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# Teachers' Perceptions of Climate Change Induced Heat Stress and Related Heat Management Strategies In Singapore's Schools

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## Abstract

Global warming is palpable in Singapore. Given that most classrooms in the country are largely affected by rising ambient temperatures, students are susceptible to heat stress, which undermines their learning productivity. This qualitative study sought to understand what six secondary school teachers in Singapore thought about the adverse effects that climate change induced warming can have on their students' learning. While thermal discomfort was a real issue to contend with, this study found that its effects on productivity varied across time, from student to student, and among schools. Instead of relying on cooling methods that involved the further use of energy/resources for temporary thermal relief, the recommendations/strategies for dealing with heat stress mentioned by the teachers were far more sustainable and contextually specific.

## Introduction

Annual mean temperatures in Singapore have been on the rise due to global warming. According to the National Environment Agency (NEA 2020), 2010 to 2019 has been identified as the warmest decade on record, with 2019 being deemed the warmest year (at an annual mean temperature of 28.4°C). As climate change continues to persist, temperatures are expected to rise by 1.4°C to 4.6°C (National Climate Change Secretariat, n.d.; Chow, 2018) in the future. This warming implies an urgent need for managing thermal comfort on a variety of scales.

Students experience heat stress when they are maladjusted to temperature changes (Spector and Sheffield, 2014; Bidassey-Manilal et al. 2016). Thermal discomfort due to heat stress adversely affects one's physiology as well as contribute to a decline in cognitive functioning, which would in turn reduce one's learning ability/productivity (Albouy et al., 2016; Park, 2016; Goodman et al., 2018). Accordingly, this study sought to understand what secondary school teachers thought about heat stress and how it could affect their students' learning productivity. In highlighting the heat management strategies that were mobilised in Singapore's public schools, this paper contended that such strategies would have to be sustainable (e.g. energy efficient, affordable) in order for it to be feasible or practical (e.g. easy to implement).

The research questions that guided this study were:

1. What were the teachers' opinions on how climate change induced heat stress had affected their students' learning productivity?

2. What kinds of strategies had been employed to cope with heat stress and to create a more conducive learning environment?

3. How else can the learning environment in schools be sustainably managed in light of a persistent climate change induced warming?

## Background on ambient temperatures, heat stress and productivity

Researchers have found that Indoor Environment Quality (IEQ) determines the productivity or performance of an individual in a workplace (Roelofsen 2002; Kosonen and Tan 2004). Various factors such as sound level, lighting and air quality contribute to IEQ, with the thermal environment being identified as one of its most important aspects. The thermal environment consists of parameters such as air temperature, mean radiant temperature, air velocity and air humidity. Notably, ventilation affects air flow/velocity, and in turn, thermal sensation (Al Horr et al. 2016). Besides objective aspects of the physical environment, thermal discomfort is also dependent on an individual's subjective sensory perception of the thermal environment (i.e. thermal sensation, ASHRAE, 2010). One's thermal sensation is a result of one's thermal balance, influenced by factors such as metabolic heat production, physical activity and clothing (Kosonen and Tan 2004).

Thermal discomfort from warm temperatures and a resultant poor IEQ can result in a condition known as Sick Building Syndrome (SBS). SBS is characterised by headache, difficulty concentrating, fatigue and lethargy (Krogstad, et al. 2001; Haneda, et al. 2009). Researchers have shown that more physical and mental effort is required for performing tasks in thermally warm environments. Physiological changes from heat exposure such as a rise in salivary cortisol levels, increased heart rate, respiratory ventilation and dips in oxygen saturation in the arteries may lead to heightened psychological stress and reduced mental arousal overall (Tham and Willem, 2010). It can also cause individuals to be less willing to exert themselves (Lan et al. 2011). Moreover, it has been argued that such physiological responses to heat might not go away even with habituation.

Students all over the world have been affected physically and cognitively by global warming. Researchers have reported that an increase in ambient temperature negatively affects students' productivity/performance (e.g. sleepiness, reduced concentration) and general well-being (e.g. headache, thirst, feeling breathless, Bidassey-Manilal et al. 2016; Park 2016; Al Horr et al. 2016). Schools have employed adaptive strategies to alleviate heat stress among their students, with the most common ones being the installation of cooling technologies (e.g. ceiling fans, air-conditioning, Park 2016) as well as improving the space's ventilation either mechanically or naturally (e.g. opening windows/doors, Rajkumar et al. n.d.). Nevertheless, these researchers have recognised that these strategies are subject to the schools' financial capabilities and resource availability (Wargocki et al. 2005; Bidassey-Manilal et al. 2016). Not only is air-conditioning high in environmental and financial costs, doing so would also potentially affect indoor air quality (Wong and Khoo, 2002). In tropical Singapore, cross-ventilation and mechanical ventilation systems are frequently put in place to deal with the heat and humidity in the classrooms (ibid.). Where this is not possible, other methods include rescheduling strenuous activities to take place during cooler periods of the day and providing allowances for students to purchase a cool beverage or install a desk fan. Taking this as a point of departure, this qualitative project attempted to find out more about sustainable and feasible ways of coping with thermal discomfort in Singapore's public schools.

## Methodology

A semi-structured interview was conducted individually with 6 full-time secondary school teachers in Singapore. During the interview, the respondents were asked to talk about the changes in their students' behaviour during temperature spikes or warmer periods of the day. They were also prompted to share their thoughts on the strategies that they or their schools implemented to deal with heat stress. These interviews were carried out virtually via on-line video calls due to the Covid-19 pandemic. They were then recorded, transcribed and coded based on recurring themes before being de-identified to keep the respondents' identities anonymous. These teachers were purposefully sampled (see Palinkas et al. 2015) to include a mix of respondents from different school types to flesh out how infrastructural differences and varying degrees of autonomy in decision making might affect attempts to improve the students' the learning environment. Out of the 6 respondents, 4 (R2, R4, R5, R6) were teachers in government schools. R1 was a teacher in a government-aided school while R3 was a teacher in an autonomous school offering an Integrated Programme. There was a good mix of teachers with a range of teaching experience as well (Table 1):

Table 1: Profile of respondents based on gender and teaching experience

| **Respondent** | **Teaching Experience** |
|---|---|
| R1 | Male; beginning teacher (BT) with close to one year of experience teaching full-time in a government-aided secondary school. |
| R2 | Female; has been teaching in her current government school for seven years. |
| R3 | Male; taught in a government school for over six years prior to teaching in an autonomous IP school for 10 months. R3 is currently serving as a Subject Head. |
| R4 | Male; beginning teacher (BT) with close to one year of experience teaching full-time in a government secondary school. |
| R5 | Male; beginning teacher (BT) with close to one year of experience teaching full-time in a government secondary school. |
| R6 | Female; taught in an autonomous and an independent school for 16 years before currently teaching in a government school for four years. R6 is currently serving as a Head of Department. |

## Effect of increased temperatures on students' learning productivity

All the teachers observed changes in their students' behaviour (e.g. becoming more fidgety and/or talkative, complaining about the heat; resting heads on the tables) and learning productivity (e.g zoning out) due to the warm(er) weather. Additionally, they noticed that their students were often more focused in the morning (which would be cooler). They reported that their students tended to display symptoms of heat stress and Sick Building Syndrome (e.g. restlessness) after 12 noon, as the hourly temperature would increase from the morning through to the mid-afternoon (data.gov.sg, 2020; Department of Statistics Singapore, 2020a).

> *R1: "They are just more talkative [and] restless or sleepy because of the afternoon heat".*

> *R5: "Some of them will start to lament that 'Wah teacher, very hot', 'Wah teacher, why today so hot'. When they're saying these things they're [often distracted and] not on task anymore".*

> *R6: "Mornings tend to be quite pleasant. So you can have lessons up to maximum 12 noon. Thereafter it begins to be quite hot and students get frustrated sometimes".*

> *R5: "Maybe they expanded a lot of energy [during recess], they come back, they need to cool down".*

Additionally, R1 and R5 realised that their students tended to become more lethargic after a recess or lunch break. Aside from the ambient temperature, the students might have been more physically active during these breaks, thereby generating more body heat. This could have been compounded by the fact that these classrooms could have had high occupant densities of up to 40 students (see Wong and Khoo, 2002).

Further, R5 (July to August) and R6 (February to April) identified certain months of the year when the students' learning productivity might dip. Whereas R5 attributed the students' restlessness to still being in the "holiday mood" after the June holidays, R6 cited the "hotter and drier inter-monsoon season" to justify their students' behaviour.

> *R1: "Especially the Secondary Ones and Twos, they have so much pent-up energy and with the heat they just get so restless very fast. In the upper sec I feel like they at least know how to control it better".*

> *R5: "Not everyone will complain that it is warm. But it does affect productivity in some way, just that correlation doesn't mean causation. There are many different reasons for why students are not performing well".*

Lastly, R1, R2 and R6 commented on how the drop in learning productivity could vary among students, with the lower secondary students being more reactive to the warmer weather. By contrast, upper-secondary students presumably had thermoregulatory systems that were better adjusted to their environment and/or were more "serious in their learning" (R6), enough to perhaps overcome the (s)lower arousal levels brought about by heat stress or to take the responsibility to cool themselves down. R5 remarked that even within a particular class at a given time some students experience greater thermal discomfort than others (see Kosonen and Tan, 2004). In summary, at least half of the teachers (R1, R4 and R5) recognised that changes in student productivity might not be caused by warm temperatures alone.

## Strategies to cope with warmer temperatures

### *Teacher-initiated strategies*

Based on the interviews, the majority of the strategies mobilised to alleviate heat stress in students were teacher-initiated. In general, these teachers did so by amending how their lessons were being conducted, improving the physical (thermal) comfort of their students and managing their responses to the warmer weather. For example, all of the teachers endeavoured to vary the pace and style of their teaching activities in a bid to keep their students better engaged, such as that of participative learning, as well as encouraging movement within the classroom (R1, R5, R6). Educational research has shown that students' productivity are likely to be optimised when they are engaged in (inter)active learning (Bonwell and Eison, 1991) vis-a-vis questioning techniques, pair and small group work. Such activities could facilitate the co-construction of knowledge and would enable teachers to check on their students' level of understanding communication (Mortimer and Scott, 2003; Prince, 2004) despite the warm weather.

*R5: "Just stop frontal teaching because students will have to focus more. You have to give students a fair share of talk time".*

*R6: "You have to include an activity in between that will energise them or get them to do a different thing after a while. I think we have to be very creative in how we go about the revision materials. Occasionally I bring in something related to the material rather than just the textbook".*

*R2: "Sometimes I give the students perhaps a timed practice or like a test so that they don't have to talk much or learn new things. They also don't need to move around so much".*

In comparison, R2 and R3 preferred didactic teaching with their students remaining in their seats so as to avoid generating more body heat. This form of teaching had its merits as it took the students mental fatigue into consideration (Haneda et al., 2009).

Meanwhile, R4 and R5 emphasised the importance of introducing short breaks during or in between lessons so that students could release their excess energy (if applicable, Camahalan and Ipcok, 2015) or to get some fresh air (and correspondingly, more oxygen in the bloodstream) as a remedy to a heat-related Sick Building Syndrome (Wargocki et al., 2005; Weslake and Christian, 2015). These breaks (or as R6 suggested, more flexible time-tabling) also presented an opportunity for students to refill their bottles, remain hydrated and cool themselves down. Relatedly, R1 and R6 proposed that more water coolers ought to be installed closer to the classrooms for easier and faster access. Such breaks were not usually pre-determined beforehand and were contingent on how focused the students were as well as the flow of the lessons.

*R1: "[The students] walk to the water cooler, to wash their face and cool down and back, to signal that lesson [is beginning] again".*

*R6: "I'm thinking that sometimes we do need to look at the hours that students have to spend in the classroom. It is unduly long. I give the students sufficient breaks for them to take a breather in the canteen, get a cold drink rather than get cooped up in the classroom".*

R1, R4 and R5 opined that spacing the students out and placing them closer to windows/doors were helpful practices, especially in view of the classroom's high occupant density (ASHRAE, 2005). Specifically, R1 stressed that discouraging the clustering of students would prevent them from being "affected by each other's body heat", while contributing to better ventilation (e.g. preventing hot air from being trapped, facilitating air flow, supply and ensuring good air quality). Crucially, these practices were not just cost-effective, they were also mindful about not increasing the school's carbon footprint. After all, these teachers conceded that greenhouse gas emissions were the root cause of thermal discomfort in the first place.

*R5: "Imagine in a classroom of 40 students where they don't get to change the seating arrangements because they* *don't get banded. The heat will get to them for sure."*

*R4: "Shift students towards the door and window where there's more air flow. Sometimes even if it's not allowed, I will still permit them to on the aircon."*

*R2: "I allow them to wear their PE attire, it is ok as long as they're learning."*

Some teachers tried to manage the students' responses to the thermal environment rather than the physical environment itself. R2 and R6 often validated complaints of thermal discomfort and sought to calm/cool their students down via breathing exercises. Extending social-emotional support to their students contributed to the fostering of positive teacher-student relationships which could bolster their readiness to learn despite the heat stress.

*R2: "I ask my students to take a deep breath, take a step back, calm themselves down. While you are calm you will feel a bit cooler."*

*R6: "I will verbalize that you know, the going is tough, and that I've been through it also. If you understand their temperament or their working style, leave them alone, they will consult you another time outside the class."*

*School-wide strategies*

Apart from teacher-initiated measures at managing thermal comfort, all the schools that the teachers were working at had 'dress-down' days especially during certain times of the year when there would be temperature spikes. During this period, students were permitted to wear their half-uniform involving a loose Physical Education t-shirt (usually made of dry fit material which would be less likely to trap heat and perspiration) instead of having to wear a blouse or shirt with skirt or trousers. The teachers interviewed felt that these 'dress-down' days could happen more frequently since it "required the least amount of effort" (R2).

*R5: "Students can report to school in half-uniform. The students were quite happy with that, the dry-fit [material] does help them a fair bit."*

However, R5 and R6 underscored the fact that not all students might be able to afford sufficient sets of Physical Education attire for wearing throughout the week, especially for those who require financial assistance. R6 averred that schools might need to co-ordinate the donation and allocation of "pass-me-down" attires to complement the 'dressing down' initiative.

Most teachers reported that equipment-based measures aimed at bringing down the temperature and improving ventilation were introduced on a school-wide level. All of them except for R2 and R5 outlined that additional mechanical fans, like the two bigger standing fans in R3's school were installed in classrooms (with at least 36 students) and/or the school hall (e.g. two bigger standing fans in the classrooms of R3's school). R6 also suggested incorporating solar powered temperature control systems in schools that can afford this.

Additionally, allowances were made have lessons in air-conditioned venues (e.g. computer labs), even though these venues were often limited in availability and justifications were required for their use. In R6's school, the graduating cohort were given the priority to use these venues so that they could "concentrate better". Notably, however, the utilisation of these cooling devices might lead to more negative economic and environmental externalities (e.g. carbon emissions). The school that R4 worked for therefore rationed each class to a "maximum of one hour [of air-conditioning] a day" to curb high electricity costs.

Interestingly, even as some schools were committed to improving their students' thermal environment, there were others that did not view heat stress as a major or significant problem (despite sentiments on the ground by teachers and students insisting otherwise). R1 and R2 pointed out that such heat management strategies were piecemeal, periodic and reactive as opposed to systematic, consistent and pre-emptive. In particular, R1's school perceived the symptoms of heat stress as an issue that could be regulated via disciplinary measures.

*R1: "I don't think it's much of a priority to [the school leaders], who think that this unproductiveness can be controlled or corrected if the boys have the correct attitude and behaviour. Or that they don't think that this [heat-related] restlessness would make a huge difference to their learning."*

Lastly, teachers were lukewarm about the effectiveness of novel heat relief tools (e.g cooling wristband and patches, which the author brought up and showed pictures of). R5 and R6 opined that having teachers buy these products for their students out of their own pocket might make their students "feel cared for" while eliminating affordability as an issue among them. Understandably, not all the teachers interviewed were willing to be that generous (each cooling wristband would cost around $8), even if the bands were to be shared among their students. The teachers were also slightly sceptical about the wristband's ability to sustain the students' thermal comfort over time.

## Conclusion

This investigative study demonstrated that students in Singapore evidently experience some level of heat stress and most teachers (as well as their schools) had taken the initiative to alleviate the thermal discomfort among their students. They provided some financially and environmentally sustainable recommendations that other educators could potentially adopt in their classrooms/schools. Nonetheless, a tension between maximising the thermal comfort and by extension the students' learning versus not overly pandering to their demands persists. As global warming goes on unabated, the exacerbation of heat stress over time implies that school leaders would eventually have to take this issue more seriously and to roll out mitigating measures at an institutional level.

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