17].</li> </ul>
Warm Colors	Orange Yellow Red	<p><i>Positive effects</i></p> <ul style="list-style-type: none"> <li>Stimulate and boost brain activity, resulting in excitement [13].</li> <li>The color yellow stimulates the nervous system and represents energy, intelligence, and expansiveness. It also refers to happiness, spontaneity, action, strength, and dynamism [11].</li> <li>Orange represents the qualities of creativity, luminosity, extroversion, as well as being lively and energetic, all of which are associated with child activity [11].</li> </ul> <p><i>Negative effects</i></p> <ul style="list-style-type: none"> <li>As mentioned in [14], red affected aggression.</li> </ul>	<ul style="list-style-type: none"> <li>It has been identified as the ideal color for increasing learners' attention and color aging active participation in activities [15].</li> <li>Better at tasks that necessarily require people's complete attention, like memorizing important information [16].</li> <li>Children's IQ levels were found to rise in classrooms painted light blue, yellow, yellow-green, and orange, while also stimulating alertness and creativity [17].</li> </ul>
Monotonous	Grey white	<p><i>Negative effects</i></p> <ul style="list-style-type: none"> <li>Resulting in exhaustion and boredom [13].</li> <li>Increased student irritability and difficulty concentrating. Both of these symptoms were found to be detrimental to learning promotion [18]</li> </ul>	<ul style="list-style-type: none"> <li>It is rated lower than areas painted in warm and cool colors in terms of "social adaption" and "individual productivities." [16].</li> <li>The use of white paint on classroom walls, due to its high light reflectance value, causes pupil constriction and distracts vision [18].</li> </ul>

To sum up, depending on the nature of the task, different colors may be advantageous. It varies according to several factors such as gender, age, and personal characteristics. This was evident in the preference for cool colors for active children as opposed to warm colors for inactive children. However, cool colors are generally preferable to warm colors; it was discovered that cool-colored walls are more motivating, provide concentration, are calm, helpful, and are more open to creativity than others. Furthermore, cool and warm colors are far superior to neutrals. Finally, the long-held belief that school environments should be painted white is no longer valid because white is known to have non-stimulating effects on students.

### A.3 Lighting

Light has a much higher impact on the environment than other elements. Understanding how light interacts with its surroundings can help interior designers or architects improve their designs for better performance [19]. Lighting is crucial in our daily lives for optimal functioning in any setting. As a result, illumination has a direct impact on every aspect on human life. Tanner stated, "Light is the most important environmental input, after food and water, in controlling bodily functions" [20].

#### *Reasons that natural light is better when comparing the two types of lighting*

Although the two types of lighting are combined to provide adequate lighting to perform various activities in architectural spaces when comparing them, it was discovered that in places like educational spaces, it is preferable to rely on natural lighting because of the

psychological and physiological benefits it provides to students over artificial lighting, and to use artificial lighting only when necessary. Several studies back this up:

- [21] mentioned that in well-designed interior zones, daylight improves visual quality and mental health benefits that are expensive and difficult to replicate with artificial lighting, it also added that Sunlight appears to be the best lighting source for schools because it provides an adequate quantity and spectrum of light as well as the proper timing and duration of light exposure.
- According to [22], people who work in natural sunlight are more productive, effective, and happy than those who work in traditional artificial light.

#### *Natural Light in learning spaces*

Natural light is an effective way to create a good and healthy visual environment, as well as a significant factor for luminous comfort, especially in educational buildings, the effect of daylight on students' perceptions, and the quality of daylighting in those spaces, have been studied for many years [23]. Various studies have shown that adequate daylight in a classroom is necessary because it has a positive effect on students' learning performance, alertness, cognitive skills, behavior, mood, circadian rhythm, vocal strength, and productivity [21]. (Table 3) will explain in more detail how natural light affects students' health, behavior, and performance.

- Natural Light recommendations for educational spaces: Various standards and guidelines are introduced to ensure adequate daylight for designing a good learning space; some of these guidelines are as follows:

**Table 3: physical and psychological effects of lighting on students.**

	Natural light effect on human health	Natural light effect on students` behavior, performance, and health
Physical effect	Natural light influences circadian rhythm, which is responsible for synchronizing the human body's internal clock. It is also responsible for many cognitive processes, including attention, alertness, mood, executive functions, and memory [21].	These cognitive processes are key ingredients in the learning processes [21]. Its implicit effects on learning and achievement in the classroom cannot be ignored [20].
	Natural light interacts with our skin and produces vitamin D through photosynthesis. Calcium absorption is aided by vitamin D, which strengthens our bones [21].	Underexposure to sunlight causes vitamin D deficiency, which can cause a range of illnesses and have an impact on student's health [21], [24].
	Through our visual system, light can influence our metabolism, endocrine, and hormonal systems [21].	Several studies have been conducted to investigate how the quality and color of lighting can affect students' visual skills and, as a result, academic performance. Visual impairments on their own can lead to behavioral issues in students, as well as decreased concentration and motivation in the classroom [20].
	(negative effect) Insufficient illuminance, flickering lights, and the absence of lighting controls in buildings can cause health problems such as eye strain, headaches, increased body temperature, and so on [25], [19]. Excessive light and luminance contrasts, on the other hand, can cause glare, which can cause eye strain and blurred and poor vision [23], [25].	Poor light spectral quality in the classroom can strain students' eyes, reduce information processing and learning ability, and increase stress levels among students. [23], [21].
Psychologically effect	Lighting can cause certain psychological behaviors, such as mood swings. Aside from emotional and biological effects, lighting conditions have been shown in studies to improve task completion speed and accuracy, as well as occupant productivity [25].	Good lighting in learning environments improves student performance. Evidence suggests that appropriate lighting quality can enhance productivity and performance, reduce eyestrain and fatigue, and improve an organization's chances of success [19].
	The presence of sunlight improves mental performance while decreasing aggressive behavior. Access to natural light and fresh air systems has been shown in [25], studies to improve health, comfort, and productivity.	The Hescong Mahone Group conducted research that discovered a link between daylight and student academic performance. It is widely acknowledged that good lighting improves student comfort, and that comfort frequently translates into higher grades, improved performance, and increased concentration [25].
	Natural light is an effective way to create a good and healthy visual environment, as well as a significant factor for luminous comfort. Additionally, daylighting is associated with emotional comfort and the perceived quality of space. [23], [26].	Visual comfort, as measured by the quantitative and qualitative aspects of natural daylight, contributes significantly to pupil well-being and, as a result, improves school performance [21].
	Natural changes in daylight balance the body's circadian rhythm, which controls sleep and eating patterns, cognitive processes like attention, concentration, memory, heart rate, hormone levels, and nearly all physiological and behavioral parameters [22], [25].	These cognitive processes are key ingredients in the learning processes [21].
	The natural healing effect of daylighting is the provision of a view of the outside world. Daylighting can improve occupants' moods by increasing their connection to nature [21].	As a result of this disconnect from the outside classroom environment, students are psychologically suffocated. The visual environment influences a learner's ability to observe visual stimuli, as well as his mental manner and, ultimately, performance [19].

- For an adequate amount of distributed light to be distributed appropriately and systematically, the longitudinal direction of this separation must be in a direction confined between 22.5C east or west of the north direction [58]. Also, using light-colored ceilings to reduce the intensity of lighting near the openings, improves the distribution of variability in the classroom [49].
- Many research studies suggest that the illuminance of classrooms should be 300 lx or higher at any point on the work surface for appropriate lighting and visual comfort [24].
- The size of the classroom windows: the optimal opening dimensions are determined by the amount of natural lighting and ventilation required in the interior space. Based on a study of the surfaces needed to provide the necessary natural lighting levels in the classroom, the minimum surfaces of the openings required are equal to 15% of the class area. Table 4 shows the proposed distribution of openings in external walls based on

geographical orientation to provide the best thermal behavior of the separation [49].

**Table 4: The size of the classroom windows according to orientation [49].**

Orientation	Area of the windows / Area of the classroom	Area of the windows m2	Window`s dimensions m2	Sun breakers
N	18%	9.2	1.2*7.6	Horizontal sun breaker
NE				Combined sun breaker
E	15%	7.65	1.2*6.5	Movable sun breaker
SE				Combined sun breaker
NW S	12%	6.2	1.2*5.2	Horizontal sun breaker
W				Vertical sun breaker
SW	10%	5.1	1*5.1	Movable/combin ed sun breaker

**Table 5: Physical and psychological effects of temperature on students**

	Temperature effect on human health	Temperature effect on students' behavior, performance, and health
Physical effect	(negative effect). High temperature can cause an increase in the concentration of carbon dioxide (CO <sub>2</sub> ) in the blood, which can cause headaches, it may also cause difficulty concentrating and thinking, which can have a direct negative effect on cognitive performance [30].	Warmer temperatures (above 24 C) tended to reduce students' performance [28].  Elevated temperatures in classrooms reduce students' ability to perform typical school tasks [30].
Psychological effect	(negative effect). Thermal discomfort sensations caused by cold or heat stress divert attention, and physiological responses to heat stress and thus decrease motivation to exert effort [30].	Thermally uncomfortable classrooms, whether too hot or too cold, can cause physical stress (thermal stress), resulting in illnesses and poor student performance [31].

To sum up, light is a significant enhancer of visual performance, regulates a variety of physical functions such as sleep and alertness, is essential for cognition and mood, aids in the production of important hormones, and is required for a healthy rest-activity cycle. Sunlight appears to be the best lighting source for schools because it provides an adequate quantity and spectrum of light as well as the proper timing and duration of light exposure, blue-cool daylight has the greatest influence in almost every aspect, so it is recommended to rely on natural lighting and to use artificial lighting only when necessary.

#### A.4. Thermal comfort

Thermal comfort can be defined as "that state of mind that expresses satisfaction with the thermal environment [27]. It is determined in detail by several factors, including thermal environments, personal factors, and other contributing factors [28]. In this section, the temperature and ventilation will be explained in more detail as the main factors affecting thermal comfort.

##### A.4.1 Temperature

The body generates and loses heat in a variety of ways. The body is in thermal equilibrium when the amount of heat gained equals the amount of heat lost. When one exceeds the other, the pressure on the thermostat to maintain a constant temperature rises, as does the feeling of thermal discomfort. Temperature is the primary and direct effect of a sense of comfort or heat stress, and while there are other effects, they all revolve around air temperature [44]. Factors such as building orientation and shading influence indoor temperature [29].

##### Temperature and educational spaces

Maintaining an appropriate temperature level in the learning environment is critical for a student's successful performance. Temperature, according to studies, affects mood, way of thinking, and ability to learn, and thus productive and behavioral capacity, and appear clearly in thoughts and

behavior. Table 5 depicts the physical and psychological effects of temperature on students [44].

To sum up, it is important to keep the temperature in the standard range, too high or too cold temperature cause many negative effects on students' performance as explained. To achieve that and have good thermal comfort, exposed surfaces should be protected by vegetation, shades, and fins, along with other treatments like shading with sun breakers or using artificial ventilation.

##### A.4.2 Ventilation

Air ventilation systems, whether natural or mechanical, can improve classroom comfort [31]. Using a natural ventilation strategy in learning spaces outperforms industrial ventilation in terms of CO<sub>2</sub> concentration [44]. It is also a significant way out of the energy crisis in educational settings, where students spend the majority of their time during the school day [44]. For students' safety and well-being, the minimum ventilation fresh air supply rate is 8 L/s (17 cfm) per occupant for moderate indoor air quality and 12.5 L/s (29 cfm) per occupant for medium indoor air quality [32]. (Table 6) below summarizes the physical and psychological effects of ventilation on students.

To sum up, natural ventilation and cooling are critical in decreasing extreme temperatures, but if it doesn't provide adequate ventilation, it is preferable to use artificial ventilation. In addition to lowering student performance, poor ventilation causes many health problems. As a result, it is essential to ensure that the ventilation rate is within standard limits to have a positive effect on students in all aspects. Employing proper building materials and passive techniques are some suggestions to do this.

##### A.5. Acoustic environment

Noise refers to sounds that impede an individual's ability to listen to what they want or need [38], so noise control is a critical problem for interior designers

##### The Factors affecting the acoustic environment

Many acoustic issues may emerge as a result of reflected noises. These issues are controlled and addressed differently depending on the type of use. The absorbability of ore varies, as does the extent to which it reflects the noises on which it falls. Many factors influence the impact of noise on users, like noise exposure time, sound intensity, the distance between sound and hearing source, and sudden sound [53].

##### Acoustic and educational spaces

Acoustics is one of the aspects that has the greatest influence on student learning performance. It can disrupt communication owing to a variety of undesirable situations. Acoustic problems necessitate more effortful listening, which may lead to lower student performance. Various outdoor and indoor sound sources may affect students' learning processes, listening, behavior, and interpersonal communication [39]. Noise in the classroom can come from external sources such as background noise or directly from students as activity noises.



**Table 6: psychological and physiological responses to ventilation**

	Ventilation effect on human health	Ventilation effect on students` behavior ,performance ,and health
Physical effect	(positive effect) Clean air is regarded as a basic requirement for subjective well-being and mental health [33].	<ul style="list-style-type: none"> <li>• A good ventilation environment is essential for the health of the occupants, particularly students who tend to congregate for learning purposes. Many infectious diseases, including COVID-19 pneumonia and SARS, are spread through air and droplets. As a result, adequate airflow and high air change efficiency may dilute virus concentrations in the air, preventing indoor cross-infection [34].</li> <li>• The increased ventilation rate could significantly improve students' learning efficiency [34].</li> </ul>
	(negative effect). A contaminated environment can cause health problems and symptoms such as coughing, headache, fatigue, and nose irritation, dizziness, and others. When exposed for an extended period, the health effects can be more damaging (cancer, neurological, and chronic lung diseases) [33], [35].	Coughing, sore throats, burning eyes, and boredom were reported among students in classrooms. These issues were more prevalent in students who had a history of respiratory disease, asthma, or allergies. Sleepiness has the greatest impact on student performance [33].
Psychologically effect	(positive effect) Clean air is regarded as a basic requirement for subjective well-being and mental health [33].	<ul style="list-style-type: none"> <li>• Improvements in neurobehavioral symptoms (alertness, attention, tiredness) and work mood were reported when ventilation was improved [35].</li> <li>• The IEQ can influence users' task performance, communication and social interaction, mood, as well as their health and safety at school [36].</li> </ul>
	(negative effect). They observed that at levels of 3,000 ppmv of metabolically generated CO <sub>2</sub> , the diastolic blood pressure increased and the cognitive responses decreased. Also, loss of concentration and well-being due to CO <sub>2</sub> exposures in the range between 3000-5000 ppm may be expected [37].	<ul style="list-style-type: none"> <li>• Individual psychological suffering Students in the classroom reported a lack of motivation, anxiety, and stress [33].</li> <li>• Higher CO<sub>2</sub> concentrations in the classroom were linked to lower student cognitive performance [37].</li> </ul>

**Table 7: physical and psychological effects of noise on students.**

	Noise effect on human health	Noise effect on students` behavior ,performance ,and health
Physical effect	<p>(negative effect).</p> <ul style="list-style-type: none"> <li>• Affects human physical health, reduces activity, and leads to anxiety, internal discomfort, stress, confusion, and inconsistency resulting in a deterioration of his mental state, which leads to a lower level of performance [44].</li> <li>• According to WHO, noise can have several effects on an individual's health and well-being, including annoyance, hearing loss, sleep disruption, interference with communication, and communication effects [40]</li> <li>• In the context of a noisy room, the following negative effects were reported: easily becoming weary, resulting in poorer efficiency; elevated heart rate; dyspepsia; poor appetite; insomnia; headache; tinnitus; and facial pallor [38].</li> </ul>	<ul style="list-style-type: none"> <li>• Noise significantly affects students' acceptance and understanding of the scientific materials they receive. They become less focused, exhausted, and feel dizzy due to the nervous system's intolerance and actual abilities to work in a noisy atmosphere that affects their attainment and performance in the educational space. A study of comments by university students exposed to noise showed that they had a lack of brain activity, resulting in low absorptive capacity and poor vision, high adrenaline in the blood, and low blood sugar at the end of the school day, which is explained by the fact that the body takes a defense against the noise effect [44].</li> <li>• According to studies, noise can cause cardiovascular, pulmonary, and gastrointestinal difficulties in the long run [38].</li> <li>• Noise not only has a detrimental impact on learning capacities, but it also has implications for their psyche and performance since it increases exhaustion and is a cause of focus loss owing to disruptions in the regular sleep cycle [41].</li> </ul>
Psychological effect	<p>(negative effect).</p> <ul style="list-style-type: none"> <li>• Affects human behavior and affects human reactions to others and their relationship with them, as noise affects their communication with others and increases the burden on them to receive and send the subject to which he speaks or listens [44].</li> <li>• High noise levels, among other stressors, can irritate, incite aggression, impair the physical and mental performance, and cause discomfort and headaches [42]. Furthermore, noise has been linked to stress-related mental health characteristics [40], [42].</li> </ul>	<ul style="list-style-type: none"> <li>• Noise is harmful to human health; it is one of the primary causes of decreased performance motivation, concentration, and distraction, resulting in inconvenience and distress and, as a result, less productivity; one second of noise exposure has been shown to reduce concentration for 30 seconds [44].</li> <li>• According to WHO's Community Noise Guidelines, noise pollution interferes with spoken communication, affects comprehension, and impairs task performance [43].</li> </ul>

Background noise might come from outside (traffic noise, noises in hallways, noises from the playground) or the inside (passive noise from equipment such as heating, air-

conditioning, and technological devices) [39]. (Table 7) shows the physical and psychological effects of noise on students.

### Acoustic Standards for learning spaces

According to the limits of permissible noise levels in indoor educational settings, and by the Executive Regulation for Environmental Protection Environmental Affairs – the Arab Republic of Egypt, the recommended noise level in the places of study is between 30 and 35 decibels. dB (AA) is a noise intensity measurement unit to which the human ear is exposed and calculates the difference between the sound pressure to be measured and the low sound pressure that the human ear can hear, as determined by the measurement device conforming to international standard 170111. ISO [44].

### Noise control factors in educational settings

Among the design acoustic processors that an architect or interior designer can perform in some of the internal spaces, whether through the sound insulation system or other elements, in learning spaces, designers can do the following processes to ensure good sound access for the educational process: [44]

- The use of various insulation methods, such as using insulating materials in walls to insulate and absorb sound released or inland for the educational space [44].
- When the space size is large enough for angle echo events, scattered or absorbent surfaces on walls or inward-facing corners are required [44].
- Design the openings in such a way that provides natural lighting through glass windows while preventing any entry or departure of any sound from the educational space [44].
- Increase the distance between the noise source and the building by placing rooms that are not functionally affected by noise, like service rooms, on the side of the building near the noise source, like the street, while protecting noise-affected spaces such as educational spaces [44].

To sum up, acoustics is one of the most critical elements in the learning space that affect students. Noise can harm students' health, affecting their behavior and performance. So, it is essential to make sure that noise levels are within the recommended range, and to do that, many noise control factors can be used as explained.

## IV. CRITERIA TO ASSESS LEARNING SPACE

Table 8 depicts a criterion for evaluating learning spaces based on their elements. It explains each element in the following order: its optimal alternative and the reasoning behind selecting it based on its impact on students, factors, and other space elements related to its performance, and finally, some solutions if the optimal alternative is not achieved. Using this mechanism for evaluating learning spaces aims to provide students with the best possible learning environment, both psychologically and physically, allowing them to reach their full potential in this learning space.

## V. CRITICAL STUDY

### A. Participants, Method, and Instrumentation

This study uses a quantitative research design. A total of 70 Form students were selected randomly as respondents from different architecture years in the architecture department in

the Faculty of Engineering in Tanta, Egypt. One of the learning spaces, in the architecture department, was chosen for the study. Students' perception of physical aspects and their effect on them were measured using the different physical elements, which are: the size of the space, its seating arrangement, its wall colors, lighting, ventilation, temperature, and acoustics. These elements measured the suitability of the physical classroom environment for students by a questionnaire. The questionnaire questions were generated as a result of the literature review in this research paper, there were seven sections with a total of thirty-eight questions with multiple choice, and a few questions asked for students' suggestions for making their learning environment better for them according to their experience. "chart 1," showed the student's opinion about the learning space elements and their applications to the standard requirement.

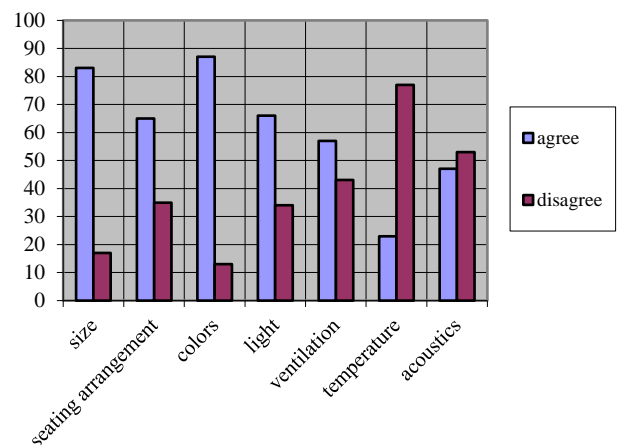


Chart 1: The extent to which elements of the educational space adhere to standard requirements and provide comfort for students in their point of view.

### B. Discussion

The primary goals of the present study were to investigate the impact of different elements of learning space on students' health, behavior, and performance. Results showed that in terms of the size of the learning space, most students (83%) feel it suitable and comfortable for them, and 73% of them found that students number is good for the space area. Student also say that the seating arrangement which is row and column is suitable for the space size and their architecture study in it with a percentage of 65%. Also, 67% of students agreed that furniture dimensions are appropriate while the rest says otherwise.

While the researchers mentioned that the off-white color of the learning space is supposed to have negative effects on them, they seem to get used to it, and it no longer bothers them, or so they believe. However, when asked if they prefer to keep it or change it to a cool or warm color, only 14 percent chose to keep it, while the majority decided to change it. Their opinions varied between cool and warm colors, with 47% preferring cool colors like light blue or green because it helps them concentrate and study, and the remaining 39% choosing warm colors because it makes them feel warm and active.

<p>performance</p>	<p>An appropriate number of students in the space according to its size with considering the other elements of the space.</p>	<p>-----</p>	<p>If the required light intensity cannot be achieved by natural light only, then industrial light could be used to provide the required light intensity in the space.</p>
<p>Seating arrangement</p>	<p>The area of the space and its ceiling height.</p>	<p>The three basic properties of colors are Hue, value, and saturation.</p>	<p>Colors Finishes materials (reflections)</p>
<p>Smaller classes help students develop positive attitudes, perceptions, and human relationships. They can function more effectively as group members and leaders; they also learn basic skills more effectively, and quickly</p> <p>Teachers in small classes are more likely to give students individual attention, effectively control and manage the classroom, and build stronger relationships with students.</p>	<p>It was discovered that cool-colored walls were more motivating, give concentration, calm, helpful, and open to creativity than warm or neutral-colored walls. It also Can activate a promotion focus to encourage people to achieve positive outcomes, thus enhancing creative tasks especially blue.</p> <p>Cool colored spaces had a more positive effect on the "individual productivities" and "social adaptation "than warm colors.</p>	<p>Natural Light Components (The sky component, the reflected internal component, reflected External Component) Natural light Orientation</p>	<p>Blue light effects may be viewed as a simple, non-pharmacological way to improve students' health, alertness, brain activity, vitality, and possibly academic performance. Sunlight appears to be the best lighting source for learning spaces because it provides an adequate quantity and spectrum of light, as well as the proper timing and duration of light exposure. Natural light has been shown to improve students' and workers' subjective mood, attention, cognitive performance, physical activity, sleep quality, and alertness. All of these elements could be considered critical for achieving peak academic and professional performance.</p>
<p>Smaller classes are better than larger ones, but a small class isn't necessarily mean a small size or area, it usually means a small number of students, or to be the more specific appropriate number of students according to the activity they do, the class size, and the teacher and his interaction with students.</p>	<p>Cold colors with suitable lighting and correct value of reflections for ceiling and walls.</p>	<p>Blue cold daylight with the intensity of lighting 300 lux or higher at any point on the working surface for proper lighting and visual comfort, and a direction confined between east or west 22.5C in the northern direction for a sufficient amount of appropriately and systematically distributed light.</p>	<p>Lighting</p>
<p>Size</p>	<p>colors</p>		

	Ideal Alternative	Its impact on students in the educational process (Reason to choose it)	Factors affecting the performance of this element	other elements that relate to this element's performance	suggested solutions in case the optimal alternative is not achieved
Temperature	<p>Temperature is between 20 and 27 degrees depending on the different conditions, and moisture percentage is between 40 and 60%.</p>	<p>Thermally uncomfortable classrooms due to high temperature or extreme cold can cause physical stress (heat stress) and are therefore responsible for diseases and poor student performance as temperature affects mood, mindset, learning ability, behavior balance, and therefore productive and behavioral ability</p>	<p>Body temperature is influenced by four factors: temperature, radiant temperature, humidity, and air movement. Indoor temperature is influenced by factors such as building orientation and</p>	<p>Ventilation</p>	<p>If the appropriate temperature for the space cannot be achieved by natural ventilation, several treatments can be used such as shading with sun breakers or using artificial ventilation to reach the required temperature</p>
ventilation	<ul style="list-style-type: none"> <li>Natural ventilation with an occupant ventilation rate of 8 L/s (17 cfm) for moderate indoor air quality and 12.5 L/s (29 cfm) for medium indoor air quality.</li> </ul>	<p>Natural ventilation techniques are the best way to save energy and thus save money while also contributing to environmental protection. Furthermore, the use of classrooms for natural ventilation strategy outperforms industrial ventilation in terms of CO2 concentration</p>	<ul style="list-style-type: none"> <li>Orientation.</li> <li>The design of spaced openings for air movement and ventilation within buildings.</li> </ul>	<p>Temperature</p>	<p>If the required ventilation rate cannot be achieved only by natural ventilation, then industrial ventilators are used to achieve the required ventilation rate for students in the educational space</p>
Acoustic	<p>The noise level in the places of study is between 30 and 35 decibels.</p>	<p>According to the limits of permissible noise levels in indoor educational settings, and by Executive Regulation for Environmental Protection Environmental Affairs – the Arab Republic of Egypt, the recommended noise level in the places of study is between 30 and 35 decibels.</p>	<p>factors that influence the impact of noise on users are Noise exposure time, Sound intensity, the distance between sound and hearing source, and sudden sound.</p>	<ul style="list-style-type: none"> <li>Finishes materials (reflection, isolation)</li> </ul>	<ul style="list-style-type: none"> <li>Using various insulation methods</li> <li>When the space size is large enough for angle echo events, scattered or absorbent surfaces on walls or inward-facing corners are required</li> <li>Design the openings in such a way that provides natural lighting through glass windows while preventing any entry or departure of any sound from the educational space.</li> <li>Increase the distance between the noise source and the building by placing rooms that are not functionally affected by noise, like service rooms, on the side of the building near the noise source, like the street, while protecting noise-affected spaces such as educational spaces.</li> </ul>

In terms of, lighting, 66 % of respondents agreed that their learning space has adequate lighting distribution, while the remaining respondents disagreed. More specifically, 64 % agree that natural light is suitable for lighting, while the remaining 36 % disagree. And they appear to be correct, as 67 % of respondents reported that artificial light is used a lot in their learning environment, this is most likely due to issues with sunlight, such as glare, that need to be treated. Overall, students prefer natural light to artificial light, but only when an architectural learning space is well designed so that the light is adequate and evenly distributed.

In terms of thermal comfort, 77% of students said that the temperature of the space is high; while 57% referred that the ventilation is good. Although in both cases, they agreed that artificial ventilation is needed because the ventilation rate is not sufficient, this may be because of the number of students in the space, besides other design issues.

In the matter of, acoustics, 53% of students said that noise is too loud and they can't communicate with others and hear them properly, which affects the whole learning process.

Students also agreed that all previous elements affect their concentration and academic performance with different percentages as follows: seating arrangement (93%), color and acoustics (97%), and environmental factors, which are light, ventilation, and temperature (98%), and finally the most effectible element in their opinion, size with 100%. They also mentioned that some elements have physical effects on their health, like acoustics, ventilation, light, and colors and their percentages were 98%, 94%, 91%, and 83% in order, as shown in "chart 2," and "chart. 3".

### c. Results

As previously stated, this learning environment has both strengths and weaknesses. When comparing students' opinions resulting from student analysis with the criteria shown in table 8, it found that the students found the size and seating arrangement of the space sufficient and appropriate. Other elements, such as lighting, ventilation, and color, received positive feedback from students but could be improved. In terms of color, the space is off-white, which has been shown in studies to have many negative effects on students, so it should be changed to a cool or warm color as shown in table 8.

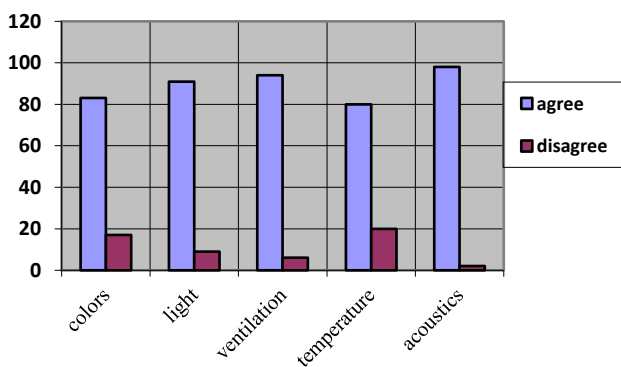


Chart 2- The extent to which elements of the educational space affect students' concentration and academic performance from the perspective of students.

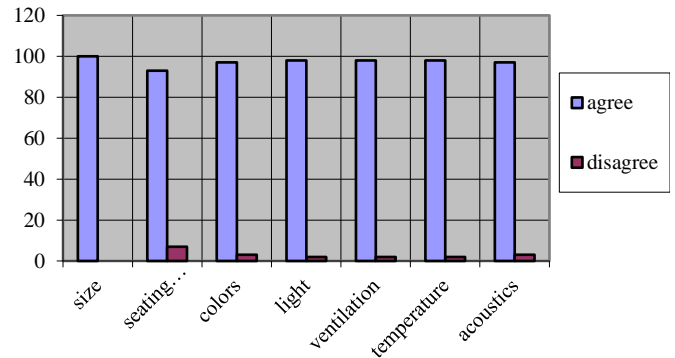


Chart 3- The extent to which elements of the educational space affect students' physical health from the perspective of students.

Students have supported this, with 86% voting to change it. Students state that natural light is good, but it is insufficient and has issues such as glare, so industrial lighting is widely used. The lighting intensity must be checked to ensure that it is within the standard range specified by the criteria. Different solutions must be used if possible to improve natural lighting. Otherwise, industrial lighting is used to achieve the necessary light intensity; the same strategy is used for ventilation and temperature. In terms of acoustics, students indicate that the noise is high and they cannot hear the teacher properly, so it is necessary to measure the intensity of the noise and use the appropriate insulations shown in table 8. In the end, many elements of the university educational spaces are not ideally suited for learning, which affects students as they explained in their questionnaire. These findings are consistent with the criteria reached in this research. For that, it is essential to follow the standards in designing each element of the learning space to ensure that it provides students with a suitable environment.

## VI. CONCLUSION

Finally, many existing educational spaces have problems with their interior design elements. Some of these problems, such as lighting, ventilation, and temperature, can be avoided from the beginning. These problems are frequently caused by improper orientation of educational spaces, resulting in insufficient natural light intensity, inadequate natural ventilation, and high temperatures due to lack of ventilation, forcing us to resort to industrial means to achieve the standard rates of those elements, thereby increasing energy consumption, cost, and other unintended consequences.

Another problem that can be avoided from the beginning is noise, this can be achieved by choosing a space location away from noisy places which contribute to mitigating external noise. The careful selection of finishing materials from soundproof materials reduces internal noise significantly. Other means of insulation that can be used in existing spaces are listed in Table 8.

On the other hand, a problem that can be easily avoided but still repeated is the white wall color, which many studies have confirmed harms student and teacher users but is still used. It

is preferable to substitute cold or warm colors, which are superior to white.

The size and seating arrangement of the space, on the other hand, are rarely a problem, and if they do arise, they are easily resolved by limiting the number of students to the size of the space and the activity in it.

This paper aimed to find criteria to determine the ideal status of each element according to its psychological, physical, and behavioral impact on students. This was done in Table 9 so that these standard requirements can be easily referred to during the design process to create a suitable educational space that meets the needs of students while avoiding all of the above problems that exist in many educational spaces.

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