Contribution of Ergonomics in Designing Accessible Classrooms for Deaf and Hard of Hearing Students in Indonesia: A Proposed Guideline

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Abstract
For the past decade, several studies have been conducted in order to assess and confirm the impact of the physical classroom environment towards students' learning effectiveness, including deaf and hard of hearing (DHH) students. Several principles of ergonomics have been gathered aiming to provide guidelines in building a classroom that serves DHH students' needs. However, there is limited research on what needs to be considered when designing classrooms for DHH students in Indonesia. Looking at the fact that there are 2,270 special schools in Indonesia (Center for Data and Information Technology, Indonesian MoEC, 2020) with more than four classrooms used for DHH students in each school, a guideline which provides minimum requirement on designing classroom for DHH students is needed in order to ensure that the classroom would present positive impacts to the students' academic progress, not hindering the process of learning. This research aims to support academic progress of DHH high school students in Indonesia by providing inclusive classrooms using our proposed guideline synthesized from a systematic review of 12 academic papers. In the guideline, the first principle is to prioritize the comfort of the students, which is crucial for their psychological safety leading to engagement in class. The second principle is to enable them to function optimally as students. This proposed guideline places emphasis on resource availability, enabling teachers to implement it in accordance with the specific requirements of DHH students within the classroom setting.

Keywords: Ergonomic Design, Inclusive Design, Classroom Design, Hearing Disability

Introduction: Background and Objective

Indonesia, committed to providing quality education without discrimination, established this principle in the Law on the National Education System (No. 20 of 2003). The law places the responsibility on both national and local governments to create a conducive learning environment where students can actively develop their potential. It is further detailed in Government Regulation No. 32/2013, specifying aspects like school buildings and classrooms. Ministerial Regulation No. 22/2023 of the Ministry of Education, Culture, Research and Technology (MoECRT) provided specific definitions regarding these facilities.

Based on the Ministerial Regulation No. 14/2017 issued by the Ministry of Public Works and Public Housing, focusing on building access requirements, including accessibility features. Despite rooting in Universal Design, the Ministerial Regulation primarily addresses physically visible disabilities. This overlooks non-physically apparent disabilities like deafness. This regulation, while a positive step, only provides examples of accessibility features like ramps for wheelchair users and tactile paving for students with vision impairments (Norman et al., 2020). Currently, DHH students are usually put in special schools because the public schools are yet to implement an inclusive learning method and environment, despite their ability to follow the curriculum in regular public schools.

Deafness poses a unique challenge as it is not immediately visually discernible, which might lead to its oversight in architectural design. This oversight is crucial as deaf and hard of hearing (DHH) students heavily rely on visual cues for communication and navigation, inadvertently leading modern architectural designs to prioritize aesthetics, inadvertently isolating them (Oliviera et al., 2020). Addressing this gap, the DeafSpace Guidelines advocate inclusivity in architectural design by delineating key design concepts for a deaf-friendly environment. These encompass sensory reach, space and proximity, mobility, light and color, as well as acoustic and electromagnetic considerations.

In examining the current state of classrooms at the oldest special school in Southeast Asia, located in Bandung, West Java, Indonesia, it becomes evident that they fall short in providing adequate sensory range. As of 2020, the vice principal revealed that one classroom, with unspecified dimensions, accommodates three to four groups of students (Alhamidi, 2022). Each group consists of at least five primary schoolers or eight middle and high schoolers. However, it is important to note that the classroom is not specifically tailored for DHH students. According to the Center for Data and Information Technology, Indonesian MoEC (2020) there are 2,270 special schools in Indonesia with more than four classrooms used for DHH students in each school. These classrooms are not specifically designed for DHH students since other students are using the class simultaneously.

A study conducted in one of the oldest universities in Bandung assessed a lecture room using DeafSpace Guidelines. Beyond the structural aspects, the study emphasized the pivotal role of interior manipulation in enhancing comfort, consequently boosting learning effectiveness for DHH students (Harahap et al., 2020).

This paper aims to synthesize a comprehensive guideline for crafting inclusive public high school classrooms for DHH students in Indonesia. Derived from a systematic review of 12 academic papers, the review is designed to offer a detailed overview of recent findings concerning the interplay between ergonomic principles and classroom design for this demographic. It outlines minimum requirements, focusing on ergonomics to enhance learning

productivity by establishing a comfortable environment that mitigates physical fatigue, consequently fostering heightened student motivation. The focus on high school classrooms is predicated on the available body of literature pertaining to this age group, comprising students typically aged between 16 and 18 years old. This scope encompasses classrooms in public special schools, considering the distinctive processes that govern the provision of facilities in public educational institutions. Clusterization is based on the level of accessibility based on resources available as well.

Methods

The Process of Systematic Literature Review

The systematic literature review aims to address the following research questions, with the objective of formulating a proposed guideline for inclusive high school classrooms that facilitate the academic progress of DHH students in Indonesia:

1. What are the prominent factors proven to be effective in improving learning productivity for DHH students in classroom design?
2. What are the prominent factors for designing a DHH classroom that can be implemented in Indonesia?

The literature search was conducted from July to August 2023, utilizing the Scopus (Elsevier) database, which provides results across various fields of interest, including ergonomic design, deaf and hard of hearing, inclusive design, psychology, and education. The selection process involved the use of Scopus search and filter engine, employing specific keyword combinations as follows:

1. '*ergonomics in classroom design in Indonesia'* followed by a 'worldwide' search using the keywords combination '*ergonomics in classroom design*'
2. '*classroom for deaf student in Indonesia*', followed by a 'worldwide' search using the keywords combination '*classroom for deaf student*'

The search also implemented inclusion and exclusion criteria. Articles were included if they were published between 2013 and 2023, mentioned tangible characteristics of classroom design (such as size, layout, arrangement, furniture, etc.) for all age groups, and utilized all methods of data collection. Articles were excluded if they were published before 2013, mentioned disabilities other than deaf and hard of hearing, or if they highlighted aspects that need to be considered in the classroom but were intangible, such as pedagogical aspects, curriculum models, teaching methods, etc., without explicit reference to the physical attributes of the classroom environment.

The authors systematically integrated all discernible and measurable attributes derived from the selected literature. This approach was adopted to provide a clear explanation of the indicators prevalent in the design of classrooms tailored for deaf and hard of hearing students. The deliberate exclusion of intangible factors stemmed from a strategic intent to ensure that the ensuing guidelines would be both comprehensive and pragmatically applicable to teachers in Indonesia. By affording exclusive attention to tangible aspects, this study aspires to offer actionable guidelines for enhancing the learning efficacy of deaf and hard of hearing students within classroom settings.

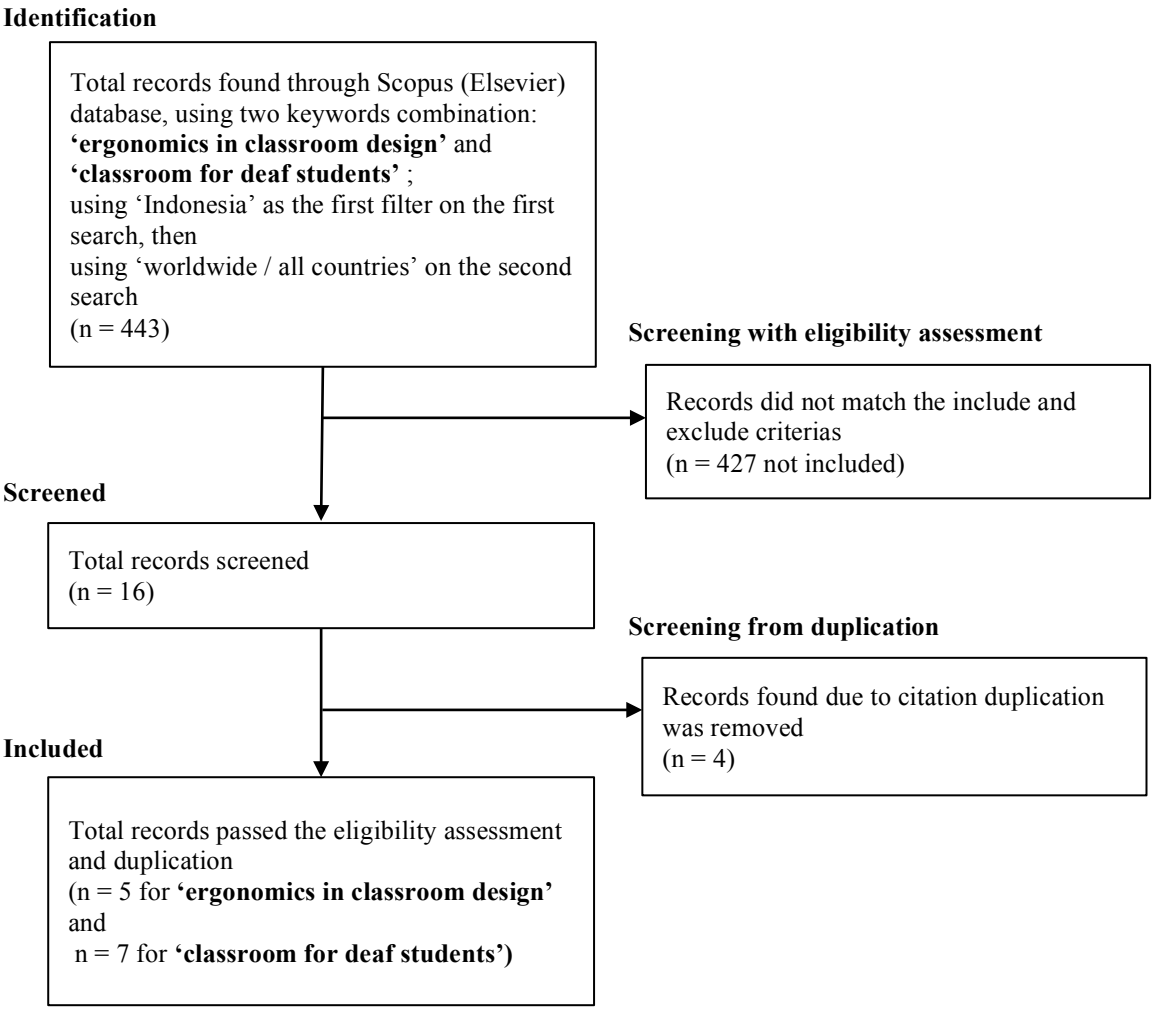

Figure 1: Summary of the literature search process

In the initial phase, a total of 443 papers were identified. Subsequently, 427 articles were excluded based on the pre-defined eligibility criteria, as previously outlined. Out of these, 16 papers were gathered, and an additional four were eliminated due to redundancy. Consequently, this search process yielded 12 articles, encompassing elements pertinent to the formulation of effective classroom design (n = 5 papers) and features conducive to the learning experiences of deaf and hard of hearing students (n = 7 papers).

During the screening process, the authors collaborated to look at the connection between the paper to the objectives by reading the abstract. For those papers that initially demonstrated the capacity to address the research questions, a comprehensive analysis was conducted, involving the systematic listing of methodologies and outcomes. Due to the limitation of personnel, the screening process was conducted qualitatively with expert supervision. without utilizing any inter-rater reliability assessment.

The systematic literature review conducted in Table 1 (Appendix) reveals several factors that have the potential to serve as foundational principles when designing classrooms for students with hearing impairments (DHH). However, the specific implementation of these factors is contingent on the unique characteristics of the students who will be utilizing the classroom on a daily basis. For example, the selection of classroom colors presents a notable consideration. Barrett et al. (2015) suggest that employing balanced and saturated colors on the walls is

appropriate for providing an intermediate level of stimulation. Nonetheless, the applicability of this recommendation hinges on the age group of the students. While this color scheme may remain suitable for children, it could potentially overwhelm adolescents, potentially overloading their visual cognition. Consequently, high school students might derive greater benefit from lighter and pastel colors on the walls.

A similar situation arises with seating arrangements. Both Manca et al. (2020) and Taylor (2020) advocate for classroom designs that afford seating flexibility, enabling students to readily adjust their seating and allowing them room for movement if required. However, this level of adaptability may not be imperative for high school students, who typically exhibit a preference for a more static approach to learning. Instead, emphasis should be placed on determining the appropriate seating layout, such as a U-shape or semi-circle arrangement. Given the potential existence of other pertinent aspects necessitating consideration, albeit with varying interpretations of implementation, a synthesis process is imperative to formulate a more comprehensive proposed guideline that can be directly applied in the design of classrooms for DHH students.

The Process of Synthesizing the Proposed Guideline

The systematic literature review has identified various aspects that must be measured and assessed when designing classrooms for students with hearing impairments (DHH). However, these findings have not been synthesized into a practical guideline that can be directly utilized by classroom designers before construction or by teachers after the classroom is built. The process and results of this synthesis will be explained in this section.

The authors believed that a proposed guideline should be specific and comprehensive to facilitate easier implementation. Due to the lack of specificity found in the literature, the authors decided to create a guideline tailored for DHH students in Indonesian high schools, specifically for those aged 16-18 years. The intention was not to focus solely on maintaining students' attention spans (assuming high school students have already outgrown this issue) but to enhance the effectiveness of the learning process.

The proposed guideline comes from synthesizing recommended aspects cited in the literature, choosing the ones that are prominent to be mentioned and necessary to be put into practice. The authors used thematic content analysis which was performed under the supervision of an expert who continuously challenged and gave feedback on how the author clustered the relevant. findings. However, the authors try to put some aspects that could be not a priority, considering the unpredictable power outages due to improper distribution of power supply and the difficulty to have maintenance budget in schools in Indonesia to fully implement it.

The aspects mentioned in the proposed guidelines are divided into two big clusters: 1) hard to change by teachers, and 2) easier to adjust by teachers. This clustering was based on High School Building Development Guidelines published by Directorate General of Early Childhood Education, Elementary Education, Middle and High Education (2020) where it talks about the process of revamping the classroom and school building. It says that to renovate the building needs several steps that have to comply with the checklist of identification of the fulfillment of space functions, the budget would be rocketing, and the request to renovate would not directly be approved by the government as well. Therefore, assuming that there are lots of classrooms and schools in Indonesia that have not yet met the

indicators to promote comfort for DHH students, the authors propose to categorize the aspects in 'hard to change' and 'easier to adjust' clusters, for easier implementation.

Conclusion: Results and Discussion

In the preceding section, the authors attempted to categorize the guideline into two primary groups: 'hard to change by teachers' and 'easier to adjust by teachers'. The former refers to aspects that are already in place and would require significant classroom renovations for improvements, making changes time-consuming. Although these aspects are crucial, the authors do not want to restrict teachers from making necessary improvements to enhance the learning experience. Therefore, the authors introduced the 'easier to adjust by teachers' cluster, encompassing aspects inside the classroom not integrated into the existing structure. This allows teachers to customize these elements, aiming to provide additional benefits for students with hearing impairments in terms of learning effectiveness.

The aspects mentioned in the 'hard to change' category also happen to provide comfort, which is essential for the psychological safety of the students and could lead to increased engagement in the class. These are the prerequisite to exist if the teachers want the students to be ready and focused to learn in the class. Citing the ergonomics principle of Built Environment, factors that are relevant to provide comfort, include: visual field (lighting, natural and electrical), acoustic, and other configurations (temperature, air flow, and the size of the classroom).

On the other hand, the 'easier to adjust' category promotes function, meaning that these aspects support the students to function and learn optimally in the class by being able to tailor the elements to the students' specific needs and cultural behavior. Based on the Stimulation-Individualization-Naturalness principle, factors that contribute to provide function are those referenced in the stimulation and individualization groups, such as: classroom color, seating arrangement, and the furniture. Stimulation and individualization lead to personalized classrooms that could further cater DHH students needs, as DHH types varied from one student to another. Other than budget considerations, these personalizations can only be performed by the teachers.

Table 2: The proposed guideline for designing classrooms for DHH high-school students in Indonesia

Category	**Aspects need to be considered**	**Indicators and parameters**
Hard to change by teachers, the ones that provide comfort	Classroom size	● The ideal size of the classroom needs to measure the users who will use the classroom daily (the age, the body scale), and what kind of activities they will perform daily in the classroom (Gaudiot et al, 2019; Harahap et al, 2020) ● Minimum ratio of 3 m^2/students (Rahmat, 2016) ● Ideal capacity of 8-10 people per classroom, assuming this is an ideal case to have effective 1-on-1 guidance from the teacher (Xue et al, 2020)
	Classroom structure	● The structure of the classroom needs to be strong and firm, not cracked, and the ceiling needs to have no leak (Widiastuti et al, 2020)

		• The building needs to comply with the disaster resistant regulations in the country, especially the natural disaster that often occurs (Lassa et al, 2022) • The classroom and the school needs to have standard operational procedures of what to do if disaster happens, including a color sign system to alert danger and a comprehensive evaluation process (Gaudiot et al, 2019; Lassa et al, 2022)
	Lighting	• Natural lighting could be improved by providing more windows with a certain size. This could be a method to save electrical spending and to utilize daylight (Barrett et al, 2015; Gaudiot et al, 2019; Manca et al, 2020; Oliviera et al, 2020; Harahap et al, 2020) • Electrical lighting needs to have a minimum 100 lux per class (Rachmat, 2016) *However*, considering there are differences in electrical capacity and classroom size in every DHH classroom in Indonesia, this aspect could be put as not a priority
	Air flow	• The existence of bigger windows mentioned above to support lighting, could also be considered to support airflow by providing the window with ventilation flow with a particular size and design (Barrett et al, 2015; Gaudiot et al, 2019; Manca et al,2 020; Widiastuti et al, 2020) • Ventilation holes need to be at least 15% of the floor surface area, and it needs to ensure the flow of >= 0.15 m/s (Rachmat, 2016)
	Temperature and humidity	• The windows (for promoting natural righting and air flow) need to be located on certain spots that minimize sun exposure aiming to reduce direct heat from the sun glare (Barrett et al, 2015) • To avoid sun exposure, the classroom could also be provided with some shades outside the room (Barrett et al, 2015) • Air humidity needs to be within the range of 40%-60% in order to avoid fatigue (Rachmat, 2016) • Overall temperature of the classroom needs to be within the range of 18C-28C, and will be better if there is a fan or an air conditioner so the people inside can control the temperature (Rahmat, 2016) *However*, considering there are differences in electrical capacity and supply stability in every DHH classroom in Indonesia, this aspect could be put as not a priority
	Acoustic	• For an unoccupied classroom, the sound level needs to be <= 30 dB, and for an occupied classroom it should be within the range of 50 dB - 85 dB in order to maintain effective communication and learning process inside the classroom and to avoid fatigue (Gremp et al, 2018; Manca et al, 2020; Taylor, 2020)

		● If possible, the wall materials, the floor materials, the ceiling tile, and the furniture materials need to not reflect the noise in order to maintain students' focus, and the materials could also be a good sound absorbing to avoid echoes (Gaudiot et al, 2019; Harahap et al, 2020; Manca et al, 2020; Oliviera et al, 2020)
Easier to adjust by teachers, the ones that provide function	Furniture	● The chairs and desk need to follow ergonomic principles, which accommodate natural resting positions, and with the height and the width following the body scale of the students. The top of the desk needs to be large enough to provide ample room for smooth sign language communication while also accommodating items on its surface (Barrett et al, 2016; Gaudiot et al, 2019; Manca et al, 2020) ● The blackboard needs to be big enough to allow better view, and needs to be placed at the appropriate spot to avoid sun glare. It is better to use blackboard rather than whiteboard since the whiteboard tends to reflect the sunlight (Gaudiot et al, 2019) ● Provide the classroom with cabinets that can store books and students' files as part of the standard operational procedure for mitigating natural disasters (Lassa et al, 2022)
	Classroom color	● Light or pastel colors on the walls (Barrett et al, 2015; Gaudiot et al, 2019; Harahap et al, 2020; Widiastuti et al, 2020) ● It is better to not utilize lots of bright color and striking decoration since it would overstimulate high-school students visually (Barrett et al, 2015; Harahap et al, 2020)
	Seating arrangement	● Recommendation for seating layout: U-shape, semi-circle, or circular. It depends on the shape of the class whether it is a square or a rectangle, and depends on the number of students (Barrett et al, 2015; Gaudiot et al, 2019; Kushalnagar, 2019; Harahap et al, 2020; Manca et al, 2020; Taylor, 2020; Widiastuti et al, 2020; Xue et al, 2020) ● The arrangement needs to provide enough range of visibility for each student. It is recommended that the students are put in a 45 degree shape so they can see the blackboard/the slides, the teachers, and their peers on their right and left sides (Gaudiot et al, 2019; Harahap et al, 2020)
	Additional learning tools and accessories	● It is better for the classroom to have visual signs and other visual information as cues to support accessibility, and to be included in the standard operational procedures for mitigating natural disasters (Barrett et al, 2015; Harahap et al, 2020)

The authors have made sure to incorporate DeafSpace principles in the aspects mentioned above to enhance accessibility and inclusivity for students who are deaf or hard of hearing. For example, selecting a U-shape or semi-circle seating arrangement aligns with the

principles of space and proximity, which would maintain the students' focus on visual communication. The inclusion of windows to maximize natural light, complemented by artificial lighting, demonstrates the application of light and color principles.

Limitations

In the course of reviewing relevant papers for the systematic literature review, the authors engaged in rigorous discussions to challenge each other's perspectives on specific studies. However, due to time constraints and a shortage of personnel, the authors did not conduct an inter-rater reliability assessment. It is advisable for future reviews to incorporate this assessment before beginning the systematic literature review process.

When synthesizing the results of the systematic literature review to create a comprehensive guideline, the authors employed thematic content analysis under expert supervision. However, the authors did not utilize a supporting methodology or conduct a readability test beforehand, again due to time constraints and limited personnel. To enhance future research, it would be beneficial to employ primary research methods such as interviews, focus group discussions, or surveys to evaluate the readability and usability of the guideline intended for implementation.

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Appendix

Table 1: Result of systematic literature review

No.	Author	Title	Research Objective	Research Design	Participants: Number of Schools (n), Sample (pp), Age (yr), Country (c)	Relevant Results and Outcomes
1	Barrett et al	(2015) The impact of classroom design on pupils' learning: Final results of a holistic, multilevel analysis	To report the final results of HEAD (Holistic Evidence and Design) project To present different approach on examining good classroom design: SIN framework	Experimental design, quantitative and qualitative	n = 153 classroom of 27 schools pp = 3766 students yr = 5-11 years old c = England	● On Naturalness: classroom orientation towards more natural lighting alongside large windows for better air quality as well, but in Indonesia's equatorial position, glare and heat effects need careful consideration; improve electrical lighting, however, it is in lower priority for regions with limited electricity accessibility in Indonesia. ● On Ownerships or Individualisation: ergonomic furniture with flexible classroom arrangements, but flexibility could be a lesser priority for high school; distinctive design features to enhance learning engagement with consideration towards DHH students' visual reliance. ● On Stimulation: add decorations and balanced colors to create moderate room stimulation and not overwhelming for DHH students' heightened visual acuity.
2	Rachmat	(2016) Prevalence and Determinants of Fatigue among Private High School Students in Bogor Tengah Sub-district, Indonesia	To find the relationship between classroom's physical environmental conditions towards fatigue among high school students	Quantitative	n = 10 private high schools pp = 288 students yr = 15-17 years old c = Indonesia	● Various factors for designing a comfortable classroom to reduce physical fatigue and enhance motivation, including: classroom size with minimum ratio of 3 m2 per learner, and room capacity no more than 30 people; light intensity with minimum 100 lux; noise level with maximum of 85dB, with also considering school location not too close to the main road of the city; provide mechanical ventilation holes equivalent to at least 15% of the floor surface area; maintain a temperature range of 18-28°C, air humidity between 40-60%, and airflow exceeding 0.15m/s. Consider the availability of air conditioners. However, given budget

						limitations in building schools in Indonesia, we view this as a lower priority. ● The study quantitatively identified key factors impacting student physical fatigue: humidity, temperature, airflow, and air conditioner availability.
3	Gremp et al	(2018) A Descriptive Analysis of Noise in Classrooms across the US and Canada for Children who are Deaf and Hard of Hearing	To obtain sound levels and acoustic characteristics in classrooms that serve DHH children	Experimental design, quantitative	n = 19 schools/42 classrooms pp = 300++ K-2 students yr = 5-7 y.o c = USA and Canada	● The study suggests assessing various aspects related to sounds in DHH classrooms: provide separate classrooms (instruction or inclusive) based on the sound level connected with its location, the sound level of an unoccupied classroom is <= 30 dB (with an overall sound level of around 70 dB to maintain a signal-to-noise ratio of +15 dB), limit the reverberation time of a 10,000 cubic feet classroom to no greater than 0.6 seconds. ● The proposals above would affect wall, floor, ceiling tile, and furniture materials.
4	Kushal nagar	(2019) A Classroom Accessibility Analysis App for Deaf Students	To make an assessment of the architectural visuals effect on the DHH students by using simple accessibility app	Experimental design, quantitative	pp = 15 students yr = >16 y.o c = USA	Besides that there was a strong correlation between participant ratings (on the classroom layout/classroom architecture visuals) and the Classroom Analysis App for accessibility, the study proposed that circular layout is recommended to be used by DHH students in classrooms since it promotes accessibility the most.
5	Gaudiot et al	(2019) The Classroom Built Environment as An Inclusive Learning Process for the Deaf Students: Contribution of Ergonomics in Design	To make an assessment of classroom design for DHH students to support their learning process, based on Built Environment evaluation	Literature review	n paper = 15 papers c = worldwide	● Based on the ergonomics principle of Built Environment, the study highlighted several aspects in the classroom, such as: its size using the student scale, arrangement promoting comfort for the students, promoting natural lighting that minimize direct sun's influence, and room dimensions determined primarily by the students and the various activities. ● Applying Human-Task-Environment principles, the study suggests focusing on several aspects, including: walls and flooring materials need to allow reverberation (helps the acoustics of the classroom), wall coloured in light or pastel colors (provide stimulation), seating arrangement allow participation

						of all DHH students by increasing visual control (e.g. in circular layout, or put them the students in a 45 degrees of shape), big blackboard for better view and spacious desks allowing seamless sign language communication yet keeping the objects on the top, furniture placed to provide comfort and safety.
6	Widiastuti et al	(2020) How classroom design impacts for student learning comfort: Architect perspective on designing classrooms	To determine the factors that affect student learning comfort in the classroom and its distribution	Qualitative and Quantitative (descriptive statistical analysis of survey)	n = several elementary schools (SD), junior high schools (SMP), and senior high schools (SMA) in Yogyakarta, under the same institution of Muhammadiyah pp = 772 students (245 SD students, 265 SMP students, 262 SMA students) yr = 10-17 years old c = Indonesia	The study proposed several aspects emerged from students opinions, which could be considered in school and classroom, including: ● School building/outdoor theme: importance of a connection with nature, though it may not be a top priority since it is associated with the predetermined school location; emphasis on building strength and durability for classroom safety; prioritize quietness by managing noise levels; considering lighting (both natural and electrical); provide air circulation/ ventilation; maintain the appropriate proportion of indoor space per learner. ● Classroom/indoor theme: adequate facilities is important, however, due to the various budgets on improving facilities, this might not be a priority to be put in the proposed guideline; cleanliness; study atmosphere (i.e. low noise level)' visual quality (e.g. decoration, wall color providing stimulation); space planning (i.e. classroom seating arrangement); lighting (both natural and electrical); air circulation or having air conditioners, however, we consider this as not a priority knowing budget limitations.
7	Manca et al	(2020) The Effect of School Design on Users' Responses: A Systematic Review (2008-	To find the impact of the educational environment design towards students' and teachers' performance	Systematic literature review	n paper = 68 papers yr = 7-12 years old c = worldwide	● Talking about the association between the indoor environmental features and users' psychological responses, the study proposed several aspects to consider, such as: ○ The school needs to be not close to the road. ○ Furniture materials need to not reflect the sound

		2017)				(Lombard effect). ○ Ventilation needs to be increased. ○ Lighting needs to use more natural light. ● Talking about the effect of classroom design and furniture on users, the study proposed some aspects to be assessed, including: ○ Classroom layout needs to have a flexible space (example: U-layout). ○ Chair and desk need to be ergonomic and accommodate a natural resting position. ○ The furniture needs to be in attractive colors. *However*, if this principle is implemented, we need to measure whether the 'attractive colors' would not be noise for the students.
8	Olivier a et al	(2020) The Application of Ergonomics of Built Environment Architectural Projects as a benefit for the Hearing Impaired	To assess building inclusivity and accessibility for DHH students based on DeafSpace principle	Literature review	n paper = 9 papers c = worldwide	The study proposed several principles that can be used in designing classrooms for DHH students. ● In terms of Accessibility of the Built Environment, aspects to be considered: ○ Understanding the environment for navigation. ○ Moving freely within both vertical and horizontal circulation areas. ○ Engaging in activities and using equipment and furniture. ○ Facilitating easy interaction between users and the environment. ● Talking about assessing Ergonomic design of the Built Environment, the classroom design needs to consider: ○ Comfort related to the surroundings. ○ The user's perspective towards the function. ○ The mental aspects of the users. ○ The factors related to completing tasks and the required sizes. ● In terms of taking DeafSpace principle, the classroom design needs to consider: ○ Sensory range ○ Space and proximity

						○ Mobility ○ Light and color ○ Acoustic and EMI
9	Haraha p et al	(2020) Study of interiority application in deaf space based lecture space	To assess the accessibility of the lecture space in CADL-ITB (Institut Teknologi Bandung) building using DeafSpace principle	Experimenta l design, qualitative	pp = 72 participants yr = >16 y.o c = Indonesia	● The study proposed several aspects based on DeafSpace principle that needs to be existed in a classroom for DHH students, such as: ○ Consider U-shape or semi-circle seating positions ○ Provide large amount of wiggle space ○ Use fresh colors and natural lighting ○ Use soundproof material
10	Taylor	(2020) One-Stop Lesson Planning: How Universal Design for Learning Can Help Students Who Are Deaf or Hard of Hearing	To promote Universal Design for Learning (DHH) principles in designing lesson plan and activities inside the classroom	Literature review	n paper = 5 papers c = USA	The study proposed that in order to increase engagement and motivation of students in the classroom, it needs to be designed by considering several aspects, such as: ○ Classroom layout or arrangement needs to utilize flexible seating ○ Allow access to quiet spots when it comes to small groups discussion
11	Xue et al	(2020) Study on the classroom attention mechanism of deaf students based on three-in-one education model	To improve deaf students' learning attention by promoting three-in-one educational model	Experimenta l design, qualitative	pp = 292 DHH students yr = >16 y.o c = China	The study resulted in mapping influencing factors for deaf people's attention: unintentional, intentional, and external. Talking about how the external environment might influence deaf students' attention, the classroom design needs to consider several aspects, including: ○ Classroom size needs to accommodate 8-10 people so it can cater 1on1 guidance of teachers ○ Classroom layout needs to be in semi-circular ○ Wall and furniture materials need to be sound-absorbing
12	Lassa et al	(2022) Understandi ng the impacts of floods on learning quality, school facilities, and educational recovery in Indonesia	To assess the effect of floods on quality learning and educational infrastructure by utilizing comprehensiv e school safety framework	Qualitative	n = 100 schools pp = 80 headmasters and 21 students yr = - c = Indonesia	The study proposed that given Indonesia's susceptibility to disasters, school buildings should be designed with resilience in mind. Additionally, schools should establish standard operational procedures, encompassing immediate response protocols in the event of a disaster, as well as designated safe locations to ensure the safety of students.

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