A scholarly review on revealing the influence of unforeseen sub-factors in the study of adaptive thermal comfort in classrooms of primary and secondary school environments

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Abstract: Abstract: *According to ANSI/ASHRAE-standard 55 definition, thermal comfort is "the state of mind that reflects happiness with the thermal environment and is evaluated subjectively." Because of this, a building's status regarding the health and welfare of its occupants, including characteristics of design, analysis, and operation, could enhance energy efficiency, promote health, and provide a comfortable built environment One-fifth of the world's population spends more than 30% of their time in educational facilities like schools and universities, which are among the most important. Poor thermal comfort in schools can significantly impact students' health and academic performance Due to their greater core body temperatures and underdeveloped thermoregulation capacities, children are more vulnerable to higher temperatures than adults. Hence a Thoughtful school design and operation can improve thermal comfort, health, and performance. There are several studies conducted worldwide addressing adaptive thermal comfort, but only very few of the studies focus on the education sector in which comparatively fewer studies have been conducted on adaptive thermal comfort in non-air-conditioned classrooms at school premises. This paper conducts a scholarly review in revealing the unforeseen sub-factors (Age, Gender, seasonal change, Local thermal comfort, Socioeconomic, Adaptive Behaviour, Passive cooling and heating, Building refurbishment, Building envelop, Orientation, Placement of windows, Assessment model) that are influencing the four main factors of thermal comfort (air temperature, radiant temperature, metabolic rate, and clothing insulation) prescribed by the standards from the papers published in past the 15 years in adaptive thermal comfort in a classroom environment of primary and secondary school.*

Keywords- *Thermal comfort, indoor environment, socio-economic, building envelop, assessment model, adaptive thermal behavior*

1. Introduction:

In modern civilizations, the majority of people's time is spent indoors. Children spend more time at school than in any other building, except in their homes, emphasizing the need to maintain appropriate indoor thermal conditions in these facilities. Initial studies in primary and secondary grades consistently point to lower temperatures recommended for schools than for individuals [1]. A student's performance and well-being are significantly impacted by the thermal environment quality of a classroom. In this regard, the current study was conducted to investigate the evolution of classroom-based thermal comfort studies over the preceding years [2]. According to prior research, children frequently experience temperature differences from adults, which should be considered when designing energy-efficient and comfortable learning spaces. Additionally, the use of various models to analyze adaptive thermal comfort can have an impact on the results of field studies and should be investigated thoroughly [3]. Additionally, it appears that there aren't any criteria for thermal comfort in educational facilities, given the laws already in place, such as ISO 7730 [6] ASHRAE 55 [7] and EN 16798-1seems to be not sufficient to provide comfortable conditions for students and teachers. These recommendations, which don't take into account due to the preferences of specific pupils and teachers, are based on research done in labs[6] or field studies using comfort data gathered from healthy adults in buildings all over the world[9][10]. Indeed, standards are frequently based on dose-response models that cannot account for people's individual preferences and needs and were frequently established for contexts like offices; as a result, they do not take into account the specifics of educational buildings. This emphasizes the need for additional research into whether the adaptive comfort model can be applied to children in its current form. Other factors besides those outlined by comfort standards influence the way individuals perceive heat in classrooms. Further investigation is necessary given the properties of buildings[4] and social variables that may affect inhabitants' thermal perception [5], thus this paper conducts a scholarly review on exposing the influence of unforeseen factors on the prescribed foreseen factors (air temperature, radiant temperature, air velocity, humidity, metabolic rate, and clothing insulation) in the adaptive thermal comfort level of the primary to secondary school children inside the classroom environment for the past fifteen years from the time of the study. which is shown in Fig 2.

2. Methodology:

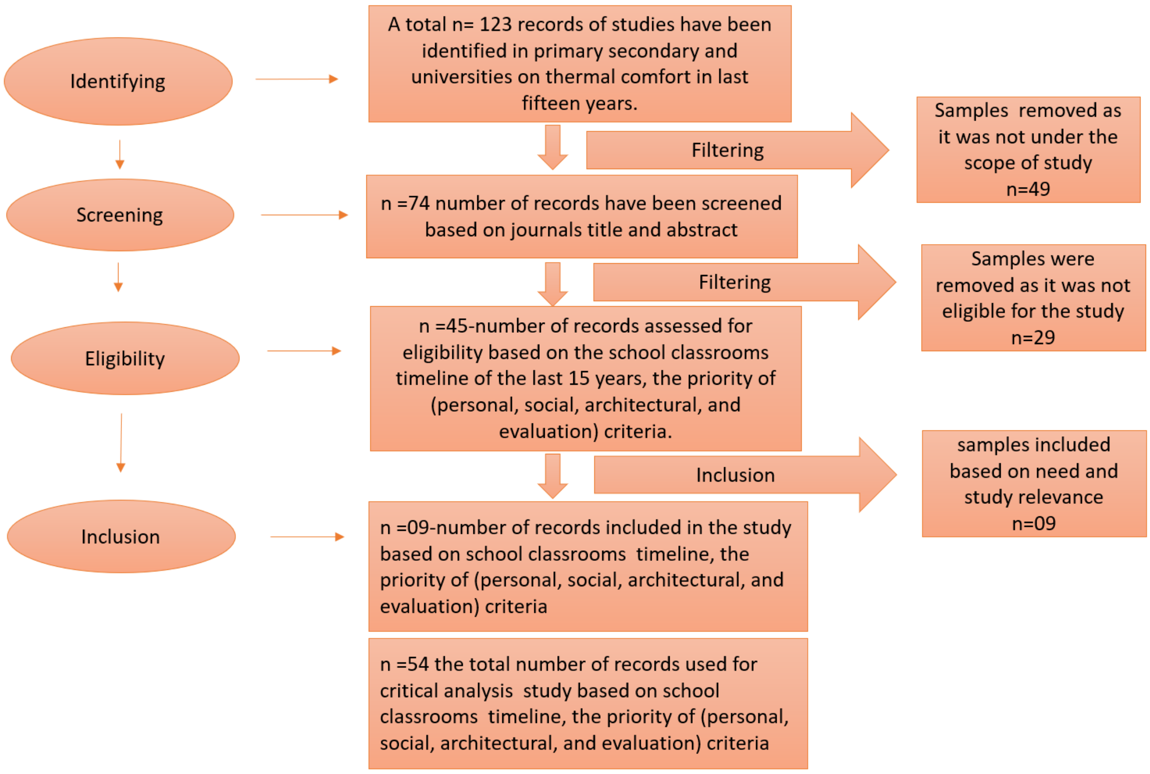

Figure 1: Application of the PRISMA methodology

The total number of records obtained from the search of the database is 123, which includes thermal studies in all education sectors from Scopus and scientific journals, these collected data have been further screened to the record of 74 based on journals title and abstracts related to primary and secondary school and further, these obtained data has been assessed for eligibility based on period, the priority of four main influencing factors (metabolic rate, clothing insulation, air temperature, radiant temperature,) that are prescribed by the standards from the preceding study of 45 on adaptive thermal comfort in the primary and secondary school classroom environment. After the inclusion of certain studies based on the period and priority, a total of 54 records have been used for the review

Table -4. This investigation of influencing factors has been carried out under different levels of criteria: personal, social, architectural, and evaluation which as discussed in the following

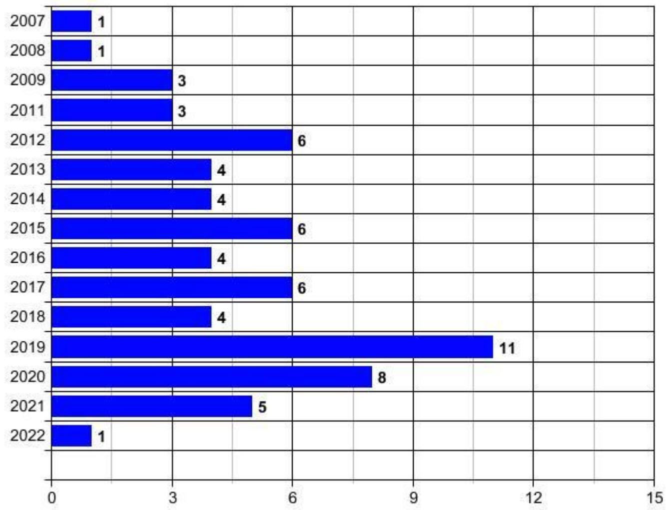

Figure 2: The past fifteen years of studies conducted on adaptive thermal comfort in the primary and secondary school classroom environment from the period (2007-2022)

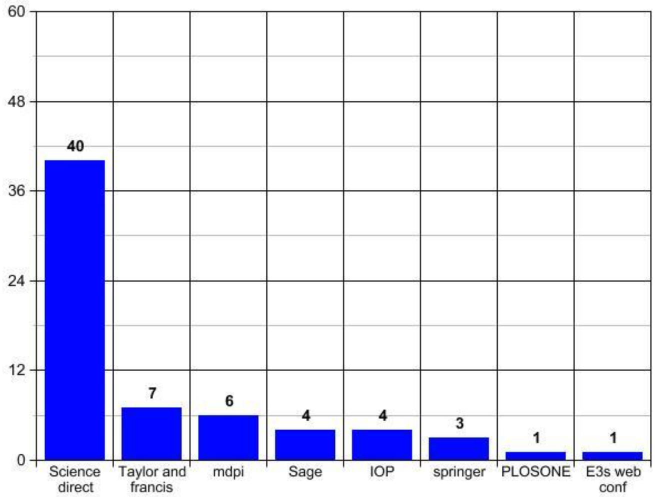

Figure 3: The total number of studies from the journal assessed for eligibility and final inclusion (2007-2022)

Influence of subfactor personal and social criteria:

Seasonal change influences children's multitudinous affections caused by the axes of climatic conditions [11]. Children are more sensitive to temperature change[12]. The yearly comfort zones for naturally ventilated areas specified in ASHRAE Standard 55 are generally found to be lower than the ASHRAE-recommended range[13]. Children in primary school are highly sensitive to outside temperature changes. In contrast, secondary school and university students are more able to describe their experiences with thermal sensation and are better able to make day-to-day modifications including adjusting garment levels, opening and closing windows, and turning on and off ceiling fans[2]. The majority of complaints from students were related to thermal comfort during the summer and solar penetration[14]. The most common complaints from students were related to the temperature in warm seasons [15], and the thermal sensations were also related to their adaptive thermal behavior, such as students preferred to increase the fan speed to achieve thermal comfort during the summer season and to close the windows and wear extra, thicker clothing during the winter season[17]. Given the impact that local discomfort can have on how an environment is perceived[3], these adjustments are crucial in defining thermal acceptability in naturally ventilated classrooms[2] and differences in thermal sensitivity, with students in locations exposed to greater weather variations demonstrating greater thermal adaptability than those in more equable weather districts[16]. Additionally, a significant correlation between the neutral temperature and the mean monthly outdoor temperature was discovered [18]. To present a more comprehensive and accurate picture of temperature neutrality and the thermal comfort range, additional studies involving more such schools located in various climatic regions need to be conducted [19].

Socio-economic factors and their influence on clothing insulation:

Compared to adults, children are more vulnerable to extreme temperatures[4]. Compared to adults, children were more sensitive to alterations in their metabolism [20]. Children's comfort temperatures decrease and their susceptibility to overheating during warmer seasons can be ascribed to fewer personal adaptation behaviors [21], which has a positive impact on students' efficiency and well-being [22]. Behavior regulation, which primarily altered the amount of clothing worn, was the main way that students were able to adapt to the classroom's temperature [23]. Elements related to behavioral norms, school operations, and building design also appeared to have a significant impact on students' thermal comfort [24]. The considered clothing level in winter is higher than in summer [25]. Depending upon their socioeconomic status, children's thermal adaptive behavior varies [26]. Children from less privileged backgrounds typically adjust to colder climates worse than those from more privileged backgrounds. This may be due to youngsters having to adapt to extreme thermal circumstances at home, which causes them to expect lower temperatures in school, Additionally current laws have not been sufficient to provide children with a comfortable environment to learn, especially those from low socioeconomic situations [27]. However, there are very few heating systems, and those that do work only sporadically because of financial limitations [28]. This shows that there is a strong correlation between economic difficulties and health issues [29]. According to a study, male and female children adapt to clothing somewhat differently, with the females showing more adaptation [30]. Also found a difference in neutral temperature between both genders [31]. Because female students had higher tolerance levels than male students[32], the acceptability limits of the male students were pushed to the warm side of the thermal continuum [33]. We must take into account not just the physical variables but also the psychological and social conditions that may affect a person's overall well-being in any setting [34]. Therefore, there is a requirement for a distinct set of norms or standards for pupils of various ages and educational stages [2]. Children frequently exhibit different thermal sensations than adults, therefore this should be taken into account when designing cozy and energy-efficient learning spaces [3].

Table 1: The classification of the receding study under personal and social criteria

Author and year	**Country**	**School level Naturally ventilated-NV/Air condition-AC/Combination of both CM**	**Season**	**Methodology (Rational, Adaptive, and Both)**	**Influencing sub-factors on main factors under personal and social criteria**	**Rf/no**
(R.L.Hwang-2009)	Taiwan	Primary + Secondary school-NV	Autumn –Winter	Both	Seasonal change outdoor temperature change (metabolic rate +clothing insulation)	[13]
(W.Zeiler-2009)	Netherlands	Primary school- AC	Spring–Winter	Rational	age (metabolic rate)	[60]
(K.E.Al.Rashidi-2009)	Kuwait	Secondary school-AC	N/A	both	Gender (metabolic rate)	[31]
(S.T.Mors -2011)	Netherlands	Primary + Secondary school-NV	winter, spring, summer	rational	Gender (clothing insulation)	[30]
M.Puteh-2012)	Malaysia	Secondary-NV	Monsoon season	other	Local thermal comfort (metabolic rate +clothing	[59]

					insulation	
Choyimanikan diyil, K. (2012)	India	Primary school-NV	Summer and winter	rational	outdoor temperature change (metabolic rate +clothing insulation	[11]
(D.Teli-2012)	U K	Primary school-NV	Spring–Summer	Both	age (metabolic rate)	[4]
(E.Z.E.Conceicao-2012)	Portugal	Kindergarten- MM	Summer –Winter	both	Age gender (metabolic rate +clothing insulation)	
(H.H.Liang-2012)	Taiwan	Primary +Secondary school-NV	Autumn –Winter	adaptive	outdoor temperature change (metabolic rate +clothing insulation	[18]
(V.D.Giuli-2012)	Italy	Primary school-NV	spring	Adaptive	outdoor temperature change (metabolic rate +clothing insulation	[15]
(M.C.Katafygiotou -2014)	Cyprus	Secondary school	N/A	Others	Age, adaptive behavior (metabolic rate +clothing insulation)	[36]
(H.yun-2014)	Korea	Kindergarten-NV	Spring–Summer	Both	age, gender (metabolic rate)	[20]
(V.D.Guili-2015)	Italy	Primary school-CM	Midseason	Both	Seasonal change, building maintenance and refurbishment, psychology (metabolic rate +clothing insulation)	[14]
(R.D.Dear-2015)	Australia	Secondary school-CM	Summer	Both	Local thermal comfort and (metabolic rate)	[16]
Choyimanikan diyil, K. (2016).	India	Primary school-NV	Summer and winter	rational	Seasonal change in outdoor temperature Change	[11]

					(metabolic rate + clothing insulation)	
(S.Haddad-2019)	Iran	Primary school-CM	Autumn – Summer –Winter	both	Seasonal change outdoor temperature change (metabolic rate + clothing insulation)	[12]
(Y.Liu-2016)	China	Secondary school-NV	Winter	Rational	socio-economic condition (clothing insulation)	[28]
(R.M.S.F.Almedia -2016)	Portugal	Primary + Secondary - NV	spring	Both	age gender, (Metabolic rate)	[52]
(A.M.Molina-2017)	Spain	Primary school-CM	Autumn –Winter	Rational	age, Socio-behaviour (metabolic rate + clothing insulation)	[50]
(M.Terbicock-2017)	Chile	Primary school-NV	Summer –Winter	adaptive	socio-economic condition (clothing insulation)	[27]
(A.Montazami -2017)	U K	Primary school-NV	Summer	adaptive	socio-economic condition And Socio-behaviour (clothing insulation)	[26]
(Manoj kumar- 2018)	India	Kindergarten to university-NV	Summer, winter, spring, autumn	Rational	Seasonal change outdoor temperature change age, social behavior (metabolic rate +clothing insulation)	[2]
(J.Kim-2018)	Australia	Primary and secondary-NV	Autumn	Both	Age, Social Behavior (metabolic rate +clothing insulation)	[58]
(S. Mishan 2019)	Nepal	Secondary school-NV	Autumn	Adaptive	Age, Gender (metabolic rate	[32]

					+clothing insulation)	
(M.A.Campano -2019)	Spain	Secondary school-CM	Autumn – Summer –Winter	Both	Age, Social Behavior (metabolic rate +clothing insulation)	[5]
(Y.H.Chen-2019)	Taiwan	Primary school-NV	Summer	Others	Age, psychological behavior (metabolic rate +clothing insulation)	[37]
(S.P.Korsavi-2020)	UK	Primary school-CM	All seasons	Adaptive	Seasonal change outdoor temperature change (metabolic rate +clothing insulation)	[21]
(J.Jiang-2020	China	Secondary school-CM	winter	Both	Seasonal change outdoor temperature change (metabolic rate +clothing insulation)	[23]
(H.A.Khatri-2020)	Arabia	Secondary school-AC	Summer	Both	age, gender (metabolic rate +clothing insulation)	[33]
(C.M.Rodrigue z-2021)	Colombia	Primary +Secondary	Summer -winter	Both	Age (metabolic rate)	[24]
betty lala-2022)	India	Primary school	summer and winter	Rational	Seasonal change outdoor temperature change (metabolic rate +clothing insulation)	[17]

Summary of the review:

From the above analysis Table-1, it indicated that the children show high sensitivity to thermal comfort, this has been identified due to poor metabolic rate from the preceding studies. These metabolic rates are influenced by their age, gender, and local thermal comfort also it varies based on seasonal change, where clothing insulation plays important role in thermal adaptation, especially during the winter and rainy seasons among children. It has been determined that children's socioeconomic status and local thermal comfort also have a significant impact on the insulation of their clothing. For example, wearing additional, thicker clothing was a common practice among students to reduce the chilly indoor air temperature in classrooms during the winter, though this was difficult for the kids from low socioeconomic backgrounds, proving the adage that the poorest in society are most affected by economic conditions. The fact that only a few schools have heating systems, and those that do only occasionally work because of financial restrictions, along with the fact that students preferred turning up fans in the summer, all point to the alleged fact that economic conditions are most strongly associated with health issues. Another finding from the analysis is that students' thermal sensitivity varies depending on where they are located. Those who are exposed to more extreme weather variations have greater thermal adaptability than those who live in areas with more consistent weather patterns; this may be because they have good metabolic rates for adjusting to local thermal sensations, but there have been relatively few studies on this subfactor. Therefore there is a scope for determining an assessment model addressing these unforeseen sub-factors such as

- Age
- Gender
- seasonal change
- Local thermal comfort
- Socioeconomic
- Adaptive Behaviour

to study adaptive thermal comfort in the primary and secondary school classroom environment under personal and social criteria

Influence of subfactors architectural criteria:

The quality of fresh air is determined by the CO2 content, whereas the air temperature is thought to be a key element that affects thermal comfort [61]. The children perceived the air to be fresher and classroom air quality to be considered to improve the task performance of the students[62] though the indoor air temperature has been influenced by outdoor climate [23] hence there is a need in complying with the design criteria regarding indoor air temperatures and CO2 concentrations [63] to create environments that reflect children's thermal preferences, advice is needed in school building design and refurbishment based on thermal comfort study with children [35]. Since the air temperature and mean radiant temperature have a significant impact on determining thermal comfort votes [64], in addition to other factors like air velocity and humidity, it is important to research the significance of these variables in school buildings and researching the impact [36] of the school's thermal comfort behavior was found to improve the indoor climate, and a refurbishment intervention in the exterior walls and windows was implemented [34]. A primary focus on reducing heating loads by protecting window openings to reduce incident solar radiation while maintaining appropriate interior environmental quality exacerbates the effects of poor ventilation and air purifier systems along with the inadequacy of present thermal systems [5]. The effects of ventilation rate and solar heat gain must be simultaneously considered in classroom window design to obtain the balance point [37]. Higher standards must be set in the design of school buildings using criteria based on children to account for children's sensitivity to extreme heat, summer comfort, global warming trends, and the challenge of designing school buildings with acceptable year-round thermal and energy performance [38] [39]. When compared to outdoor settings, the temperature environment within might also be appropriately guaranteed. By correctly measuring and assigning the fenestration places as well as the geometry of the space cross-section, you may promote natural ventilation [40]. We require a suitable manually regulated airing routine to provide thermal comfort [22]and the mechanically ventilated classroom had the greatest estimated average air-change rate [41]. The claimed efficiency is mostly caused by the poor building envelope, incorrect heating and lighting system control, a lack of appropriate legal actions, and, most importantly, a lack of interest in the reported efficiency [42]. Students favor the indoor air quality of the renovated classrooms, and the school with the worst microclimate conditions was likewise considered the worse for building-related and psychological reasons [14]. Additionally, including passive features in school buildings is necessary [19] and extremely successful in delivering indoor thermal comfort on hot and sunny days[44] to keep them thermally comfortable throughout the year while utilizing the amount of energy in the structures. The Classroom Comfort Index (ventilation type, window frame color, floor material, and frequency of vacuum cleaning) and the Classroom Symptom Index (location of school building, heating system, solar devices impeding opening windows or ventilation) are linked to the physical building characteristics of the classrooms [45]. the comfort of the student and, thus, their health, attitude, and performance can be improved by reconsidering and adjusting the operation of energy systems in a retrofitted building [46]. As a result, installing air conditioning in primary schools may not be necessary as it could result in excessive energy use and carbon emission [47]. Instead, passive design is advised to be used in the development and maintenance of school buildings. Additionally, there is a lot of possibility for passive design to adapt to children's requirements by using lower classroom temperatures [48].

Table 2: The classification of the receding study under Architectural criteria

Author and year	**Country**	**School level Naturally ventilated-NV/Air condition-AC/Combination of both CM**	**Season**	**Methodology (Rational, Adaptive, and Both)**	**Influencing subfactors on main factors under architectural criteria**	**Rf/no**
C.Nitatwichit - 2011)	Thai	Primary	N/A	other	Building envelope orientation and window Openings	[57]
(P.Wargocki-2013)	Denmark	Secondary school-AC	Summer	rational	Building envelope (openings, materials, and passive cooling/heating Technique)	[56]
(D.Teli-2014)	UK	Primary school-NV	Summer	Both	building maintenance and refurbishment	[35]
(J.Gao-2014)	Denmark	Primary school-AC	All seasons	Adaptive	Building envelope (openings, materials, and passive cooling/heating Technique)	[41]
System(R.M.S. F.Almedia-2015)	Portugal	Secondary school-CM	Spring–Summer –Winter	Others	building maintenance and refurbishment	[43]
(K.T.Huang-2015)	Taiwan	Primary school-NV	Autumn –Spring–Summer	Adaptive	Building envelope (openings, materials, and passive cooling/heating Technique)	[40]
(L.D.Pereira - 2015)	Portugal	Secondary school-NV	spring	Rational	building maintenance and refurbishment, psychology	[34]
AradhanaJindal- 2018)	India	Middle school, senior-NV	Monsoon and winter	Both	Building envelope (openings,	[19]

					materials, and passive cooling/heating Technique)	
(B.Hamzah-2018)	Indonesia	Secondary school.-NV	summer	Rational	Building envelope (openings, materials, and passive cooling/heating technique)	[48]
(P.M.Bluyssen-2018)	Netherlands	Primary school-NV	spring	others	Building envelope (openings, materials, and passive heating /cooling Technique)	[45]
(S.Monna-2019)	Palestina	Secondary school-CM	All seasons	others	Building envelope (openings, materials, and passive heating/ cooling Technique)	[44]
(T.Colinart-2019)	France	Secondary school	All seasons	others	Building envelope (openings, materials, and passive heating/ cooling Technique)	[46]
(C.M.Calama-Gonzalez-2019)	Spain	Secondary school-NV	All seasons	Adaptive	Building envelope (openings, materials, and passive heating/ cooling Technique)	[39]
(C.Munonye-2020)	Nigeria	Primary school-NV	Autumn –Spring	Both	Building envelope (openings, materials, and passive heating/ cooling Technique)	[47]

(C.Heracleous -2020)	Cyprus	Secondary school-CM	Summer –Winter	Adaptive	Building envelope (openings, materials, and passive heating/ cooling Technique)	[22]
(F.C.Barbosa-2020)	Portugal	Secondary school-CM	Spring–Winter	Others	building maintenance and refurbishment,	[55]

Summary of the review:

According to the study mentioned above in Table 2 air temperature has an impact on thermal comfort, and CO2 concentration influences the quality of fresh air. Fresh air perception also significantly affects students' work performance, thermal adaptability, and indoor air quality. The indoor air quality has been further influenced by the outdoor climate which shows an impact certainly on the children in their adaptive thermal behavior habits and psychological expectation. It is also found that air temperature along with mean radiant temperature has a significant impact influence in evoking the level of thermal comfort vote inside the building compared to other factors such as air velocity, and humidity. The challenge of designing school buildings with acceptable year-round thermal comfort and energy performance with architectural criteria for primary and secondary school students arises as a result of the need to provide suitable ventilation and air purifier systems along with the current thermal system. It is found from the study that these challenges can be addressed by the influence of the sub-factors such as building envelope enhances the heating and lighting system, passive design to provide positive environmental control system and operation, working with electrical fans and other HVAC systems, and the positioning of the windows and blinds in naturally ventilated classrooms also significantly affects adaptive thermal comfort. Renovation and maintenance are also regarded as subfactors since they can assist operation and have a beneficial effect on adaptive thermal comfort. Hence it has been confounding that these unforeseen subfactors

- Passive design
- Building maintenance and refurbishment
- Building envelop
- Orientation
- Placement of window

Which can support determining an assessment model to study adaptive thermal comfort in the primary and secondary school classroom environment under architectural criteria.

Assessment model and its influence on evaluation criteria:

Children showed a basic awareness of topics like temperature and heating when asked about comfort, but they didn't appear to understand the distinction between the two. When treating children, the adaptive approach must be taken into account [49]. Teachers' and students' subjective assessments of indoor thermal comfort were shown to differ, with students exhibiting a higher and more complicated threshold [50]. As a result, the inquiry considered various methods for determining the percentage of dissatisfied samples. If the correct expectancy factor is known based on a direct question on the acceptability under different climatic areas, Fanger's basic approach for the assessment of thermal comfort is effective also in naturally ventilated environments and could be helpful to obtain more precise expectancy factor values [51]. The predicted mean vote-predicted percentage of dissatisfaction (PMV/PPD) are model used to determine children's actual thermal sensation and percentage dissatisfied in the thermal comfort investigation in classrooms [12]. The metabolic rate must be adjusted when using the PMV analytical approach, thus the ideal method is to use children's body surface area as a correction factor [52]. When comparing results from real votes and votes based on thermal sense, the adaptive models used to determine students' neutral temperatures produced identical findings (TSV). The adaptive model emerged as the most effective approach for illuminating kids' thermal comfort in tropical elementary schools [53]. A poor decision may result in a flawed assessment of the overall quality of the indoor environment. Planning subjective surveys in circumstances that do not enable in-depth research of the entire building or recurrent analysis in representative moments may lead to this [54].

Table 3: The classification of the preceding study under the Evaluation criteria

Author and year	**Country**	**School level Naturally ventilated-NV/Air condition-AC/Combination of both CM**	**Season**	**Methodology (Rational, Adaptive, and Both)**	**Influencing subfactors on main factors under Evaluation critera**	**Rf/no**
(K.Fabbri-2013)	Italy	Kindergarten	Autumn	rational	Assessment model Social(age gender, Metabolism)	[49]
(F.R.A.alphano-2013)	Italy	Primary + Secondary-NV	Summer –Winter	rational	Assessment model and prediction (Fanger's model of assessment)	[51]
(R.M.S.F.Almedia -2016)	Portugal	Primary + Secondary -NV	Spring	Both	Assessment model and prediction Social(age gender, Metabolism)	[52]
(L.Pistore - 2019)	Italy	Secondary school.-NV	Heating season	Rational	Building envelope (openings, materials, and passive heating/ cooling Technique) assessment model	[54]
(S.Haddad-2019)	Iran	Primary school-CM	Warm season	Rational	Assessment model and prediction Social(age gender, Metabolism)	[12]
(B.Hamzah-2020)	Indonesia	Primary school-NV	Spring	Both	Assessment model and prediction Social(age gender, Metabolism)	[53]

Summary of the review:

It is challenging for children to understand questions and discussions about thermal comfort and fundamental concepts like temperature and heating because they appear to not understand the distinction between them, according to the study mentioned above in Table 3. Children with high and more difficulty in achieving the threshold for indoor thermal comfort, and also the adaptive model is considered to be one of the best methods for exploring thermal comfort in elementary school, also while using the predicted mean vote (PMV) analytical approach, the metabolic rate must be determined, and to use children's body surface as a correlation factor. Further considering the psycho-pedagogical point of questionnaire elaboration to provide an in-depth understanding of the difference between comfort and temperature and also fanger's basic approaches for the assessment of thermal comfort has been considered to be one of the effective methods for assessing thermal comfort in naturally ventilated (NV) classroom environment with rightly known expectancy factor. Further, the studies need to be focused on the specific climatic zone, where some of the zones worldwide still haven't been much explored Fig-4.

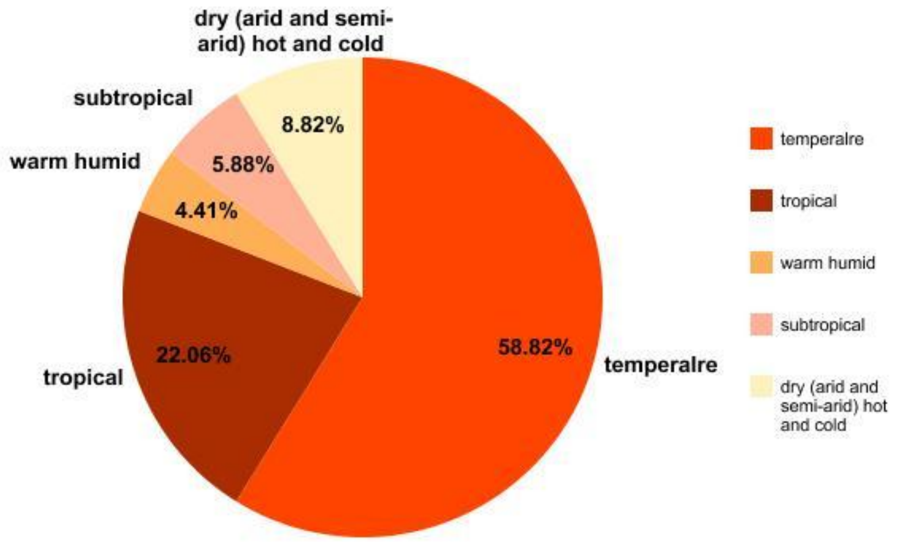

Figure 4: Percentage of fifteen years of thermal comfort studies conducted under certain climatic zones in primary and secondary school (2007-2022)

Hence these studies indicate that considering a strong children-based assessment model is one of the main factors which are influenced by unforeseen subfactors such as

- Expectancy factor
- Children's body surface /metabolic rate
- Psycho-pedagogical issue
- Climatic zone

to study adaptive thermal comfort in the primary and secondary school classroom environment under evaluation criteria.

Table 4: The influence of unforeseen factors on the foreseen factors under significant criteria in thermal adaptability for school children inside a classroom environment.

Foreseen the main factor	unforeseen sub-factor	No.fo journal highlighting the influence of unforeseen sub-factor on the foreseen main factor	Classified under criteria
• **Metabolic rate** • **Clothing insulation**	• Age • Gender • seasonal change • Local thermal comfort • Socioeconomic • Adaptive Behaviour	31	Personal criteria + Social criteria
• **Air temperature** • **Radiant temperature**	• Passive design • Building maintenance and refurbishment • Building envelop • Orientation • Placement of window	16	Architectural criteria
• **Assessment model**	• Psycho-pedagogical issue • Expectancy factor • Children's body surface /metabolic rate • Climatic zone	6	Evaluation criteria

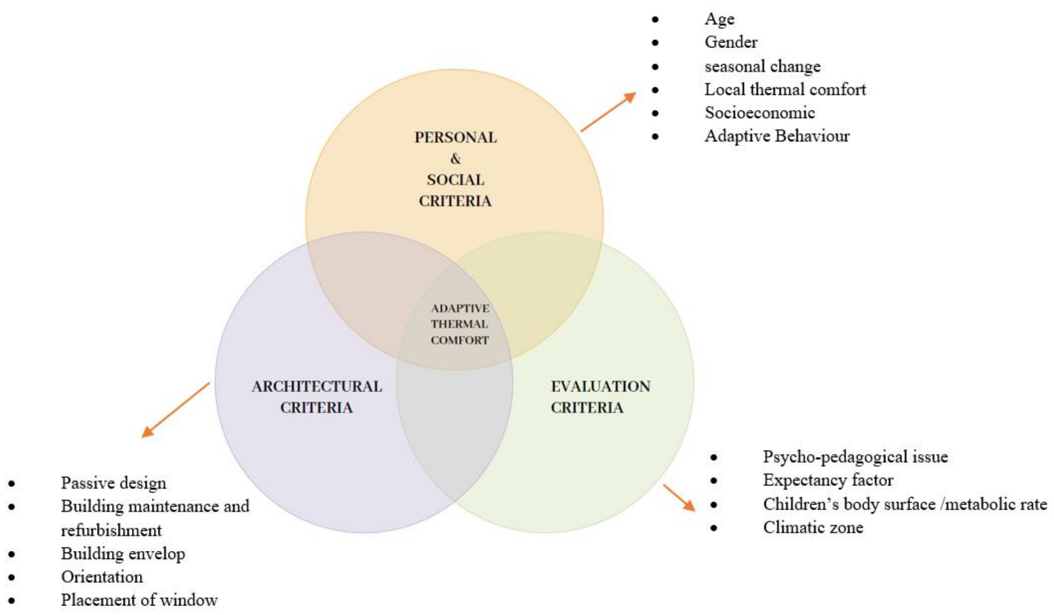

Figure 5: The conceptual assessment model

3. Conclusion and future direction of the study:

The metabolic rate of the school children has been influenced by seasonal change, local thermal comfort, and also their age, and gender it can also have scope for further missing attributes in the preceding study such as height, weight, and size of the children. In further, the seasonal change that led to clothing insulation of these children is certainly influenced by their socioeconomic condition this impacts children, especially those from economically weaker or low-income sections, this could be one of the issues that could negatively impact the student's performance and their well being in most of the developing or under developing countries government school classroom environment. From the above study, it has been observed that When it comes to air temperature, and radiant temperature, as factors the building characteristics play an important role which is influenced by building passive design, building maintenance, and refurbishment placement of windows has an unavoidable impact on the students in thermal adaptability, task performance and well being. From the above review, there has been a gap in determining whether the children-based assessment model is one of the main factors which are influenced by unforeseen subfactors such as expectancy factor, children's body surface /metabolic rate, Psycho-pedagogical issue and climate, as it is difficult for children to express their thermal perception compared to adults with a straight direct approach, it is a challenging task for the researchers to address these attributes in a holistic approach that can further help in conducting a field study under a case-specific to determine their impact level in the study.

For this, the study has to be conducted under three major criteria such as Fig-5 1. personal criteria (Age, Gender, seasonal change, and, Local thermal comfort) and social criteria (Socioeconomic, Adaptive Behaviour) 2. Architectural criteria (Passive cooling and heating, Building refurbishment, Building envelope, Orientation, Placement of window) 3. Evaluation criteria (Expectancy factor, Children's body surface /metabolic rate, Psycho-pedagogical issue, and climatic zone) Additionally, investigations must concentrate on a particular climatic zone because many of the world's zones have not yet been sufficiently examined. Fig-4. Thus from the above literature investigation, it has been revealed that the four main influencing factors of thermal comfort (air temperature, radiant temperature, metabolic rate, and clothing insulation) prescribed by the standards have been certainly influenced by unforeseen subfactors such as (Age, Gender, seasonal change, Local thermal comfort, Socioeconomic, Adaptive Behaviour, Passive cooling and heating, Building refurbishment, Building envelop, Orientation, Placement of window, Assessment model). Hence these identified sub-factors can act as an additional attribute for the assessment of adaptive thermal comfort in primary and secondary school children in a classroom environment, to check further, the study will be directed at developing an assessment model with these attributes with a specific case study of primary and secondary school children in a classroom environment under a specific climatic zone in India as there are only very few studies have been identified for this context.

Reference:

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