Thermal comfort studies of primary school students in Tangerang, Indonesia

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Abstract
A thermal comfort study has been conducted in two primary schools in Tangerang, West Java, Indonesia. The first school was a state school with all of its classrooms were naturally ventilated (NV). The second one was a private school with its classrooms was air conditioned (AC). Climatic parameters, i.e. air and globe temperatures, relative humidity and air velocity were recorded along with the seven-scale subjects’ comfort vote. There were 501 pupils in the state school, consists of 252 males and 249 females involved in this study, while in the private school 207 pupils involved in this study, consists of 125 males and 82 females. Subjects were between 8 and 13 years old in the state school and 9 and 13 years old in the private school. Subjects’ comfort temperature in the NV state school was about 1.5 °C higher than comfort temperature of subjects in the AC private school. The pupils’ comfort temperatures in both schools were higher than the current Indonesian comfort standard. This paper discusses the whole study and draws some conclusions from it.

Keywords: air conditioning (AC), comfort temperature, Indonesia, naturally ventilated (NV), primary school

1 Introduction
A thermal comfort study has been conducted in two primary schools in the town of Tangerang, Indonesia. Tangerang is a medium town located next to the Indonesian capital city of Jakarta at 6° south latitude, This town is in the warm, humid tropical climate, and has two main seasons throughout the year: dry and rainy seasons. Like in most of the other Indonesian towns, the diurnal and annual outdoor temperature variation in Tangerang is very small. There has been almost no temperature difference throughout the year. The monthly average outdoor temperature and daily temperature are about the same throughout the year, which is around 28 °C. During the rainy season, the outdoor temperature tends to be slightly lower by about 1 to 2°C than in the dry season (Indonesia Climate, online, 2015).

The study was conducted in two primary schools, the one which is naturally ventilated (NV) is belonged to the government and the other, which is air conditioned (AC) belongs to a private institution. Not all the state schools are naturally ventilated, neither all the private schools are air conditioned. However, on average, the private primary schools tend to be air conditioned, while most of the state primary schools are naturally ventilated. In this private school, the split-unit AC system was used in every classroom and also in the school offices. The AC units started to turn on at about 6.15 am, just about 15 minutes before the class begins at 6.30. The units were turned off soon after the class end at about 3 pm.
There might be some small socioeconomic backgrounds between pupils in the state and private schools. However, there was no further investigation in this study whether or not pupils were using AC in their homes. In terms of socioeconomic backgrounds, on average, pupils in the private school have a better economical background than those in the state school. Entering the state schools is free, while it does not apply to private schools, in which pupils must pay. Therefore, on average, pupils in the private school tend to come from rich families, although the gap might be not so big. Some good students tend to go to the state schools as they are free and the schools’ qualifications tend to be higher than in the private ones. Since these two schools were closely located, only separated about 200m, pupils from both schools tend to live side by side.

In the Indonesian educational system, a primary school has six grades; started from grade one and ended at grade six. In some established and good schools, pupils start their first grade at the age of 7 or 6.5 years old; however, most of ordinary school pupils can start their first grade at the age of 6 or even 5 and can be at 8 years old. So, they finish their study at the age of between 11 and 13 years. Following the primary school, pupils will continue their studies for three years in the secondary school and another three years in the high school. This study intends to select the subjects of pupils in the primary schools, from grade four and above, therefore, pupils participated in this study were between 8 and 13 years old.

A number of thermal comfort studies have been conducted in the primary schools (Humphreys, 1977; Teli, et al, 2012; Wong, 2003), however, there has been no report on thermal comfort study of young people, involving school pupils in Indonesia. About 9% of the Indonesian population are those in the age of between 5 and 14 years old (Index Mundi, 2015), and most of them are primary school pupils who also need to be thermally comfortable when engaging their school activities in the classrooms. An Indonesian comfort standard based on the SNI 6390:2011 (BSN, 2011) states a comfort range for adults who work mainly in the office building. Having no thermal comfort studies of people in younger age in this country, this study is an attempt to see whether the young people aged between 8 and 13 may have a similar comfort temperature such as adult people.

To answer this kind of curiosity, two primary schools, which are separated about 200 meters, are selected for thermal comfort studies. The first primary school is a state-own school, with all of the classrooms were naturally ventilated, with a small fan attached to the wall above the open windows in every classroom. The second primary school is a private-own school, with every classroom had one split-unit air conditioner (AC), attached to the wall above the closed windows. There was also a ceiling fan provided in every classroom in this private school.

In terms of the number of subjects, there were 501 pupils in the state school, consisting of 252 males and 249 females aged between 8 and 13 years old involved in this study, while in the private school there were 207 pupils, consisting of 124 males and 83 females, aged between 9 and 13 years old participated in this study.

Figure 1 shows the state primary school buildings. The buildings are single floors with tile pitch roofs. There are verandas at the front of the classroom used as corridors to access to the classrooms. The buildings were naturally ventilated, having high-level windows on the corridor sides and low-level windows on the opposite walls.
Figure 1 Tangerang state’s primary school

Figure 2 shows the private primary school building. The building consisted of four floors with its top level was used as an auditorium. The building was air conditioned with a minimum cooling, aimed to minimize the use of electricity energy, creating the indoor temperatures not quite low, about 27.8 °C on average.

The basic reasons for comparing these two school buildings is, firstly, these two schools were located closely in the same area with about 200 m away between each other; secondly, they had a different rooms’ cooling systems, one was naturally ventilated and the other was air conditioned. The thing to be investigated is whether subjects, with similar ages, participating in this comfort study would have different comfort temperatures due to the different cooling systems in the classrooms; one was naturally ventilated and the second was air conditioned.

A number of thermal comfort studies showed that comfort temperatures of subjects in NV buildings tended to be higher than subjects in AC buildings. Yang and Zhang’s comfort study (Yang et al, 2008) showed that subjects in the NV buildings felt comfortable at 28.3 °C, while
those in the AC buildings were comfortable at 27.7 °C, which is about 0.6 degrees lower. A comfort study by de Dear, et al in Singapore (de Dear et al, 1991) showed that subjects in the NV buildings were comfortable at 28.5 °C \( T_o \), while subjects in the AC buildings were comfortable at a lower temperature of 24.2 °C \( T_o \). Busch (Busch, 1990) has done a comfort study in Bangkok, Thailand, showed that subjects in NV buildings were comfortable at 28.5 °C effective temperature (\( ET \)), which was higher than the subjects in AC buildings who were comfortable at 24.5 °C \( ET \).

A comfort study by Karyono (Karyono, et al, 2015) involving students from two different universities in Jakarta showed that students having full AC in their homes tend to have a lower comfort temperature than those homes were not air conditioned. It seems that people tend to adapt to their surrounding thermal environment. Karyono’s study (Karyono, 1996) showed that, on average, people live in the warm and humid tropical climate in South East Asia countries have a higher comfort temperature than people live in the temperate regions. The long exposure to the high temperatures in the tropics tends to raise comfort temperatures of people in these regions. A comfort study done by De Vecchi, et al showed that subjects being exposed to AC were more intolerable with the higher temperatures compared to those unexposed (De Vecchi, et al). de Dear and Brager develops the adaptive ASHRAE comfort standard by reanalyzing data on thermal comfort studies across the world (de Dear, et al, 1997; Brager, et al, 2001) showed that comfort temperatures tend to have a correlation with the average monthly temperature at any given location. It was found that, the higher the average running mean temperature experienced by a person, the higher the comfort temperature would be for this person (Nicol, et al, 2012).

2 Methodology
There were 501 pupils in the state school, consists of 252 males and 249 females ages between 8 and 13 years old involved in this study, while in the private school there were 207 pupils, consists of 124 males and 83 females, ages between 9 and 13 years old participated in this study.

Subjects were asked to give their personal data such as age, weight and height, and their thermal sensations votes (TSVs) based on the ASHRAE (ASHRAE, 2010) seven-point thermal sensation scale [19]: Cold (−3), Cool (−2), Slightly cool (−1), Comfort (0), Slightly warm (+1), Warm (+2) and Hot (+3). All the questions were written on the questionnaire sheets, using the Indonesian language. The ASHRAE seven-point scale was translated carefully to this language to have the same thermal meaning. A similar seven-point scale’s translation has been used many times in the thermal comfort studies carried out in this country. In terms of ‘0’ category, it’s described as ‘comfort’ not ‘neutral’ as it usually did to ask adult subjects in some thermal comfort investigations. The word ‘neutral’ was avoided to be used in this study as the central category in the thermal sensation choices as we suspect the pupils would not understand the meaning. The word ‘comfort’ was used instead, assuming that this would be easier to be understood by the pupils. Pupils filled in the questionnaire by themselves independently.

There were short of instruction given to the pupils in both of the schools before the investigation took place in every classroom. The researchers introduced briefly about the purpose of the research and the way to fill in the questionnaire sheets. Pupils were instructed to fill in the questionnaire independently based on their own thermal sensation feeling. This study involved pupils who were already in the grade 4, 5 and 6, not in the lower
grades. The reason was, pupils in the upper grades might have more understanding and more awareness about their thermal sensation occurred in their immediate environment than those in the lower grades. In terms of the ability to read the text, in the Indonesian educational system, starting in grade 2 pupils should be able to read a rather complex text like a newspaper. So, the reason not to involve pupils in the lower grades in this study was not related to this matter. During the investigation, the researchers were easily supervising the pupils to answer the questions independently since there were only three to five pupils in a group. While pupils filled in the questionnaires, some climatic parameters were recorded: air temperature ($T_a$), globe temperature ($T_g$), relative humidity ($RH$) and air velocity ($V_a$).

The air temperature was recorded using an alcohol thermometer (resolution 0.1°C), the globe temperature was recorded with a 15cm-diameter globe thermometer of thin-walled coppersphere painted black (resolution 0.1°C), the relative humidity ($RH$) was recorded with DEKKO 642 Digital Thermo-Hygro Meter (resolution 0.1%) and the air velocity was measured by a digital anemometer SANVIX GM8908 (resolution 0.1m/s). The anemometer, thermometer and the thermo-hygrometer were checked for calibration by using similar laboratory equipment.

Figure 3 shows the atmosphere of the measurement in the state primary school, while Figure 4 shows the atmosphere of the measurement in the private primary school. Since all the pupils were sitting during the investigation, and due to the limitation of spaces, the probes were mounted on the tables, about 70 cm above the floor, which did not fulfil compliance with ISO 7726, which requires 0,10 m, 0,60 m, 1,10 m for a seated person (ISO 7726, 1998).

Measurements were taken mostly during the rest hours when the pupils had no formal lectures. Pupils were seated in a group of three to five, when the measurements were taken. The measurements were repeated in different time with similar subjects. Therefore, most of the pupils had voted twice during the investigation. All the measurements took place between September and November 2014, between 8am and 2pm. All the data were tabulated and analysed by Microsoft Office Excel 2007, while the statistical tests were done with Statistical Package for the Social Sciences (SPSS) version 17.
3 Data and Analyses

3.1 Data on Participants

Subjects were primary school pupils with their school uniforms and engaging light activities in the classrooms. Table 1 shows the statistical data of subjects participating in this study. In the state primary school, subjects were between 8 and 13 years old, with an average of 10.4 years and SD of 0.8 years. In terms of height, only 301 out of 501 subjects indicated their heights. The shortest subject was 110 cm and the tallest was 165 cm with an average of 138.6 cm and standard deviation (SD) of 10 cm. In terms of weight, only 350 out of 501 subjects indicated their weights. Subjects’ weights were between 20 and 65 kg with an average of 32.8 kg and SD of 7.5 kg. The estimated clothing insulation of the subjects, wearing their school uniforms, were between 0.26–0.44 clo.

<table>
<thead>
<tr>
<th>Type of School</th>
<th>Gender</th>
<th>Descriptive statistic</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Estimated clothing value (clo)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>n</td>
<td>501</td>
<td>301</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>8</td>
<td>110</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>10.4</td>
<td>138.6</td>
<td>32.8</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>13</td>
<td>165</td>
<td>69</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.8</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Primary School</td>
<td>124</td>
<td>83</td>
<td>n</td>
<td>207</td>
<td>151</td>
<td>196</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>9</td>
<td>120</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>9.8</td>
<td>141.2</td>
<td>31.4</td>
<td>5.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>13</td>
<td>165</td>
<td>69</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.8</td>
<td>9.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the private primary school, subjects were between 9 and 13 years old, with an average of 9.8 years and SD of 0.8 years in terms of height, only 151 out of 207 subjects indicated their heights. The shortest subject was 120 cm and the tallest was 165 cm with an average of 141.2 cm and standard deviation (SD) of 9.9 cm. In terms of weight, only 196 out of 207
subjects indicated their weights. Subjects’ weights were between 20 and 69 kg with an average of 31.4 kg and SD of 5.9 kg. The estimated clothing insulation of the subjects, wearing their school uniforms, were between 0.26–0.44 clo.

3.2 Data of Indoor Climatic Parameters and the distribution of subjects’ Thermal Sensation Vote

Table 2 shows data of indoor climate, while Table 3 shows the distribution of the thermal sensation vote (TSV) in the state and private primary schools. In the state primary school, the measured indoor air temperatures were between 28 and 34.7 °C with an average of 32.3 °C and SD of 1.7 °C. The globe temperatures were between 28 and 34.8 °C with an average of 32.2 °C and SD of 1.7 °C. Both in the state and private schools, the air and globe temperatures tend to be identical. This is a reflection of the small variation of outdoor temperature in the warm and tropical climate such as Indonesia, and due to the small difference between the indoor temperature of the classrooms and the outdoor temperatures of the surrounding building.

The indoor RH ranged between 55 and 83% with an average of 65.7% and SD of 8%. Measured by an anemometer, the air velocities were between 0 and 0.4 m/s with an average of 0.01 m/s and SD of 0.05 m/s. In the humid and tropical climate such as Tangerang, air movement is very low and tend to be still in the indoor environment. Only in some spots of measurements which were close to the fan, the air movements reached the highest speed about 0.4 m/s, while in many spots away from the fan, the air movements were still \(V_a = 0\) m/s.

<table>
<thead>
<tr>
<th>Type of School</th>
<th>Descriptive statistic</th>
<th>Air temp (^\circ\mathrm{C})</th>
<th>Globe temp (^\circ\mathrm{C})</th>
<th>RH (%)</th>
<th>Air velocity (\text{m/s})</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Primary School</td>
<td>Min 28</td>
<td>28</td>
<td>55</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean 32.3</td>
<td>32.2</td>
<td>65.7</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max 34.7</td>
<td>34.8</td>
<td>83</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD 1.7</td>
<td>1.7</td>
<td>8.0</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of School</th>
<th>No of Subject</th>
<th>−3 Cold</th>
<th>−2 Cool</th>
<th>−1 Slightly cool</th>
<th>0 Comfort</th>
<th>+1 Slightly warm</th>
<th>+2 Warm</th>
<th>+3 Hot</th>
<th>Mean vote</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Primary School</td>
<td>501</td>
<td>0</td>
<td>6</td>
<td>19</td>
<td>46</td>
<td>138</td>
<td>229</td>
<td>63</td>
<td>1.5</td>
</tr>
<tr>
<td>Private Primary School</td>
<td>207</td>
<td>0</td>
<td>23</td>
<td>19</td>
<td>28</td>
<td>69</td>
<td>53</td>
<td>15</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Figure 5 shows the atmosphere of the classroom at the state primary school. A single fan is attached above the window of the classroom. Figure 6 shows the atmosphere of the classroom at the private primary school where a ceiling fan is provided, including a single split AC unit attached above the windows.
Subjects’ thermal votes were distributed in such a way in which out of 501 respondents, 46 (9.2%) were neutral, 430 respondents (85.8%) voted in the warm and hot sides and only 25 (5%) were in the cool sides. The mean vote was 1.5, which means, on average, subjects were felt uncomfortably warm.

In the private primary school, the measured indoor air temperatures were between 24.4 and 30.8 °C with an average of 27.8 °C and SD of 1.8 °C. The globe temperatures were between 24.5 and 31 °C with an average of 28 °C and SD of 1.9 °C. The indoor RH ranged between 53 and 81% with an average of 66.9% and SD of 8.1%. Measured by an anemometer, the air velocities were between 0 and 0.4 m/s with an average of 0.1 m/s and SD of 0.1 m/s. About at the centre of the classroom below the ceiling fan, the air movements reached the highest speed about 0.4 m/s, while in many spots away from the fan, the air movements were still ($V_a = 0$ m/s).

Subjects’ thermal votes were distributed in such a way in which 28 respondents (13.5%) were neutral, 137 respondents (66.2%) voted in the warm and hot sides and only 42 respondents (20.3%) were in the cool sides. The mean vote was 0.7, which means, on average, subjects were felt toward a slightly warm.
3.3 Comfort temperature and comfort range in the State Primary School

To find out the neutral temperature and comfort range of the subjects, linear regression analyses were conducted by using Microsoft Office Excel 2007, while the statistical test were analysed by SPSS version 17. Comfort temperature is defined as a temperature where the TSV is zero, while a comfort range is defined as a range of temperatures where the TSV is between -0.5 and +0.5 (Fanger, 1970). When the comfort temperature is achieved, it’s expected that about 95% of the subjects are comfortable, while within the comfort range, about 90% of subjects would be comfortable (Fanger, 1970).

Figure 7 shows the regression line of thermal sensation votes (TSV) on air temperature ($T_a$) in the state primary school. This regression produces an equation of $TSV = 0.375T_a - 10.575$, with a coefficient of determination ($R^2$) of 0.37. The correlation between TSV and $T_a$ is significant ($p<0.01$). This has produced a neutral temperature of subjects as 28.2 °C and subjects comfort range of between 26.9 and 29.5 °C.

Analysing the regression line of thermal sensation votes (TSV) on globe temperature ($T_g$) of the state primary school (SPS), it produces an equation of $TSV = 0.386T_g - 10.928$, with a coefficient of determination ($R^2$) of 0.37. The correlation between TSV and $T_g$ is significant ($p<0.01$). This has produced a neutral temperature of subjects as 28.2 °C and subjects comfort range of between 27.0 and 29.6 °C. The result was almost identical to the air temperature, therefore the regression graphic is not provided in this paper.

3.4 Neutral Temperature and Comfort Range of Subjects in the Private Primary School

Figure 8 shows the regression line of thermal sensation votes (TSV) on air temperature ($T_a$) in the private primary school. This regression produces an equation of $TSV = 0.576T_a - 15.282$, with a coefficient of determination ($R^2$) of 0.54. The correlation between TSV and $T_a$ is significant ($p<0.01$). This has produced a neutral temperature of subjects as 26.7 °C and subjects comfort range of between 25.7 and 27.4 °C.

Analysing the regression line of thermal sensation votes (TSV) on globe temperature ($T_g$) of the private primary school. This regression produces an equation of $TSV = 0.539T_g - 14.338$, with a coefficient of determination ($R^2$) of 0.52. The correlation between TSV and $T_g$ is significant ($p<0.01$). This has produced a neutral temperature of subjects as 26.6 °C and subjects comfort range of between 25.7 and 27.5 °C. The result was almost identical to the air temperature, therefore the regression graphic is not provided in this paper.
Table 4 shows the neutral temperatures, comfort ranges, regression equations and the $R^2$ values of the study in the state and private primary schools.

![Regression line of thermal sensation vote on air temperature in the private primary school](image)

**Figure 8** Regression line of thermal sensation vote on air temperature in the private primary school

### 3.5 Neutral Temperature and Comfort Range of Subjects in the State and Private Primary School

Table 4 shows the subjects’ comfort temperature and comfort range in the state and private schools. In terms of air temperature, subjects in the state school were comfortable at 28.2 °C, which was about 1.5 °C higher than subjects’ comfort temperature in the private school, which were comfortable at 26.7 °C. The difference was significant ($p<0.01$). In terms of globe temperature, subjects in the state school were comfortable at 28.2 °C, which was about 1.7 °C higher than subjects’ comfort temperature in the private school, which were comfortable at 26.6 °C. The difference was significant ($p<0.01$).

The comfort temperatures of both pupils in the state and private schools are about 1 to 2.5 °C higher than the current Indonesian comfort standard based on the SNI 6390:2011 (BSN, 2011), which states a comfort temperature of 25.5 °C with a range of ± 1.5 °C.

Comparing this study with a previous comfort study in the NV buildings in Jakarta (Karyono et al, 2015) with a similar prevailing outdoor temperature, the comfort temperature of subjects in the NV schools was slightly lower. The previous study shows that subjects with the NV buildings (Cathedral, museum and market) were comfortable at 27.7 and 27.3 °C (Karyono et al, 2015), which were about 0.5 to 0.9 °C lower than in the NV school.

Wong et al study in Singapore showed that the neutral temperature of the pupils in the NV classrooms was 28.8 °C, which was relatively close to the comfort temperature of the Indonesian pupils in the state NV buildings (Wong et al, 2003). Kwok et al study in Hawaii showed that pupils in the NV buildings were comfortable at 26.8 °C, while in the AC buildings was 27.4 °C. Hawaii’s study showed an opposite result with the Indonesian study, in which pupils in the Indonesian state NV schools were more comfortable at a higher temperature than in the private AC schools (Kwok et al, 1998). de Dear et al found the neutral temperature of Australian school students aged 10 to 18 years were about 22.5 °C operative temperature (de Dear et al, 2014), which was lower than the comfort temperature of the Indonesian pupils in this study.
In this study, the $R^2$ of TSV in both air and globe temperatures were lower in the state school than in the private school. The spread of the subjects’ comfort range was wider in the state school than in the private one. The range was about 2.6 °C in the state school while in the private school was narrower, about 1.7 °C. This figure shows that there was a larger variation in thermal responses in the state school than in the private school. The low $R^2$ in the state school also gives the same indication that the pupils’ thermal responses had larger variation.

This has been indicated in the thermal comfort study by Teli et al in the UK primary school (Teli, et al, 2012) that even when the average assessed thermal sensation were neutral, slightly warm or slightly cool, there were a number of pupils who gave a more extreme evaluation, such as voting within (-3,-2) or (+2, +3).

The lower the $R^2$ and the wider the spread of comfort temperature in the state school than in the private school could be a matter of adaptation, in which subjects in the NV buildings tend to be more tolerable and adaptable to the changing of their thermal environment.

| Table 4 Neutral temperature ($T_a$) and comfort range ($T_{cr}$) in the state and private primary schools |
|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------|-----------------------------------------------|
| Climatic parameters | Comfort temp (°C) ($T_a + 95\%$ comfortable) | Comfort range (°C) ($T_{cr} + 90\%$ comfortable) | Regression equation | Coefficient of determination /correlation ($R^2 / r$) | Significance |
| State Primary School | Air Temperature | 28.2 | 26.9 to 29.5 | $T_{SV} = 0.375T_a - 10.575$ | 0.37 / 0.61 | p<0.01 |
| | Globe Temperature | 28.3 | 27.0 to 29.6 | $T_{SV} = 0.386T_g - 10.928$ | 0.37 / 0.61 | p<0.01 |
| Private Primary School | Air Temperature | 26.7 | 25.7 to 27.4 | $T_{SV} = 0.576T_a - 15.282$ | 0.54 / 0.73 | p<0.01 |
| | Globe Temperature | 26.6 | 25.7 – 27.5 | $T_{SV} = 0.539T_g - 14.338$ | 0.52 / 0.72 | p<0.01 |

4 Conclusions

Thermal comfort study in the two primary schools in the town of Tangerang, Indonesia has shown that pupils aged between 8 and 13 years in the state NV school have a higher comfort temperature than pupils in the private primary school. In terms of air temperature, the state school pupils were comfortable at 28.2 °C $T_a$, which was about 1.5 °C higher than pupils in the private school, which were comfortable at 26.7 °C $T_a$. The difference was significant at 95% confidence level. In terms of globe temperature, subjects in the state school were comfortable at about 1.7 °C higher than subjects’ comfort temperature in the private school. Subjects’ comfort temperature in the state school was 28.2 °C $T_g$, while in the private school subjects were comfortable at 26.6 °C $T_g$. The difference was significant ($p<0.01$). The comfort temperatures of the pupils both in the state and private schools were about 1 to 2.5 °C higher than the Indonesian comfort standard.

The comfort temperature and comfort range both in the air and globe temperatures are practically identical. In the warm and humid tropical climate, the daily, monthly and annual outdoor temperature variations are very small. This tends to create a small difference between air temperature and globe temperature in a number of investigations, such as in this study.
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References


