

## Commentary

# Ergonomics factors influencing school education during the COVID-19 pandemic: A literature review

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### Abstract.

**BACKGROUND:** The school is one of the most critical social, educational, and training institutions and the main pillar of education in society. Education and, consequently, educational environments have the highest effect on the mentality, development, growth, welfare, concentration, performance, and learning efficiency of students.

**OBJECTIVE:** The present study aimed to examine the effects of environmental ergonomics on the learning and cognition of pre-school students during the COVID-19 pandemic.

**METHODS:** The study was carried out as a review article using some keywords, namely “children”, “learning”, “pre-school”, “COVID-19”, “ergonomics”, and “environmental factors”. Scopus, PubMed, Science Direct and Web of Science were searched to find related articles.

**RESULTS:** Factors like color, form, and layout of classrooms, lighting and ventilation, interior decoration, and educational equipment are effective in creating interest and motivation for students to learn.

**CONCLUSIONS:** A review of these articles showed that the presence of ergonomics in educational spaces for children increases the quality of learning and reduces stress and anxiety, and by observing health protocols, a healthy and safe environment can be provided for students.

## 1. Introduction

The school space is called the “third teacher” by famous experts, which consists of labs, hallways, building materials, wall colors, light, furniture, and all educational materials. School is a unique environment in which students live, learn, experience, and communicate with others [1, 2]. In such an environment, education, personality growth, correct

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39 educational methods, a proper physical space, and  
40 also a favorable psychological space are formed and  
41 managed [3]. One of the factors influencing a child's  
42 personality is his/her environment, and schools are  
43 one of the environments in which children spend  
44 a great deal of their time. Researchers believe that  
45 personality growth is the result of the interaction  
46 between the individual and the environment. Accord-  
47 ing to Washburn, the interaction of a child with the  
48 physical-social environment is a key factor in effi-  
49 cient learning and can only be achieved if there is a  
50 deep and experienced relationship in the environment  
51 [4]. The learning environment is formed by elements  
52 such as color, light, voice, equipment and schoolyard  
53 [5].

54 The specifications and quality of each one of these  
55 elements affect the formation of different behaviors.  
56 Jean Piaget puts great importance on the child's abil-  
57 ity to comprehend the world actively. He believes  
58 that children do not receive information passively, but  
59 they see, hear, and feel the world around them, and  
60 then they choose and interpret [5, 6]. One of the most  
61 fundamental concerns in revising the school environ-  
62 ment is the observance of ergonomics in school. In  
63 other words, school is a large house in which many  
64 children and adolescents spend long hours of their  
65 lives. This place should be lovely so that students  
66 can enter it with enthusiasm and interest and learn  
67 science and knowledge with strong motivation and  
68 vitality. A beautiful, attractive, and hygienic school  
69 in which ergonomic standards are observed prepares  
70 the ground for better learning and the realization of  
71 talents. Such standards are about paying attention to  
72 students' health, improving educational environment  
73 quality, using standard equipment, and controlling  
74 posture disorders [7].

75 As part of a social-distancing policy in coun-  
76 tries, schools in many countries are closed during  
77 the COVID-19 Pandemic [8]. Studies have shown  
78 that COVID-19 is highly contagious, and attending  
79 crowded and dense environments can increase the  
80 incidence of this disease [9]. Schools are among the  
81 highly dangerous places as they are densely populated  
82 with children. Also, children with this disease can  
83 transfer it to their family members and friends. There-  
84 fore, following the closure of schools, education has  
85 continued virtually. However, due to the continuation  
86 of the corona pandemic, the necessity of face-to-face  
87 education, and the need for students to attend schools,  
88 the school environment should be prepared based on  
89 the requirement of the pandemic period and under  
90 the health protocols recommended by health institu-

91 tions. In such an environment, the safety of students  
92 and teachers is preserved while the education process  
93 is reestablished.

94 Based on ergonomics principles, schools are  
95 divided into four sections of students, educational  
96 environment, educational organization, and educa-  
97 tion. In each of these four sections, the environmental  
98 conditions of the educational facilities are crucial.  
99 Environmental variables such as school temperature,  
100 noise, lighting, dimensions of the classroom [6, 10],  
101 temperature, air quality, wall colors [7, 11], ventila-  
102 tion, bench layout, adequate space, and classroom  
103 layout are the factors affecting students' learning  
104 performance [10, 12]. On the other hand, these vari-  
105 ables should also be considered in the prevention of  
106 COVID-19. Therefore, with Considering the large  
107 population of students in Iran and the importance  
108 of maintaining the health of these national assets  
109 during the corona pandemic and considering the pri-  
110 mary purpose of educational organizations, which  
111 is learning [11, 13], this study aims to review the  
112 ergonomic factors in schools during the COVID-19  
113 pandemic.

## 114 2. Method

115 The study is a descriptive-analytical one to exp-  
116 lain the necessity of ergonomics in the design of  
117 kindergarten and school spaces. The research was  
118 conducted by a literature review method. The re-  
119 search papers used in this study were found by search-  
120 ing ScienceDirect, PubMed, Scopus, and Web of  
121 Science databases. The search was done using key-  
122 words, namely "school", "learning", "COVID-19",  
123 "ergonomics", and "environmental factors".

## 124 3. Results

125 The term "learning environment" refers to a wide  
126 range of factors of micro design and macro econ-  
127 omy that can affect learning [14, 15]. Therefore, these  
128 factors are discussed separately in the following sec-  
129 tions.

### 130 3.1. Learning and cognition

131 Education and the educational environment have  
132 the most effect on and role in the mentality and  
133 civilization of societies. Among the requirements of

educational programming is to create environments related to students' activities. By such environments, suitable conditions for physical, mental, emotional, and social development are provided, and the realization of these environments entails paying attention to the details of spaces based on the behavioral patterns of children. By studying children's behaviors in educational environments, researchers have emphasized items like the area of schools, the layout of classrooms, lighting, the absence of noise, and ventilation, which play a prime role in enhancing learning performance [5, 6, 16]. Learning motivation is boosted in children when they experience an educational space, and they may have a sense of repulsion when this space is not consistent with their expectations, and as a result, children show no interest in learning. Factors like color, form, and layout of classrooms, lighting and ventilation, interior decoration, and educational equipment are effective in creating interest and motivation for students to learn [17].

A peaceful environment in schools depends on a mixture of several factors like adequate and suitable physical space, noise control, lighting, temperature, and hygiene [12, 18]. However, due to specific limitations, educational environments tend to be soulless and uninteresting. Observing the standards and principles of designing educational environments can lead to the development of space appropriate to the psychological and spiritual needs of students and society as a whole [17, 19, 20]. Preschool facilities space has a key role in the development of students' potentials so that they affect the development of children's capacity to a specific level of growth and constructive interaction with the environment [13, 21]. According to studies, the extent of peace and tranquility felt by individuals is affected by physical factors like light, noise, temperature, ventilation, and air quality [17, 22]. Also, environmental factors like lighting, noise, temperature, and air quality affect learning [7, 11]. According to [23], light, temperature, air quality, and color affect educational development.

### 3.2. Noise

Noises beyond the standard level are critical obstacles to learning [18, 24]. Also, noise degrades the physical energy and performance of students [25]. Besides, noises outside the classroom may penetrate the classroom while students try to focus on the teacher's voices and only allow educational content into their brains. However, when the noise overshadows

the teacher's voice, students stop focusing on what they hear, even the teacher's voice; this creates chaos in the classroom. Factors like classroom furniture, room shape, sound echo time, and noise source all affect students' hearing ability, and these factors should be taken into account in the design and construction of an educational environment [17]. The acoustics of a learning space has a relationship with noise control in this space. The main objective is to fulfill the quality requirements to generate and receive voices properly. The quality of auditory perception and noise control are two main aspects that determine the acoustics of a building. Easy auditory comprehension and being protected against background noise not only improve the connection with the lecturer but also improve learning performance [21, 26]. Holding classrooms in open spaces and the observance of social distancing can affect the quality of the teacher's voice heard by students and their ability to concentrate.

### 3.4. Light

Our knowledge of the world around us is mainly by seeing that it requires the presence of light [22]. The effect of light on the learning process is so high that 83% of it happens through light. Light has physical, spiritual, and physiological effects on the man so that it affects the activity, behavior, and performance of children in the classroom [22, 27]. Proper lighting improves visual perception and increases children's ability for the perception and cognition of visual information [24, 28]. Light can also help us have an exciting experience with space. However, the classroom should use natural light as much as possible. Classroom lighting is either through natural light (windows, openings, etc.) or artificial lights (by different types of lamps). The quality, direction, and quantity of light are highly important. As recommended by studies, the total area of windows should be at least one-fifth of that of the classroom to make sure that enough light for reading and writing enters the space. In addition to adequate light, the light distribution should be uniform in classroom space to avoid annoying reflexes and shadows. Lighting design should be based on a standard that protects eyes from bothering reflections or glares [29].

Students that enjoy more natural light in the classroom (e.g. daylight) have better performance than those using less natural light [25, 30]. It is notable that sunlight also affects the temperature in the classroom, and it should be used given all its effects on

the environment and requires balance [26, 31]. During the COVID-19 pandemic, some classes may be held in school gyms while the lighting of such spaces is designed for sports activities and is not suitable for educational purposes or reading and writing and thus decreases educational performance; it is because the distance between lights and bench surfaces in school gyms is too high.

### 3.5. Temperature

Over the past few decades, researchers have paid more attention to the optimum temperature for learning [21, 26]. Results have shown that an increase in temperature and humidity makes students uncomfortable, and their performance decreases due to reduced attention. Therefore, a cooler environment is better for the learning performance of students [27, 32]. Also, the high temperature that causes sweating may cause distraction and decrease performance [10, 12]. According to Haren, the best temperature range for learning, reading, and mathematics is 20–23.3°C. Therefore, proper heating and cooling equipment should be used in the educational environment to avoid learning performance decline and other damages. The suitable temperature for the classroom is 18°C. The best ways to adjust and control temperature are central heating/cooling systems; Since using them is not possible in all schools, it is best to use long-tube gas heaters to provide adequate heating in the classrooms [17]. According to studies, the higher the temperature and humidity, the more discomfort felt by students, and as a result, they have lower performance and concentration [28, 33]. Studies have shown that low temperature facilitates the transmission of COVID-19 so that low temperature has a positive linear relationship with the expansion of the disease [34]. On the other hand, an increase in temperature has a significant effect on decreasing the number of patients [35]. Since schools are mostly open during fall and winter -i.e. the cold seasons – it is imperative to adjust the temperature of the educational environment properly and respect hygienic principles.

### 3.6. Air quality

Children are particularly vulnerable to a variety of contaminants due to their high respiratory rate and metabolic rate [29, 36]. Exposure to low-quality air increases the rate of absence from the classroom and degrades teachers' ability to provide high-quality education [30, 37]. Therefore, it is essential to control

contamination, unpleasant smell, air quality, and so on in the educational environment. Studies have shown that COVID-19 can be transmitted via air, coughing, sneezing, and talking within a few meters distance. The virus can be transmitted by airflow, and also it remains in the air for a few hours [38]. Therefore, students must use masks to prevent the spread of the virus in the classroom. If there are asymptomatic carriers in the classrooms and students do not wear masks, other students will be exposed to COVID-19. The number of students in the classrooms should be lowered to enable the students to keep a safe distance from others. Proper ventilation is also needed to decrease the concentration of contaminants. To this end, it is better to keep the windows and doors of classrooms open. A study at Harvard University on school students about the minimum air needed by students showed that with an increase in activity, individuals need more air than normal conditions. Also, classroom air should be refreshed three to five times every hour, and the concentration of CO<sub>2</sub> must not exceed 1% [17].

### 3.7. Educational space

Studies have shown that the creativity and capabilities of an individual are formed during childhood and the best time to improve one's creativity and imagination power is between the ages of two and ten years [31, 33]. The educational environment has a key and important role in learning [31, 40, 41]. An educational environment should be appropriate so that all children can activate freely in it. Also, benches should be suitable for students' use [32, 42]. Professor Gary Moore showed that the quality of newly designed spaces in preschool facilities, as a physical environment, affects the growth, cognitive development, and social behaviors of children [36, 43]. The size and form of spaces can facilitate the aggregation of individuals and the formation of social interactions [37, 45]. Studies have shown that there is a direct relationship between the educational performance of students and classrooms' structural conditions. Therefore, it is imperative to take these variables into account to improve education standards in schools, preschools, and elementary schools [46, 47]. Studies have shown that 72.5% of the surveyed schools did not have the required ergonomic conditions. The physical space of three-fourth of the surveyed schools lacks proper drinking water, toilets, and educational equipment (blackboard, bench, etc.) suitable for the psychological and physical conditions of students.

332 According to Moudi, the preschool age group are  
333 exposed to risks when they use such non-standard  
334 educational equipment. Another key issue is that  
335 many high schools or junior high schools are now  
336 used as elementary schools with previous equipment  
337 that does not fit elementary school children [46].  
338 Factors such as classroom and building design also  
339 affect the success of the learning goal [40, 48]. The  
340 dimensions of spaces, buildings, and any equipment  
341 and tool should be designed based on anthropomet-  
342 ric measures done for the users. The first condition in  
343 designing any system from an ergonomic viewpoint  
344 is to pay attention to the size of the user of the system.  
345 Therefore, anthropometric measurements are among  
346 the widely used ergonomic data in the design process  
347 [42, 49]. User characteristics and structural anthro-  
348 pometric dimensions must be taken into account in  
349 the design of any facility [39, 50]. Students need  
350 appropriate furniture to sit or stand up without dif-  
351 ficulty during the education-learning process [44].  
352 Also, choosing the best suitable color is a top pri-  
353 ority, and it is better to use light colors for children  
354 [43, 51].

355 Classrooms have the most important role in educa-  
356 tional spaces as the main places where learning takes  
357 place. Classrooms can provide a variety of learning  
358 opportunities for different individuals. The layout of  
359 classroom furniture has a notable effect on the com-  
360 fort felt by students and also their interaction with  
361 other students and teachers [52, 45]. Chairs should  
362 be comfortable, in line with ergonomic design prin-  
363 ciples, lightweight, durable, and easily moveable.  
364 Students cannot place their feet on the ground when  
365 their chair is too high, and this induces extra pressure  
366 on the hamstring muscles [47, 52] and blood circula-  
367 tion. Chairs with adjustable height can be a better  
368 choice than chairs with fixed height, as their height  
369 can be adjusted for different learning activities such  
370 as using laptops or desktop computers, and as a result,  
371 the distance between the user and screen is safe [48,  
372 53].

373 The concerns about tables are similar to those of  
374 chairs in many cases. To maximize the flexibility of  
375 tables, they should be light and easy to move, and their  
376 height and size should be suitable for the learning  
377 activities of students. The height of the table should  
378 be proportional to the height of the chair. So that  
379 if chairs are adjustable, tables should be adjustable  
380 as well [49, 54]. The use of tables and chairs with  
381 the required standard significantly improves the sit-  
382 ting posture and performance of students [3]. During  
383 the COVID-19 pandemic, gathering in closed spaces

384 should be minimized, which means that the num-  
385 ber of students in classrooms should be decreased.  
386 Therefore, schools can work in two different shifts to  
387 lower the number of children in classrooms. Also, the  
388 layout of classroom furniture should facilitate social  
389 distancing so that the distance between the positions  
390 of children should be at least 2 m [55].

391 It is notable that online and remote education is  
392 another option during the COVID-19 pandemic so  
393 that a group of students can stay at home and con-  
394 tinue their education using mobile devices or desktop  
395 computers. These students also need to have a suitable  
396 chair and table at home based on their anthropometric  
397 variables. Studies have shown that neck aches, wrist  
398 pain, and shoulders and hands problems are prevalent  
399 in students who use mobile devices like phones and  
400 tablets [56]. Bending over or squatting in the long-run  
401 creates musculoskeletal problems in children [57].  
402 Studies have reported trivial forms of accumulated  
403 disorders in students who use mobile phones [58,  
404 59]. Besides, lighting should be enough at home to  
405 prevent damages to the eyes. In short, the effects  
406 of environmental ergonomics, design of spaces, and  
407 lighting on performance in educational environments  
408 are emphasized [60]. Also, in the school environment,  
409 the type of carrying bags and backpacks and other  
410 management policies can affect the performance and  
411 efficiency of students [52–54].

#### 412 4. Conclusion

413 School is an environment to realize the talents,  
414 creativity, and potentials of students. The physical  
415 condition at school has a direct effect on the comfort,  
416 concentration, performance, learning, and efficiency  
417 of students, and also the prevalence of diseases in  
418 them. Therefore, environmental factors such as light,  
419 noise, ventilation, temperature, inner space condition,  
420 and furniture layout should be taken into account in  
421 the design of schools. If these factors are not based on  
422 ergonomic standards, the connection between teach-  
423 ers and students might be interrupted and learning  
424 performance might be degraded. It is notable that neg-  
425 ligence of environmental conditions and the effect  
426 of ergonomics on learning performance increases  
427 costs, and causes waste of assets, equipment, and  
428 energy, and decreases educational performance. A  
429 proper learning environment based on ergonomic  
430 standards not only creates motivation and facilitates  
431 the learning process, but also guarantees the orga-  
432 nizational health of schools. It is notable that poor  
433

environmental condition creates obstacles to educational development, increases the transmission of diseases in students and personnel, and decreases educational performance. Also, observing hygienic protocols and combining hygienic and ergonomic principles surely have a positive effect on the educational performance of students.

## Conflict of interest

None to report.

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