

**A STUDY ON THE CORRELATION
BETWEEN INDOOR CO₂
CONCENTRATION AND
AIR-CONDITIONER WORKING
EFFICIENCY**

Taiwan Partnership

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Motivation

Climate change affects habitats and lifestyles, with two strategies to deal with its impact: "adaptation" and "mitigation" through reducing carbon emissions. Air conditioner is now essential due to rising temperatures, but closing windows and doors to save power increases indoor carbon dioxide concentration, affecting indoor temperatures and air conditioner power consumption. Reducing air conditioner consumption can mitigate climate change by reducing carbon emissions from thermal power generation. This study aims to explore the relationship between air conditioner power consumption, and indoor carbon dioxide concentration. Then, make recommendations to improve air conditioner efficiency in order to mitigate climate change's impact.

Purposes

1. To understand the correlation between air conditioner temperature, carbon dioxide concentration, and air conditioner power consumption.
2. Reduce the improper use of air conditioner, in order to lower energy consumption and thus decrease carbon emissions.

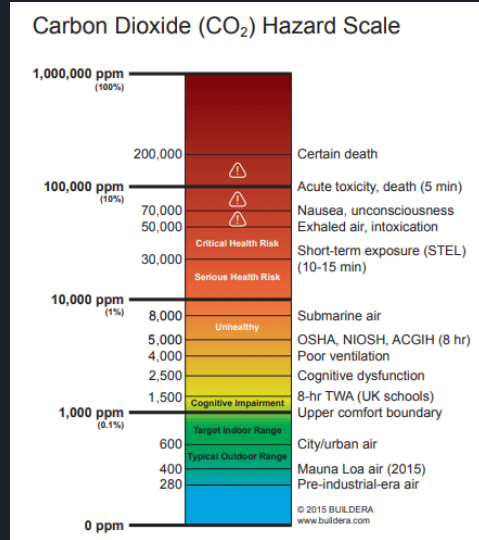


Literature review -1

【CO₂ concentration scale】

A study conducted in Hong Kong found that even with only one person present in a room equipped with a split air conditioner system, the outdoor ventilation rate does not meet ASHRAE standards. While the outdoor ventilation rate for window-type air conditioner may be higher than that for split air conditioner, its effectiveness in controlling ventilation is still limited.

Another research report from South Korea showed that the use of air conditioner in Seoul offices and the energy consumption of offices exceeded the assumptions of building energy consumption design predictions. The study also found a significant correlation between air conditioner energy consumption and the number of people indoors.



Credit: <https://pse.is/4t5qy6>



Literature review -2

A CO₂ study conducted in a primary and secondary school classroom showed that continuous monitoring data of CO₂ in ten classrooms varied over time and with the entry of students into the classroom. CO₂ levels rose at the beginning of class, decreased at the end of class, and reached equilibrium after a period of time. Approximately half of the classrooms had an average CO₂ concentration exceeding 1000ppm, with two classrooms as high as 1929ppm and 2248ppm. Although air conditioner was installed, the ventilation rate inside and outside was insufficient. However, there was a trend of improvement after installing an exhaust fan. In a study of 54 elementary schools in the United States by Shaughnessy R.J. (2006), there was a significant difference in ventilation rates and math learning outcomes in classrooms. Another study showed that increasing one exhaust fan could reduce indoor CO₂ concentration by approximately 10.4%, and two exhaust fans could reduce it by approximately 17.3%.



Research assumptions

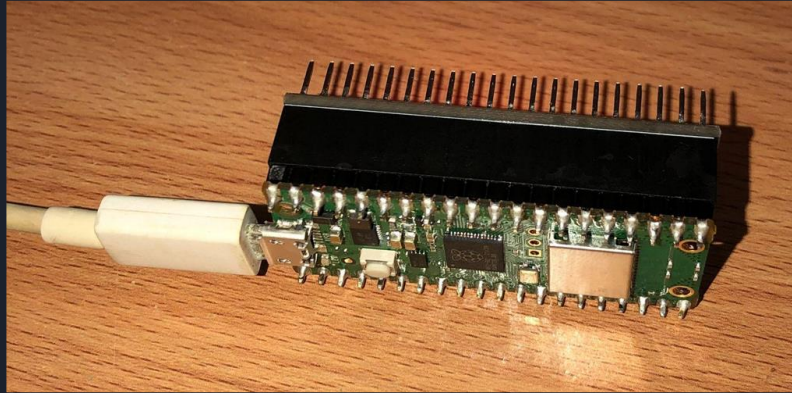
1. The classroom is a closed, homogeneous space with equal air composition.
2. Each person releases the same amount of carbon dioxide and infrared radiation.
3. Carbon dioxide concentration can absorb infrared radiation, leading to an increase in indoor temperature.



Research methods

This study uses handheld carbon dioxide monitors, Raspberry Pi Pico W, and environment sensors provided by MIT Media Lab to monitor the temperature and carbon dioxide concentration in the classroom. The daily air conditioner energy consumption is recorded using the on-campus air conditioner billing system. Finally, SPSS is used to analyze the data with Pearson correlation.

Research materials



Raspberry Pi Pico W +
Environment Sensor



Handheld carbon
dioxide monitor



Variables

Experimental group: To set at 27°C

Control groups: To set at 26°C

- **Independent variable:** Air conditioner temperature.
- **Controlled variables:** Air conditioners settings (except temperature), the configuration of fans and windows.
- **Dependent variables:** Indoor temperature, carbon dioxide concentration, air conditioner power consumption.



Research results

Data analysis:

The table below shows the data for the CO₂ concentration and power consumption of air conditioner for the experimental and control groups.

	Group	9/29	9/30	10/3	10/04	10/5
Daily average concentration of CO ₂ (ppm)	Experimental	2196.01	1568.76	2081.62	1667.51	1975.62
	Control	1888.04	1499.58	1933.38	2053.44	1912.12
air conditioner power consumption (kWH)	Experimental	38.20	34.36	48.83	38.71	46.41
	Control	31.36	22.24	29.63	43.73	23.81



Analyze

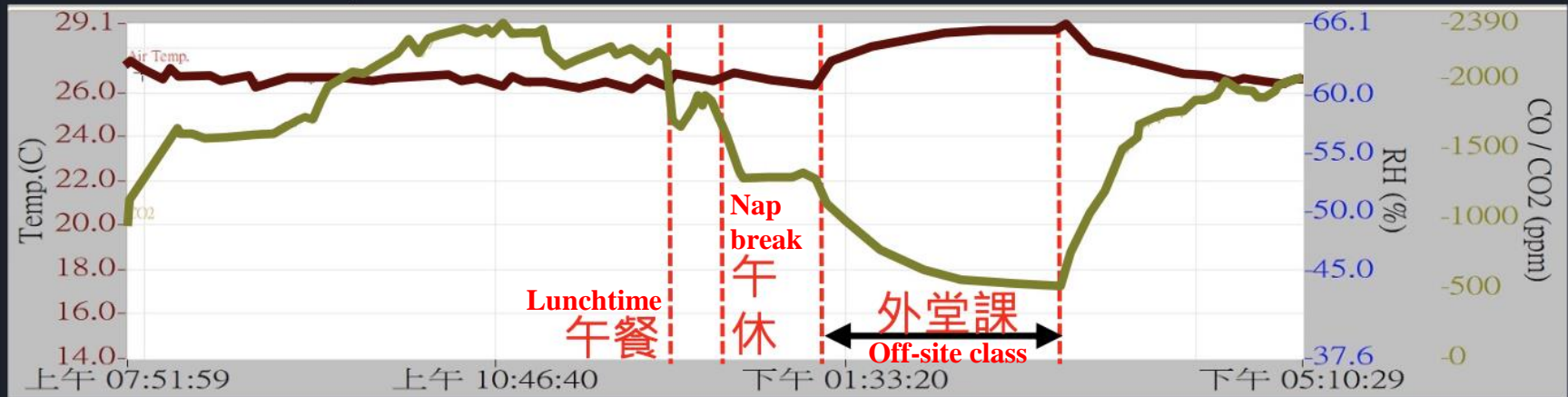
Data analysis:

This study used SPSS for data analysis and Pearson Correlation for statistical analysis.

		CO ₂	Power consumption
CO ₂	Pearson Correlation	1	.534
	Sig. (2-tailed)		.112
	N	10	10
Power consumption	Pearson Correlation	.534	1
	Sig. (2-tailed)	.112	
	N	10	10

Discussion -1

Data analysis: Experimental group (2022/9/30)

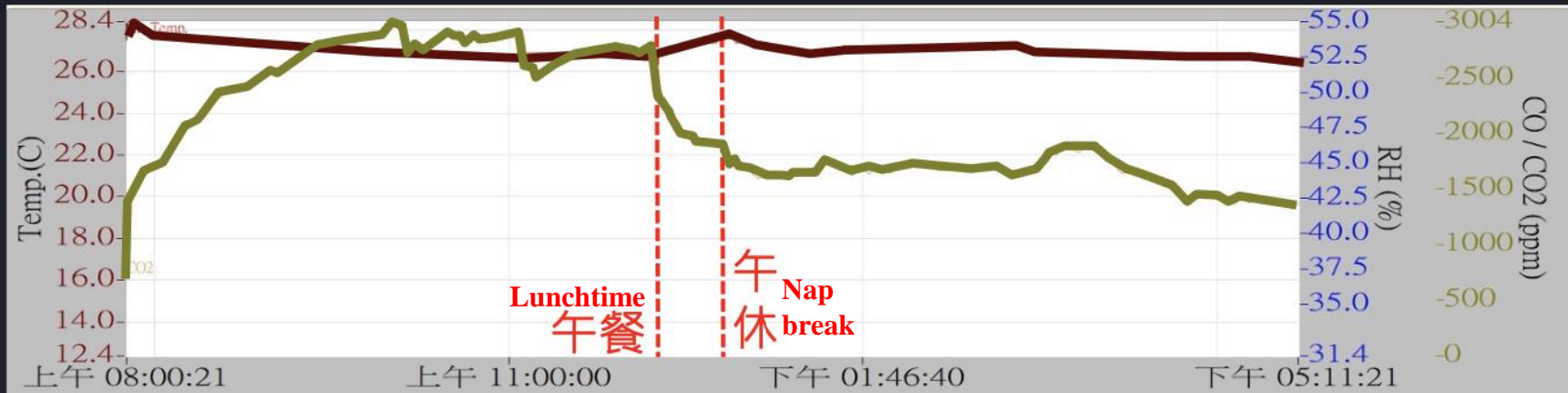


Power consumption of air conditioner on the day: 34.30kWH

Average concentration of carbon dioxide on the day: 1568.76ppm

Discussion -2

Data analysis: Experimental group (2022/10/3)

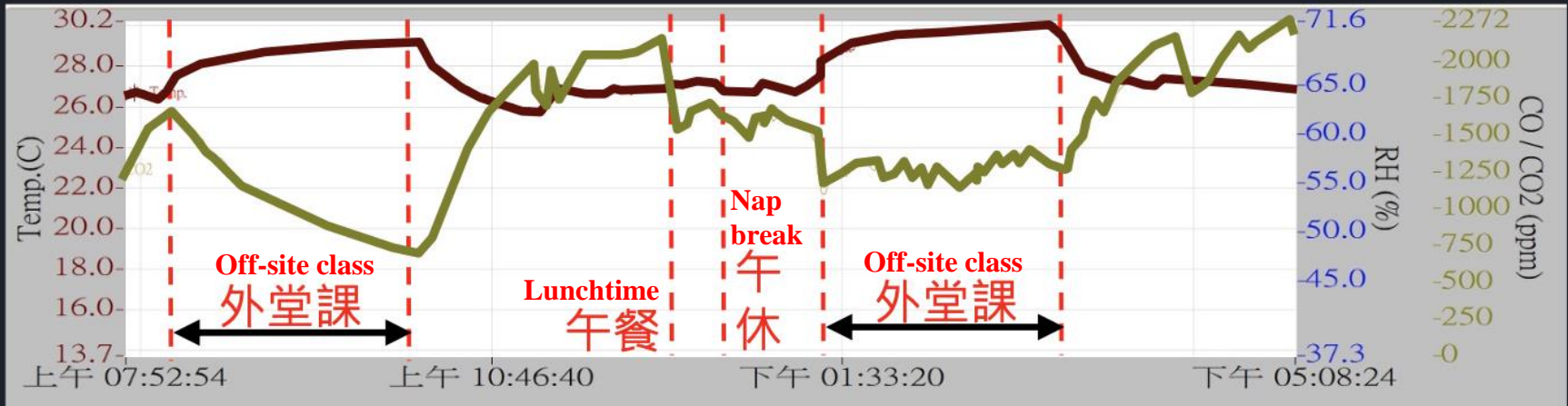


Power consumption of air conditioner on the day: 48.83kWH

Average concentration of carbon dioxide on the day: 2081.62ppm

Discussion -3

Data analysis: Control group(2022/9/30)

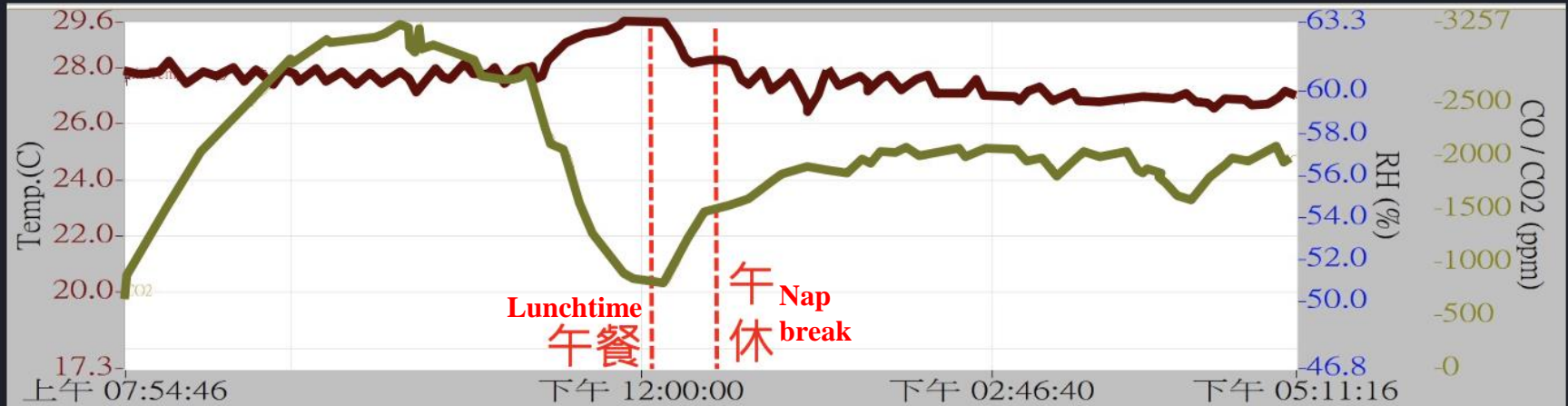


Power consumption of air conditioner on the day: 22.24kWH

Average concentration of carbon dioxide on the day: 1499.58ppm

Discussion -4

Data analysis: Control group(2022/10/4)



Power consumption of air conditioner on the day: 47.74kWH

Average concentration of carbon dioxide on the day: 2053.44ppm

Summary

Moderate use of ventilation equipment can help slow down the decrease in indoor carbon dioxide concentration when there are many people present, thereby reducing air conditioning power consumption and ultimately reducing carbon emissions from power generation.





Research limitations

1. The amount of data collected may not be sufficient.
2. The equipment may produced bias due to lack of calibration.
3. The classroom is not a closed ideal system.
4. The amount of carbon dioxide and infrared radiation emitted by each person is not equal.
5. The temperature inside the classroom may be affected by external environmental radiation.



Conclusion

1. The carbon dioxide concentration and air conditioner power consumption in the classroom show a moderate positive correlation without significant difference. If the sample data is sufficient, a positive correlation result with significant difference may be obtained.
2. If indoor ventilation is improved, it may reduce the burden on air conditioner and thereby lower the carbon produced by electricity consumption, helping to mitigate climate change.



References

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