



Building an ergonomics conceptual framework: Identification of compliance with educational facilities and infrastructure standards

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ARTICLE INFO

Article History

Received:

29 January 2023

Revised:

18 February 2023

Accepted:

20 March 2023

Available online:

15 May 2023

Keywords

ergonomics; facilities and infrastructure management; education.

ABSTRACT

The lack of knowledge about the rules and principles of ergonomics in managing educational facilities and infrastructure will reduce the concentration and comfort of students in learning. This article aims to examine the understanding of ergonomic principles in the management of school infrastructure and learning activities in the classroom. The approach used in this research is descriptive qualitative, which is library research. The data collection technique is done by tracing literature such as books, journals, and other articles that support the writing process. The chosen method is qualitative descriptive analysis, which is by understanding and compiling the collected data and then organizing it systematically to draw conclusions. The results of this study indicate that the knowledge of management managers regarding the principles of ergonomics of facilities and infrastructure in learning is relevant to efforts to increase student concentration and comfort in learning. By compiling this article, it is hoped that educators will pay more attention to ergonomic principles in managing educational facilities and infrastructure. So that students get comfort and total concentration in learning.



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How to cite:

Azizah, C. P. N., & Isnaini, R. L. (2023). Kerangka konseptual ergonomi dalam manajemen sarana dan prasarana pendidikan. *Jurnal Akuntabilitas Manajemen Pendidikan*, 11(1), 95-104. doi: <https://doi.org/10.21831/jamp.v11i1.58162>

INTRODUCTION

Until now there are still many schools and educational institutions that have not applied ergonomic principles in the design of infrastructure and supporting devices (Sutajaya, 2016). Of course, this affects the concentration and comfort of students in learning. One of the causes is the lack of understanding of ergonomic principles by infrastructure managers and educators (Susanti & Aulia, 2016). Factors that have an essential role in supporting student development here are the quality of teachers, learning activity programs, and the surrounding environment. A surrounding environment is a place for students to learn, educational facilities, and understanding. To obtain optimal educational and learning activities, a complete learning space plays an essential role in supporting educational and teaching activities (Mahira et al., 2018).

One of the learning facilities is a classroom, with tables and chairs that must be designed according to the student's height. Ergonomic classroom desks and chairs can give students a sense of security, comfort, and health. On the other hand, if ergonomic aspects are not considered, it will cause a variety of adverse effects, both in the near and distant future, such as students who quickly feel tired and pain during the learning process (Harahap et al., 2013). Research on the compatibility between the ergonomics of study tables and chairs and student anthropometry is still being studied little. It has yet to be considered necessary there are no specific rules or provisions linking these aspects to healthy school standards. Student anthropometry is an issue to consider, especially for Asians, when designing ergonomic school furniture to avoid future health problems such as spinal diseases (Tarihoran et al., 2021).

The ergonomics approach in the learning process balances students' task needs (workload) and capacities (abilities, abilities, limitations) so they can learn effectively, healthily, and safely to get the best learning results. Ergonomic classrooms are the primary variable in making learning activities so that they can lead to the desired goals (Herwanto et al., 2018). There are still examples of classroom designs that need more attention to ergonomics. For example, there is a classroom that looks very narrow and suggests that the LCD projector and projection screen must be installed relatively high. Thus, students must stretch their heads to see the material being taught. Students sitting in the rows to the left and right were also forced to turn their heads when they tried to view the material on the projector (Aryadi & Susilowati, 2021).

So far, only a few researchers have discussed the ergonomic theory of facilities and infrastructure in educational institutions. This is believed to be one of the causes of school management's need for more attention to ergonomics when procuring facilities and infrastructure. Therefore, there is a need for a lot of research regarding developing a conceptual framework for ergonomic principles to be considered later in designing study rooms or classes for students. Based on the problems above, the purpose of compiling this article is to serve as an additional reference for the school so that it can be considered in designing comfortable and safe classrooms and their learning environment.

METHOD

This article is about library research (library research), activities related to how library data is collected, read, and recorded, and research data processing. (Zed, 2008). The data collection technique is carried out by tracing and identifying relevant literature such as books and journal articles for review, namely, those related to the ergonomics theory of educational facilities and infrastructure to support the writing process. Writing this article attempts to discuss ergonomic principles or rules that must be understood by educators and managers of school facilities and infrastructure as an understanding that can later be applied in the learning process at school. This literature review focuses on finding appropriate, effective, and efficient knowledge that can later be utilized in schools and other learning environments. Besides that, the analytical method used is descriptive qualitative analysis, namely by understanding and compiling the information collected and then arranged systematically so that it is easy to conclude. As for processing data, this is by not including calculations (statistics) but by expressing ideas or ideas from experts and events that exist in everyday life (Moleong, 2009).

RESULTS AND DISCUSSION

The phrase "ergonomics" was born from the Latin *ergon* (work) and *nomos* (natural law), or it can be described as the study of human dimensions in the work environment. In ergonomics, it discusses how humans and facilities work with humans (Widiastuti, 2007). Ergonomics can be interpreted as a study of human aspects in the work environment regarding anatomy, physiology, psychology, engineering, management, and design (Hidayati, 2018). Humans need tools designed to simplify and speed up their work in work process. Developing a tool from an ergonomics point of view is a method that must be applied, taking into account the capabilities and limitations of the human body so that the designed product truly meets human needs (Hapsari, 2011).

Ergonomics is a structured knowledge that uses information about human nature, strengths, weaknesses, and characteristics to design tools, processes, and environments that enable people to work more comfortably, safely, and productively (Idkhan et al., 2021). The space provided for learning activities must measure and analyze elements of room comfort and the environment as a division of ergonomic dimensions, such as lighting, noise, room temperature, and classroom equipment arrangement to provide comfort to students (Herwanto et al., 2018). Ergonomics is a science, art, and technology aimed at harmonizing tools, methods, and work environments with skills, talents, and all human limitations so that humans can work as well as possible without causing adverse effects on their work (Idkhan et al., 2021).

Ergonomics is sometimes called human factors engineering, human-centered design, or occupational engineering. Ergonomics is a field of science that studies the relationship of human interaction with other system components by applying rules, nature, data, and design methods to maximize human usability and total system performance. (Hidayati, 2018). The ergonomics approach changes how people think about product design so that humans no longer have to adapt to the technology they use. But, technology must first be designed by considering the shortcomings and advantages of humans who use (Idkhan et al., 2021). Sometimes students and teachers must pay more attention to the benches to sit on. Chairs are essential, especially for students and teachers who sit for long periods. A complete chair requires at least legs, seat cushion, hips and backrest, and armrests (Sutajaya, 2016).

Several school facilities still need to meet the rules of student ergonomics so that they can hinder children in the teaching and learning process (Mahira et al., 2018). The design of supporting facilities for learning activities, such as tables, chairs, and Liquid Crystal Display (LCD) projectors not by ergonomic principles, is also often found, causing students to have awkward postures while studying. This awkward posture causes various complaints, such as disorders of the skeletal muscles in the shoulders, neck, back, and hands (Aryadi & Susilowati, 2021).

Like the problems that occurred at TKA-TPA AMM Yogyakarta, there were also problems with the design of the chairs provided for educators. The size of the wooden chairs provided does not match the height and size of the user's body, causing them to sit hunched over to be able to listen privately to the recitation of all the students for quite a long time. This will also impact the health of the teaching staff at TKA-TPA AMM Yogyakarta. Some of them complained of back pain and neck cramps in the waist and legs due to being bent for a long time. (Fauzi et al., 2022)

Errors in designing student study chairs also occurred in 3 SDN Margorejo I/403 Surabaya students. This can be seen from the curved back due to the inability to lean comfortably on the back of the chair. If left continuously, this can cause bone abnormalities such as lordosis, kyphosis, and scoliosis because the mismatch of the shape of the furniture can also affect the body of the students' bone growth. (Devinasari et al., 2019)

The definition of ergonomics focuses on adapting the design to humans, as has been proposed by Annis & McConville (1996) and Manuaba (1999). They say that ergonomics applies information according to human characteristics, abilities, and limitations when designing jobs, machines, workspaces, and the environment so humans can live efficiently, healthily, safely, and comfortably (Tarwaka et al., 2004).

There are three general objectives of ergonomics studies. One is to improve physical and mental health by preventing injuries, accidents, and occupational diseases, reducing physical and

mental burdens, and increasing promotions and job satisfaction. Second, Improve social welfare through improving the quality of social relations, good management and coordination, as well as increasing social security during productive and post-productive periods, and third, to build a rational balance between various aspects of each work system implemented, including economic, technical, anthropology, and culture, to produce quality work and life (Hadi et al., 2020).

In addition, the principles of ergonomics are generally divided into 5 points, including the following: (Wahyudin et al., 2020)

1. Use (Utility); that is, every product created can be useful in supporting their work and needs to the fullest.
2. Security (Safety): All goods produced have uses and values that do not harm the wearer.
3. Convenience (Comfortability): goods produced have the right purpose and do not interfere with their users' work.
4. Flexibility, which can be used for interests and needs in every situation and condition.
5. Strength (Durability), namely, the goods are durable or durable and not easily damaged when used.

In its development, ergonomics is divided into four areas of study, viz : (Idkhan et al., 2021).

1. Study of display: a device (interface) that displays and conveys information to people, such as letters, numbers, and symbols.
2. Study of human physical strength: is an observation and research on measurements of the endurance and strength of the human body when working in the workplace, which includes designing objects and equipment according to human physical abilities.
3. Study of the size of the workplace; an investigation that intends to obtain a workspace design that fits and fits the size of the human body.
4. Study the work environment; observe and research the circumstances surrounding the workspace and its facilities, such as lighting, noise, and temperature settings.

As for this study, the researcher intends to examine ergonomic theory only in investigations of the workplace size and the work environment. Because this study aims to provide a conceptual description of the ergonomic design of facilities and infrastructure in the classroom to create a comfortable and safe learning environment.

Ergonomic Tables And Chairs

Fulfilling ergonomic aspects in the design of tables and chairs can offer many benefits, including the user's sense of security. The meaning of self-comfort, according to Kroemer (Sugianto Putri, 2014) is: (1) The environment feels comfortable, so there is no psychological burden (2) an attractive appearance can have a good influence (3) There is a backrest or padding and space on the lumbar (4) create a feeling of comfort and security; (5) share the value of health, satisfaction, and happiness; (6) users can feel relaxed when working

In learning activities involving writing and reading activities, body posture is important in ergonomics, such as sitting for hours. Therefore, ergonomically designed chairs and tables must be able to maintain the physiological posture of the spine. This is expected to eliminate the need for excessive muscle contractions (Biomi & Dharmayanti, 2021). When sitting, the skeletal muscles (musculoskeletal) and spine (vertebral), especially the waist (sacrum, lumbar and thoracic), must be used as a backrest and placed on the back of the chair to avoid pain (back pain), free from rapid fatigue (fatigue) (Santoso et al., 2011).

For the chair to feel comfortable when used for studying, its size must match the anthropometry of the person wearing it. Therefore, it can refer to these dimensions when designing seats (chairs). However, if student anthropometric data is not available, the main seating requirements may be used as follows: (Sutajaya, 2016).

1. Seat height from the floor 38 – 54 cm (height from the sole to the back of the knee or popliteal).
2. We recommend that the seat cushion is slightly tilted back (14° – 24° from the horizontal plane or the floor). So that the body does not sag forward when sitting, this tilt is very necessary.

3. The seat cushion's front edge is designed to be slightly rounded to avoid pressure on the lower thigh. This front end can be raised $4^{\circ} - 6^{\circ}$ from the seat cushion.
4. The area of the seat cover will be better if it is adjusted to the size of the buttocks, namely: 40 – 45 cm across and 38 – 42 cm long.
5. The waist and back should be slightly tilted at $105^{\circ} - 110^{\circ}$ to the seat cushion. The design of the waist and backrests will be better if they are adapted to the curvature of the vertebrae in the human body. The backrest is useful for properly supporting the back and waist if the height is 48 – 50 cm and the width is 32 – 36 cm.

A study table is a table that is used as a means of learning activities. If the study table seems a bit high, then the shoulders will often be raised when writing or hitching a ride, and if it looks a bit low, the body posture will be slouched when writing (Sutajaya, 2016).

Students' fatigue when using a desk is localized to the neck and back. Fatigue can affect posture. Fatigue is a condition characterized by fatigue and decreased alertness, which affects work productivity (Mutmainah & Sari, 2018) This is because the table where the laptop is placed is very low, so the line of sight of the laptop screen tends to make students crouch. Fatigue is visible not only in the neck and back but also in the limbs. The position of the hands that are not parallel to the position of the laptop and the hanging of the student's elbows can cause fatigue or tiredness in students (Yusuf et al., 2021).

Students need well-designed furniture. Because if it's not designed properly, they become stuck in awkward postures when doing certain activities in class, such as writing, drawing, reading at the table, and etc (Taifa & Desai, 2017).

Superior ergonomic table and chair design are to use anthropometric measurements to find the right table and chair shape for the user. By fulfilling the ergonomics rules, users get many benefits, such as a sense of comfort when used (Safri Setiawan et al., n.d.).

As for designing a study table, you should pay attention to the ergonomics of the study table, which consists of table height, length, and width. In addition, the following conditions are also included: (Hermanto et al., 2017)

1. Table height, in determining the height dimension of a table, namely using the size of the elbow height sitting with the 50th percentile value, because if the table is relatively high, it can raise the elbows when doing writing or typing activities.
2. Table Length, to determine the dimensions of the Length of the table, namely using the dimensions of the width of the fingertips stretching from left to right, the size used is using the 95th percentile.
3. Table Width, to determine the dimensions of the width of the table, namely using the dimensions of the long reach of the hand forward from the shoulder to the fingertips, the size used is using the 95th percentile.

Thermal Comfort

Thermal comfort in KBBI is called thermal comfort. Where thermal is something related to heat, and comfort is an extension of the origin of the word comfortable, which means relaxed or comfortable so that when the two terms are juxtaposed, thermal comfort has a close relationship with the response to temperature in a thermal environment which can later affect the conditions of these subjects (Hadi et al., 2020). Temperature is one of the four main factors in the physical work environment that affect worker performance and productivity. Thermal comfort must be met to increase the productivity of students who study (Baharudin & Palerangi, 2017).

Suppose the temperature in the classroom is too high or too low. In that case, it can cause diseases such as heat cramps, heat exhaustion, heat stroke, and heat rash in hot temperatures; Chilblain, trench foot, and frostbite in cold temperatures. Rooms that are too humid and wet can cause various students' psychological reactions. In addition, it also causes physical discomfort for students, such as fatigue, easy drowsiness due to low oxygen, and easy sweating/evaporation (Sarinda et al., 2017).

Six factors influence thermal comfort, as described by ASHRAE (1989) (Susanti & Aulia, 2016):

1. Air temperature
The temperature around the person is also one of the main factors for thermal comfort.
2. radiant temperature
It is the heat that radiates from the object that gives off heat. The radiant temperature has a more significant effect than the indoor air temperature when we release and receive heat from or to the environment.
3. Wind velocity
In terms of thermal comfort, wind speed is also an essential factor. If the air in a closed room cannot move, it can cause the occupants of the room to feel uncomfortable, such as stiffness and sweating quickly.
4. Humidity
The ratio between the amount of water vapor in the air and the maximum amount of water vapor the air can hold at that temperature. An environment that has a high enough humidity level can prevent the evaporation of sweat from the skin. In a relatively hot climate, the amount of effort that comes out is relatively small due to the high Humidity in the room.
5. Metabolic Rate
Does the body produce heat during each activity or work. If a person does a more physical job, more heat is generated. For this reason, excessive heat needs to be reduced so the body does not overheat.

Every human body temperature has a different size under normal conditions. The human body keeps trying to stay in normal conditions with a perfect body system so that later it can adapt even if changes occur outside the body; even so, the human body's ability to adapt has its limits, namely that the human body can still adjust itself to outside temperatures. If the change in outside body temperature in hot conditions is not more than 20% while in cold conditions it is not more than 35%, from the body's normal state (Hutabarat, 2021).

The efforts that can be made to obtain thermal comfort are (1) Minimizing heat gain (2) Providing sufficient airflow (3) Removing heat from the room (4) Preventing heat radiation, either directly or indirectly (Idkhan et al., 2021). Meanwhile, the standard set by SNI 03-6572-2001 contains a comfortable temperature level for the average Indonesian in three parts, namely: a. Comfortable cool, between effective temperatures of 20.5°C - 22.8°C, b. Optimum comfort between effective temperatures of 22.8°C - 25.8°C, c. Comfortable warm, between effective temperatures of 25.8°C - 27.1°C (Sarinda et al., 2017).

Sufficient Lighting

Lighting has a reasonably strong effect on human abilities. In particular, when viewing objects clearly, quickly, and accurately. On the other hand, the lack of lighting can quickly tire workers' eyes. This eye strain causes mental fatigue and can also lead to eye damage (Idkhan et al., 2021). Many studies explain that lighting is one of the fundamental factors in the work area that can affect eye fatigue (Herwanto et al., 2018). If the classroom has a low or too high lighting level, it will affect the physical condition of students and other room users so that later it will also affect student learning outcomes (Baharudin & Palerangi, 2017). Dim or glare lighting conditions can cause various eye complaints, such as the general symptom, namely that the eyes feel heavier so that it is easy to fall asleep. Whereas the result of the eyes working excessively to adjust to the lighting conditions is that the neck and shoulders which often feel tense (Witjaksono & Kurniasari, 2018).

The thing that needs to be considered in designing school facilities and infrastructure is the lighting in the classroom. According to RI Minister of Health Decree No. 1429/MENKES/SK/XII/2006, the lighting standard required in classrooms at a school is 200 to.d. 300 lux. Writing and reading activities require a light intensity of 350 to.d. 700 lux (Grandjean, 1988). Meanwhile, SNI 03-6575-2001 recommends a lighting intensity of 250 lux in classrooms. Inappropriate classroom lighting during the learning process, either less or more than these provisions, can be a cause of eye fatigue in students (Sutarnitri et al., 2020)

In addition, several things must be considered in designing a lighting system in the classroom, including: (Idkhan et al., 2021):

1. It is better to avoid placing direct light sources in the viewing area.
2. When using paint on a table or tool, you should avoid colors that have the opportunity to reflect light.
3. Use diffused lighting to provide a good working environment.
4. It would be better to use many lights with low power than a few lights with much power.
5. It is better to avoid placing the light source in the 30o area of the NLS (Normal Line of Sight).
6. It is better to avoid the less stable light's origin.

Noise Free

Based on the Decree of the State Minister for the Environment No. KEP-48/MENLH/11/1996, the definition of noise is unwanted sound from work or activities at a certain level and time because it can cause disturbance to human health and environmental comfort. (Decree of the State Minister for the Environment, 1996). Noise is a sound or sound that is unwanted by the human ear. Noise is actually a mixture of several simple waves with different frequencies (Idkhan et al., 2021). One place that needs to be noise free is a school. The process of education and learning requires a calm and comfortable school environment. The environment also influences the concentration of students when absorbing material. An uncomfortable student learning environment can disrupt student concentration and make material not fully absorbed. (Indrawati et al., 2017)

Therefore, it is best to avoid placing classrooms close to noise sources, for example, highways and corridors where many people pass by. It must also be ensured that voices or sounds from outside cannot enter the classroom so that later will disturb the lesson (Nurhuzna & Alahudin, 2017). One way to deal with schools and classrooms located in noisy roadside environments is to plant trees. With this, it is hoped that it can help reduce noise while reducing pollution (Nurhajati, 2016). Several strategies can be applied to deal with room noise, including (1) trying to attenuate the origin of the noise, (2) separating the origin of the noise or you can also use a sound barrier, (3) coordinating the room, which is considered noisier, moving the rooms those that do not need quiet as a protector of rooms that need quiet (4) place the source of noise in large building parts, such as basements (5) reduce noise due to stampede with flexible materials (6) noisy rooms can be overcome by using dampening materials (7) Reducing noise by concentrating the path of sound propagation through the building structure (Aditya et al., 2017).

CONCLUSION

Based on the results of a study of the ergonomic principles of learning facilities and infrastructure in schools, the design of school facilities and infrastructure by ergonomic principles influences the concentration and comfort of students in learning. Globally, the discussion in this research study is divided into 4: ergonomic tables and chairs, thermal comfort, lighting, and noise. Students need well-designed facilities and infrastructure that take into account ergonomic principles. For the chair to feel comfortable when used for studying, its size must match the anthropometry of the person wearing it. In addition, it also pays attention to factors that affect thermal comfort, such as air temperature, radiant temperature (heat), wind speed, humidity, and others. As for designing lighting systems in classrooms, several things must be considered, such as avoiding placing direct light sources, using paint/colors that reflect light, using lots of lamps with low power, avoiding unstable light sources, etc. Finally, the classroom must be away from sources of noise, such as roads or corridors where many people pass. Noise from outside should not disturb the activities in the class.

REFERENCES

- Aditya, Y., Salayanti, S., & Palupi, F. R. (2017, December 1). *Perancangan Interior Islamic Boarding School As-syifa Kampus 2 Tangerang*. E-Proceeding of Art & Design. <https://openlibrarypublications.telkomuniversity.ac.id/index.php/artdesign/article/view/5007/0>
- Aryadi, V. F., & Susilowati, I. H. (2021). Kajian Ergonomi Sarana Pendukung Proses Belajar Terhadap Keluhan Gotrak Mahasiswa Institusi Pendidikan X. *Prepotif: Jurnal Kesehatan Masyarakat*, 5(2), 742–748. <https://doi.org/10.31004/PREPOTIF.V5I2.1928>
- Baharudin, F. R., & Palerangi, A. M. (2017). Analisis Ergonomi Lingkungan Fisik Bengkel Kerja Program Keahlian Teknik Permesinan SMK di Kota Makassar. *Jurnal Teknik Mesin Teknologi*, 17(1), 39–48. <https://ojs.unm.ac.id/teknologi/article/view/7382>
- Biomi, A. A., & Dharmayanti, C. I. (2021). Meja Dan Kursi Belajar Ergonomis Mengurangi Keluhan Muskuloskeletal Siswa Smp Tunas Daud Di Denpasar. *Jurnal Ergonomi Indonesia*, 7(2), 129–134. <https://ojs.unud.ac.id/index.php/jei/article/view/71380>
- Devinasari, N., Wibowo, M., & Suprobo, F. P. (2019). Studi Antropometri Siswa Sekolah Dasar Negeri untuk Desain Mebel Ruang Kelas yang Ergonomis di Kecamatan Wonocolo, Surabaya. *Intra*, 7(2), 493–502. <https://publication.petra.ac.id/index.php/desain-interior/article/view/8959>
- Fauzi, S., Lukluk Isnaini, R., Dzunur'aini, R., & Fajrin, N. (2022). Dampak Ketidakesesuaian Ergonomi Sarana Kursi Kayu Pada Kenyamanan Pendidik : Field Study AMM Yogyakarta . *Jurnal Ergonomi Indonesia (The Indonesian Journal of Ergonomic)*, 8(2), 14–22. <https://ojs.unud.ac.id/index.php/jei/article/view/86830>
- Hadi, Y., Azaria, T., Purnomo, Putrianto, N. K., Oktiarso, T., Ekawati, Y., & Noya, S. (2020). Analisis Kenyamanan Termal Ruang Kuliah. *Jurnal Metris*, 21(1), 13–26. <http://ojs.atmajaya.ac.id/index.php/metris/article/view/1640>
- Hapsari, P. S. (2011). Kenyamanan Furnitur Kelas B di TK Aisyiyah 61 Serengan Berdasar Ergonomi Dan Antropometri. *Gelar: Jurnal Seni Budaya*, 9(2). <https://jurnal.isi-ska.ac.id/index.php/gelar/article/view/1397>
- Harahap, P., Nurul Huda, L., & Pujangkoro, S. A. (2013). Analisis Ergonomi Redesain Meja dan Kursi Siswa Sekolah Dasar. *Jurnal Teknik Industri FT USU*, 3(2), 38–44. <https://www.neliti.com/id/publications/219410/analisis-ergonomi-redesain-meja-dan-kursi-siswa-sekolah-dasar>
- Hermanto, Sinambela, S., & Irvan, M. (2017). Usulan Rancangan Ukuran pada Meja dan Kursi Lipat Belajar yang Ergonomis untuk Rumah Petak di Jakarta. *Jurnal Sains & Teknologi: Ikra-Ith Teknologi*, 1(2), 9–15. <https://journals.upi-yai.ac.id/index.php/ikraith-teknologi/article/view/94>
- Herwanto, D., Nugraha, A. E., Kusnadi, K., Herwanto, D., Nugraha, A. E., & Kusnadi, K. (2018). Kajian Aspek Ergonomi pada Laboratorium Komputer untuk Meningkatkan Kenyamanan Belajar Siswa. *JTERA (Jurnal Teknologi Rekayasa)*, 3(1), 1–10. <https://doi.org/10.31544/JTERA.V3.I1.2018.1-10>
- Hidayati, L. (2018). Kajian Ergonomi di Sentra Persiapan BCCT: Menggugah Minat Baca-Tulis Anak Usia Dini Melalui Penataan Lingkungan Belajar yang Ergonomis. *Al-Hikmah: Indonesian Journal of Early Childhood Islamic Education*, 2(2), 127–142. <https://doi.org/10.35896/IJECIE.V2I2.33>
- Hutabarat, J. (2021). *Dasar-Dasar Pengetahuan Ergonomi* (MNC Publishing, Ed.; 1st ed., Vol. 1). Media Nusa Creative.

- Idkhan, M., Rera Baharuddin, F., & Palerangi, A. M. (2021). *Analisis Ergonomi* (H. Upu, Ed.; 1st ed., Vol. 1). Global Research and Consulting Institute. <https://www.freepik.com/free->
- Indrawati, S., Santika, B. B., & Suyatno, S. (2017). Analisis Kebisingan Arus Lalu Lintas terhadap Kegiatan Belajar Mengajar (KBM) di SMA Swasta Surabaya. *Jurnal Fisika Dan Aplikasinya*, 13(1), 14–18. <https://doi.org/10.12962/J24604682.V13I1.2131>
- Mahira, E. D., Fasilitas, P., Dan, B., Yang, B., Bagi, E., & Paud, A.-A. (2018). Perancangan Fasilitas Belajar Dan Bermain Yang Ergonomis Bagi Anak-Anak Paud (Studi Kasus: PAUD Angsa, Gugus Mawar, Denpasar Utara). *Jurnal Ilmiah Vastuwidya*, 1(2), 79–86. <http://www.ejournal.universitasmahendradatta.ac.id/index.php/vastuwidya/article/view/28>
- Moleong, L. J. (2009). *Metodologi Penelitian Kualitatif* (1st ed., Vol. 1). PT Remaja Rosdakarya.
- Mutmainah, M., & Sari, M. (2018). Perancangan Alat Bantu Alat Pemantau Area Produksi Yang Ergonomis Dengan Metode Value Engineering (Studi Kasus PT BT). *JISI: Jurnal Integrasi Sistem Industri*, 5(1), 51–62. <https://doi.org/10.24853/JISI.5.1.51-62>
- Nurhajati, N. (2016). Pelaksanaan Penghijauan Kota Dalam Menanggulangi Pencemaran Udara Di Wilayah Kecamatan Ngunut Kabupaten Tulungagung. *Publiciana*, 9(1), 1–20. <https://journal.unita.ac.id/index.php/publiciana/article/view/71/65>
- Nurhuzna, A., & Alahudin, M. (2017). Evaluasi Kinerja Ruang Kelas Sd Negeri Cenderawasih Kabupaten Merauke. *MUSTEK ANIM HA*, 6(1), 57–83. <https://doi.org/10.35724/MUSTEK.V6I1.673>
- Safri Setiawan, M., Agripina Hadyanawati, A., Ragil Suryoputro, M., & Teknik Industri, J. (n.d.). *Seminar Nasional IENACO-2019*.
- Santoso, G., Stasiun, :, Secara, K., Untuk, E., Belajar, K., Kelas, D., Kerja, S., & Secara, K. (2011). Stasiun Kerja Komputer Secara Ergonomis Untuk Kegiatan Belajar Di Kelas Gempur Santoso. *WAKTU: Jurnal Teknik UNIPA*, 9(2), 59–62. <https://doi.org/10.36456/WAKTU.V9I2.922>
- Sarinda, A., Sudarti,), Subiki,), Program, M., & Fisika, S. P. (2017). Analisis Perubahan Suhu Ruangan Terhadap Kenyamanan Termal Di Gedung 3 Fkip Universitas Jember. *Jurnal Pembelajaran Fisika*, 6(3), 312–318. <https://doi.org/10.19184/JPF.V6I3.5329>
- Sugianto Putri, R. (2014). Hubungan Ukuran Meja dan Kursi Ergonomis dengan Kenyamanan Melalui Posisi Duduk Murid Taman Kanak-kanak Dewi Sartika Surabaya. *BioKultur*, III(1), 277–291.
- Susanti, L., & Aulia, N. (2016). Evaluasi Kenyamanan Termal Ruang Sekolah SMA Negeri di Kota Padang. *Jurnal Optimasi Sistem Industri*, 12(1), 310–316. <https://doi.org/10.25077/josi.v12.n1.p310-316.2013>
- Sutajaya, P. W. M. I. M. (2016). Ergonomi Dalam Pembelajaran Menunjang Profesionalisme Guru Di Era Global. *JPI (Jurnal Pendidikan Indonesia)*, 5(1), 82–96. <https://doi.org/10.23887/JPI-UNDIKSHA.V5I1.8933>
- Sutarnitri, N. P. D., Citrawathi, D. M., & Sutajaya, I. M. (2020). Perbaikan Pencahayaan Ruang Kelas Menurunkan Kelelahan Mata dan Kebosanan Belajar Peserta Didik pada Pembelajaran Biologi di SMA. *Jurnal Pendidikan Biologi Undiksha*, 7(3), 164–172. <https://ejournal.undiksha.ac.id/index.php/JJPB/article/view/31716>

- Taifa, I. W., & Desai, D. A. (2017). Anthropometric measurements for ergonomic design of students' furniture in India. *Engineering Science and Technology, an International Journal*, 20(1), 232–239. <https://doi.org/10.1016/J.JESTCH.2016.08.004>
- Tarihoran, D., Irawan, R., Astiarani, Y., & Heidy, H. (2021). Kesesuaian Ergonomi Meja Belajar dengan Data Antropometri Siswa di Sekolah Dasar Jakarta Utara. *Jurnal Kesehatan Masyarakat Dan Lingkungan Hidup*, 6(1), 10–22. <https://doi.org/10.51544/JKMLH.V6I1.1682>
- Tarwaka, Bakri, S. H., & Sudiajeng, L. (2004). *Ergonomi Untuk Keselamatan, Kesehatan Kerja dan Produktivitas* (A. Manuba, I. S. Aziz, & H. Santosa, Eds.; 1st ed., Vol. 1). UNIBA Press. <https://123dok.com/document/q5wn1lgq-ergonomi-untuk-kesetan-kesehatan-kerja-produktivitas-solichul-achmad.html>
- Widiastuti, I. (2007). Tinjauan Prinsip-prinsip Ergonomi dalam Perbaikan Sarana Pembelajaran di Prodi Pendidikan Teknik Mesin UNS. *Performa: Media Ilmiah Teknik Industri*, 5(1), 87–92. <https://doi.org/10.20961/PERFORMA.5.1.11614>
- Witjaksono, A., & Kurniasari, W. (2018). Gambaran Intensitas Pencahayaan Dan Kelelahan Mata Pada Siswa SDN Pagadean Subang. *Jurnal Sehat Masada*, 12(1), 73–84. <https://doi.org/10.38037/JSM.V12I1.58>
- Yusuf, M., Simanjuntak, R. A., Rahmawati, N., & Susiladewi, D. M. (2021). Perancangan Ulang Meja Belajar Mahasiswa Menggunakan Metode Rekayasa Nilai dan Pendekatan Ergonomi. *Jurnal Teknologi*, 14(2), 186–191. <https://doi.org/10.34151/JURTEK.V14I2.3629>
- Zed, M. (2008). Metode Penelitian Kepustakaan. In R. Kreative Design (Ed.), *Yayasan Obor Indonesia* (2nd ed.). Yayasan Obor Indonesia. https://books.google.com/books/about/Metode_peneletian_kepustakaan.html?hl=id&id=iIV8zwHnGo0C