# Appendix A. Supplementary Data

## 1. HVAC system type, manufacturer, and fuel type

HVAC systems serving the 104 classrooms were either rooftop units (RTUs) or wall-mounted single package vertical systems (SPVS). Portable classrooms generally had wall-mount equipment while permanent classrooms generally had RTUs, though this was not always the case (Table A-1). At one school, RTUs were mounted on the roof of two portable classrooms. At another school, wall-mount systems served a permanent building.

A variety of brands were represented across the sample; however, each individual school possessed only one or two brands of equipment (e.g., a single brand for RTUs and a single brand for wall-mounts). RTU brands included Amana, Carrier, Trane, and York. Wall-mount brands included Bard and Marvair. All wall-mount units contained electric heat pumps. Most RTUs contained gas heating, with the exception of the two Amana RTUs, which utilized heat pumps.

Table A-1 Distribution of HVAC System Type by Classroom type

| Classroom Type | RTU | | | | | Wall Mount | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | *Total* | Amana | Carrier | Trane | York | *Total* | Bard | Marvair | |
| **Permanent** | 61 | -- | 31 | 20 | 10 | 10 | 10 | -- | 71 |
| **Portable** | 2 | 2 | -- | -- | -- | 31 | 21 | 10 | 33 |
| **Total** | **63** | **2** | **31** | **20** | **10** | **41** | **31** | **10** | **104** |

## 2. Ventilation equipment

This section describes the five types of ventilation equipment installed in the studied classrooms. Field inspection of the HVAC equipment found that 16 out of the 104 classrooms in the study were not configured in a manner expected to provide adequate outdoor air. There were six ventilation devices with low-flow spring dampers that are not designed for classrooms and cannot provide the required airflow rate, three ventilation devices for which the electric power and control signal were not connected, and seven economizers that were configured or wired incorrectly.

- Fixed position ventilator:
  - Description: These systems featured a fixed opening on the suction side of the supply fan that brings outdoor air into the building and exhausts room air through a pressure relief.

In some designs, the dampers move into the set position when the supply fan turns on, while in others the intake and exhaust always remain open. The installer must set the damper position or the size of the opening to provide the design ventilation rate to the building.

   - Observations: These systems were found in 19 classrooms. The ventilation devices on three of the wall-mount systems at one school were not operating, so no mechanical ventilation was provided to these classrooms. It appeared the installers did not connect the wires powering and controlling the ventilation system, most likely because an adjacent electrical disconnect restricted access to the service panel. In another school, four wall-mount systems had a functioning device but the setting was insufficient to provide enough ventilation, which was determined by using a flow hood (Shortridge Instruments CFM-88L, Arizona, USA).

- Low airflow system with spring damper:
   - Description: These systems had a spring-closing damper without pressure relief that is field-adjustable and designed to provide up to 15% of the rated supply airflow as outdoor air. These systems generally are intended for low ventilation applications, such as data centers, and are not expected to provide the required outdoor air for classrooms.
   - Observations: A total of six wall-mount units with this type of damper were found at two schools in the same district. Using a flow hood, the research team measured that these classrooms were receiving between 0-84 CFM of outdoor air, with an average of 35 CFM.

- Energy Recovery Ventilator:
   - Description: An energy recovery ventilator (ERV) transfers heat and moisture between the entering outdoor air and room exhaust air.
   - Observations: ERVs were installed in five of the wall-mount units surveyed. The installed ERVs consisted of a rotatory energy recovery cassette designed to transfer both sensible and latent heat. The manufacturer reported a heat transfer efficiency of 67% during summer and 75% during winter. The energy impact of the ERV varies by climate. In wall-mount units, the manufacturers offer either the ERV or the economizer option, but not both concurrently, since the mechanical components occupy the same physical space. Adding an ERV to an RTUs is possible; however, manufacturers do not readily offer this option in small capacity units that are common for classrooms. This study did not encounter any ERVs in RTUs.

- Economizer:
   - Description: Economizers reduce cooling energy consumption through “free-cooling,” meaning that when the room calls for cooling and the outdoor air temperature is below a set threshold, the outdoor air damper will open fully and deliver up to 100% outdoor air to the classroom. The room air is exhausted outside. The energy impact of the economizer varies by climate.
   - Observations: Economizers were installed in 74 of the units surveyed and were common in both RTUs and wall-mount units. In four classrooms at one school, the economizer was wired incorrectly so that the classrooms were not receiving any outdoor air (i.e., the damper remained closed at all times). In one of the four classrooms, the ventilation package was designed for a horizontal supply/return configuration instead of the vertical supply/return configuration actually in use. This means that, even if the economizer were

wired correctly, the system would not function as designed. Additionally, three economizers at two schools did not appear to be providing any outdoor air when the fan was running, suggesting a problem with the installation and minimum damper position setting. Finally, at another school, one economizer had a wire blocking the damper to stop it from closing completely.

- Demand control ventilation:
  - Description: Demand control ventilation (DCV) adds $CO_2$ sensing to the classroom and controls ventilation to maintain $CO_2$ levels below a set threshold, generally 1000 ppm. Demand control ventilation systems can display the classroom $CO_2$ level on the thermostat and transmit $CO_2$ data to the facility energy management system.
  - Observations: In the installations observed, the DCV controller actuated an outdoor air damper to modulate the outdoor airflow rate. In all of the systems in the study sample, the actuated damper provided for both economizer and DCV functions. DCV systems were installed in 25 of the RTUs surveyed and were not installed in any of the wall-mount units, although wall-mount unit manufacturers do offer this option.

The field team measured outdoor air flow using a flow hood in a subset of the classrooms (N=21). Four of the measured classrooms had no HVAC hardware or control problems. In those four classrooms, the measured outdoor air flow rates agreed very well with the ventilation rates estimated from $CO_2$ measurements during school operation (Table A-2). However, the agreement between measured and estimated outdoor air flow rates was poor for the other 17 classrooms that had HVAC hardware or control problems. Other factors, such as air infiltration through building envelope and natural ventilation via door opening, can contribute to the overall ventilation rate, especially in cases where mechanical ventilation is inadequate. The mean estimated ventilation air flow from 17 classrooms was 290 CFM (median = 240 CFM), which is higher than the measured outdoor air flow rate (mean = 154 CFM, median = 84 CFM) as expected because of contributions from air infiltration and natural ventilation. As a reference, California code requires 480 CFM for a typical classroom with 30 students and one teacher (15 CFM per person x 31 people).

Table A-2: Comparison of measured outdoor air flow rate and estimated minimum VRs.

| Ventilation System Type | HVAC Problems Identified | (i) Measured Outdoor Air Flow Rate (CFM) | (ii) Estimated VRs from $CO_2$ (CFM) |
|---|---|---|---|
| Low Airflow, Spring Damper | Ventilation system not intended for classrooms | Too low to measure | 374 |
| | | Too low to measure | 496 |
| | | 15 | 580 |
| | | 33 | 214 |
| | | 77 | NA (missing $CO_2$ data) |
| | | 84 | 344 |
| Fixed Position Ventilator | None | 371* | 376 |
| | Inadequate damper opening | 124 | 173 |
| | | 204 | 158 |
| | | 220 | 124 |
| | | 364 | 199 |
| | Vent | 414* | 245 |
| Economizer | None | 302 | 325 |
| | None | 154 | 169 |
| | None | 299 | 291 |
| | Hardware | Too low to measure | 369 |
| | Hardware | 16 | 238 |
| | Control | 80 | 232 |
| | Control | 338 | 383 |
| | Control | 326 | 330 |
| | Control | 320 | 181 |

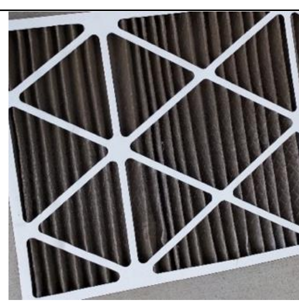
* Outdoor air flow rate was measured by a powered flow hood built using a TEC Minneapolis Duct Blaster (USA) in two cases (both are RTUs). In all other cases (all wall-mounts), measurements were made using the Shortridge Instruments CFM-88L Meter (Arizona, USA).

## 3. Filter type and inspection

Inspection of the filter in each HVAC system identified two types of filters: pleated 2” thick filters and non-pleated polyester media filters. Section 150.0 of California’s 2016 Building Energy Efficiency Standards requires a MERV rating of 6 or greater for all buildings[1]. All the pleated filters inspected in this study had a MERV rating of 7 or 8. The non-pleated polyester media filters did not have visible writing to identify the manufacturer or MERV rating. Table A-3 shows a sample photo for each filter condition rating level. Filters with a rating of 4 or 5 appeared to need replacement.

[1]Minimum efficiency rating value (MERV) is a standard method for rating the overall effectiveness of particle removal in filters.

Table A-3: Filter Condition Example Photos

| Filter Condition | Pleated | Polyester Media |
|---|---|---|
| Filter Condition: 1<br>Like new |  | None found during inspection |
| Filter Condition: 2<br>Lightly used |  | None found during inspection |
| Filter Condition: 3<br>Used |  |  |
| Filter Condition: 4<br>Time to change |  |  |
| Filter Condition: 5<br>Past service life | None found during inspections |  |

### 4. HVAC Heating / Cooling Mode

The heating and cooling mode of the HVAC system was determined based on the supply air and room air temperature. The system was assumed to be in cooling mode if the room temperature was higher than supply air temperature by a threshold value or if the supply air temperature decreased faster than a certain rate of change. On the other hand, the system was assumed to be in heating mode if the supply air temperature was higher than room temperature and outdoor air temperature by a threshold value. Outdoor air temperature from the nearest weather station was obtained from the National Weather Station (NWS) network[2] for this analysis. Suitable threshold values were determined for each classroom by plotting room air temperature, supply air temperature, and outdoor air temperature, to make sure that heating and/or cooling modes were properly identified using this method. Figure A-1 shows an example of the cooling and heating periods identified for a classroom.

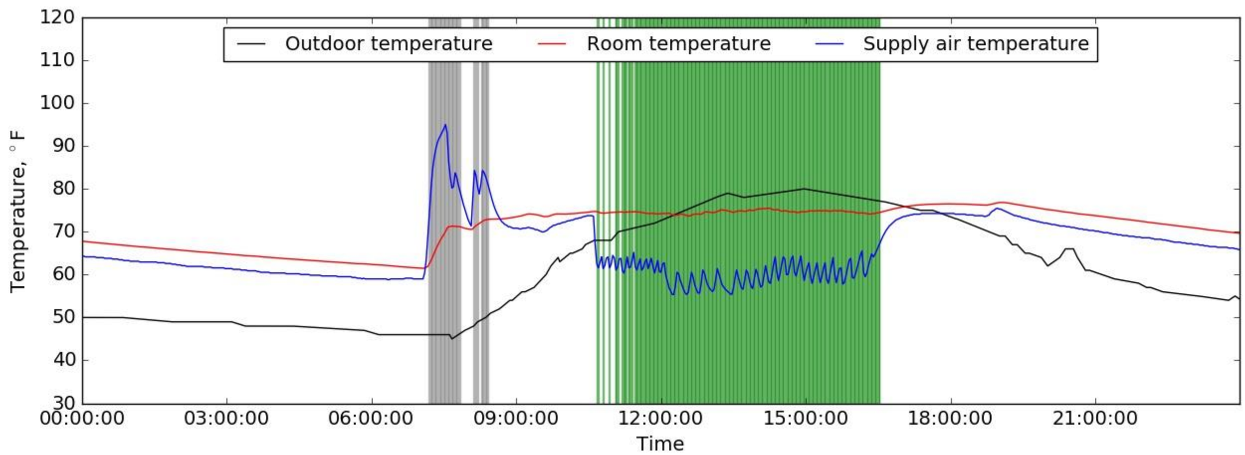



Figure A-1 Example of cooling and heating periods identified. Grey bars indicate times when the system was in heating mode. Green bars indicate times when system was in cooling mode.

Figure A-2 shows the mean fraction of runtime that HVAC systems were operating in heating or cooling mode for the 11 schools, determined using the method described above. Schools 3–6 were monitored during heating season (late November through March). The other schools (1–2, and 7–11) were monitored during cooling and shoulder season (September to early November, and April to June) when cooling and some heating occurred in the classrooms. Figure A-2 shows that schools 1, 8–11 were cooling dominated. On the other hand, both heating and cooling occurred when schools 2 and 7 were monitored.

[2] Mesowest. University of Utah. http://mesowest.utah.edu/

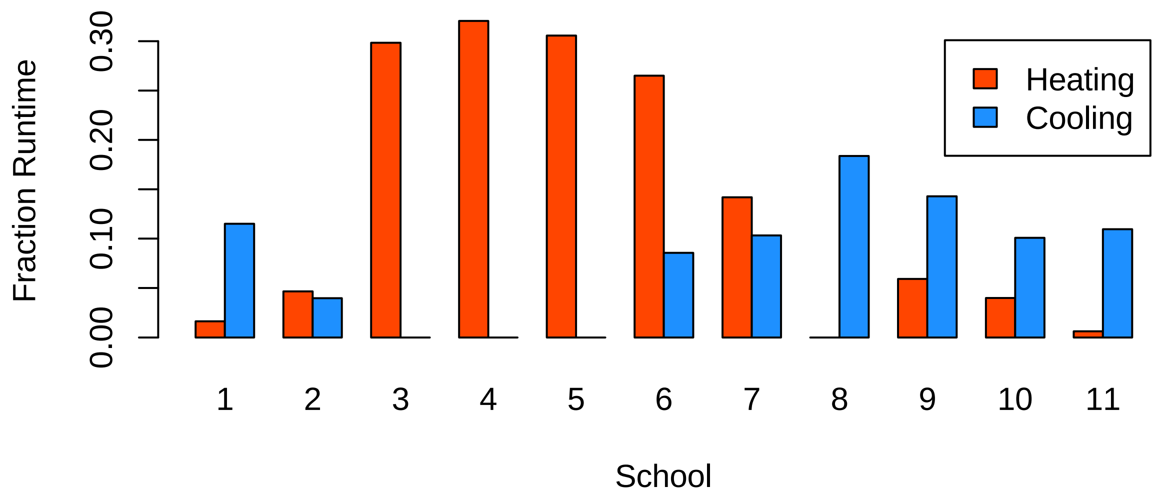



Figure A-2 Estimated mean fraction HVAC runtime in heating or cooling mode during school hours.

## 5. Statistics of estimated VRs and mean $CO_2$ concentrations by classroom and HVAC system characteristics

Table A-4: Estimated VRs

| Classroom / HVAC Characteristics | | N | Estimated VR (L/s-person) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | **Mean** | **SD** | **5%** | **25%** | **50%** | **75%** | **95%** |
| All Classrooms | | 94 | 5.2 | 2.0 | 2.6 | 3.5 | 5.0 | 6.3 | 8.6 |
| Grade Level | K-3 | 40 | 5.1 | 2.0 | 2.2 | 3.4 | 5.3 | 5.8 | 8.8 |
| | 4-8 | 36 | 5.0 | 2.0 | 2.7 | 3.3 | 4.4 | 7.2 | 8.1 |
| | 9-12 | 18 | 5.7 | 1.9 | 3.2 | 4.4 | 5.5 | 6.5 | 8.7 |
| Building Type | Portable | 32 | 4.0 | 1.8 | 2.3 | 2.8 | 3.5 | 4.5 | 7.2 |
| | Permanent | 62 | 5.7 | 1.8 | 2.9 | 4.6 | 5.6 | 7.1 | 8.7 |
| HVAC Type | Wall Mount | 38 | 4.2 | 1.8 | 2.3 | 3.0 | 3.7 | 4.8 | 7.6 |
| | RTU | 56 | 5.8 | 1.8 | 2.9 | 4.7 | 5.6 | 7.2 | 8.9 |
| Ventilation System Type | Fixed Ventilator | 19 | 4.7 | 2.2 | 2.3 | 2.8 | 4.4 | 6.2 | 8.7 |
| | Manual Damper | 5 | 5.5 | 1.9 | 2.2 | 2.6 | 3.5 | 5.1 | 7.4 |
| | ERV | 5 | 3.2 | 0.8 | 2.3 | 2.6 | 3.3 | 3.7 | 4.0 |
| | Economizer | 44 | 5.4 | 2.2 | 2.8 | 3.7 | 5.0 | 7.2 | 9.2 |
| | DCV + Economizer | 21 | 5.4 | 1.2 | 3.2 | 5.0 | 5.4 | 6.0 | 7.3 |
| Filter Condition (N=91) | 1 = Like new | 20 | 6.6 | 2.1 | 2.9 | 5.6 | 7.3 | 7.9 | 9.3 |
| | 2 = Clean | 33 | 5.7 | 1.7 | 3.1 | 4.7 | 5.6 | 6.0 | 9.1 |
| | 3 = Used | 12 | 4.1 | 1.3 | 2.4 | 2.9 | 4.3 | 5.3 | 5.4 |
| | 4 = Time to change | 23 | 4.2 | 1.6 | 2.4 | 3.1 | 3.7 | 4.8 | 7.4 |
| | 5 = Past service life | 3 | 3.4 | 0.6 | 2.8 | 3.1 | 3.5 | 3.7 | 3.8 |
| HVAC Failures | None | 47 | 6.1 | 1.9 | 3.2 | 5.2 | 5.8 | 7.3 | 9.7 |
| | Hardware/Control Problems | 18 | 4.5 | 1.7 | 2.6 | 3.0 | 4.5 | 5.7 | 6.8 |
| | Hardware/Control + Filter | 14 | 4.5 | 1.8 | 2.8 | 3.2 | 3.6 | 5.5 | 7.7 |
| | Filter Due/Past Change (4 or 5) | 15 | 3.5 | 0.9 | 2.2 | 2.7 | 3.9 | 4.2 | 4.7 |
| Door Opening (N=89) | <20% | 41 | 5.1 | 1.7 | 2.8 | 3.7 | 5.3 | 5.9 | 7.5 |
| | 20-50% | 27 | 5.0 | 2.4 | 2.3 | 3.2 | 4.4 | 7.0 | 9.0 |
| | >50% | 21 | 5.5 | 2.1 | 2.8 | 4.1 | 5.1 | 7.0 | 8.8 |

Table A-5: Mean $CO_2$ concentrations

| **Classroom / HVAC Characteristics** | | **N** | **Measured $CO_2$ (ppm)** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | **Mean** | **SD** | **5%** | **25%** | **50%** | **75%** | **95%** |
| All Classrooms | | 94 | 895 | 263 | 619 | 685 | 841 | 1015 | 1433 |
| Grade Level | K-3 | 40 | 797 | 186 | 582 | 671 | 764 | 886 | 1198 |
| | 4-8 | 36 | 985 | 312 | 624 | 734 | 939 | 1155 | 1513 |
| | 9-12 | 18 | 933 | 239 | 661 | 790 | 875 | 982 | 1345 |
| Building Type | Portable | 32 | 1111 | 297 | 676 | 883 | 1052 | 1354 | 1522 |
| | Permanent | 62 | 784 | 153 | 608 | 669 | 759 | 876 | 1063 |
| HVAC Type | Wall Mount | 38 | 1068 | 290 | 693 | 870 | 1008 | 1293 | 1508 |
| | RTU | 56 | 778 | 160 | 601 | 662 | 746 | 865 | 1052 |
| Ventilation System Type | Fixed Ventilator | 19 | 1040 | 323 | 661 | 820 | 892 | 1250 | 1568 |
| | Manual Damper | 5 | 903 | 188 | 738 | 836 | 866 | 883 | 1150 |
| | ERV | 5 | 1390 | 90 | 1301 | 1323 | 1364 | 1468 | 1495 |
| | Economizer | 44 | 829 | 222 | 574 | 657 | 751 | 1002 | 1219 |
| | DCV + Economizer | 21 | 783 | 92 | 632 | 721 | 774 | 852 | 924 |
| Filter Condition (N=91) | 1 = Like new | 20 | 776 | 172 | 605 | 633 | 732 | 875 | 1030 |
| | 2 = Clean | 33 | 757 | 135 | 579 | 662 | 721 | 859 | 963 |
| | 3 = Used | 12 | 995 | 307 | 697 | 741 | 872 | 1129 | 1522 |
| | 4 = Time to change | 23 | 1059 | 278 | 718 | 851 | 969 | 1261 | 1442 |
| | 5 = Past service life | 3 | 1177 | 216 | 1049 | 1052 | 1055 | 1241 | 1389 |
| HVAC Failures | None | 47 | 748 | 170 | 576 | 647 | 686 | 796 | 950 |
| | Hardware/Control Problems | 18 | 961 | 215 | 697 | 827 | 927 | 1036 | 1357 |
| | Hardware/Control + Filter | 14 | 1094 | 327 | 710 | 844 | 1055 | 1334 | 1541 |
| | Filter Due/Past Change (4 or 5) | 15 | 1093 | 220 | 813 | 939 | 1048 | 1246 | 1453 |
| Door Opening (N=89) | <20% | 41 | 880 | 227 | 631 | 705 | 852 | 954 | 1350 |
| | 20-50% | 27 | 913 | 266 | 614 | 687 | 879 | 1052 | 1395 |
| | >50% | 21 | 910 | 321 | 573 | 676 | 807 | 1048 | 1468 |

The boxplots in Figures A-3 to A-8 present the estimated VR and mean $CO_2$ across classrooms (N), grouped by classroom and HVAC characteristics as described in Table A-5. Boxes show the interquartile range (25$^{th}$ and 75$^{th}$ percentiles), and whiskers extending to 5$^{th}$ and 95$^{th}$ percentiles. The solid horizontal line inside each boxplot shows the median. Open circles show the means. In cases where there are too few data for a boxplot to be informative, individual data points are shown instead.

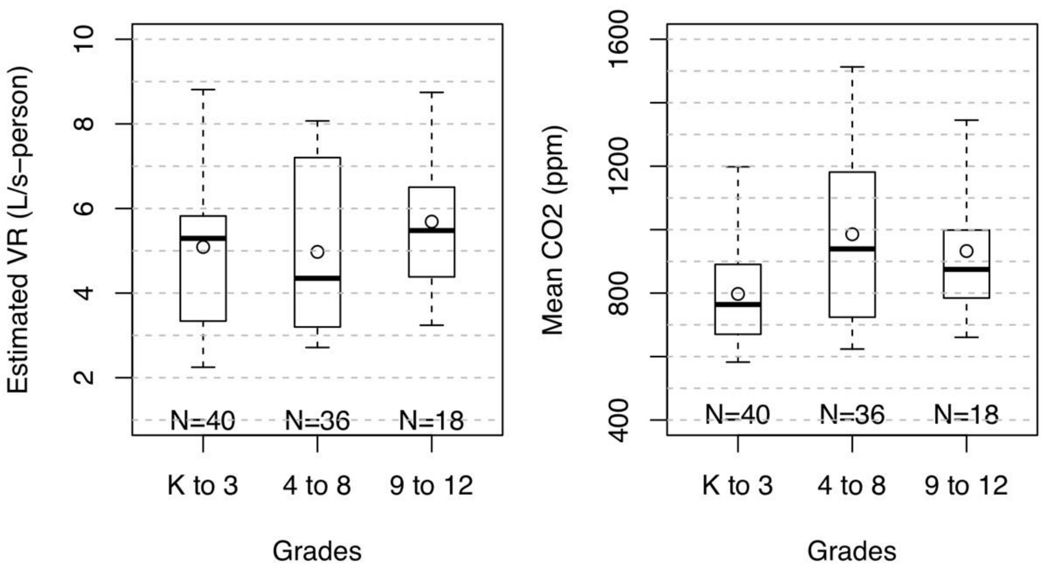



Figure A-3 Boxplots of estimated VR and mean $CO_2$ across classrooms (N), grouped by grade levels: K to 3rd, 4th to 8th, 9th to 12th. Boxes show the interquartile range (25th and 75th percentiles), and whiskers extending to 5th and 95th percentiles. Solid horizontal line inside each boxplot shows the median. Open circle shows the mean.

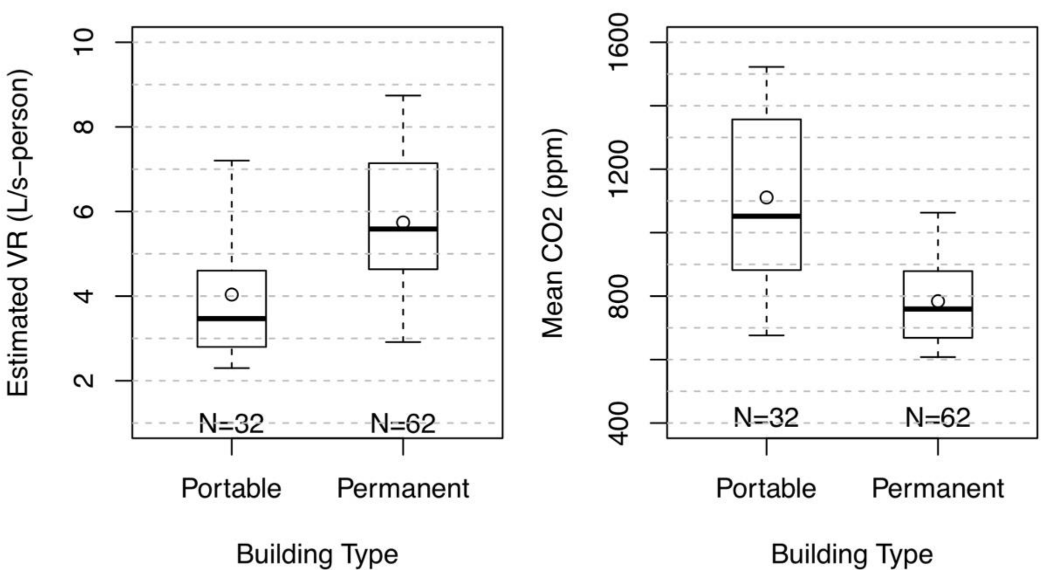



Figure A-4 Boxplots of estimated VR and mean $CO_2$ across classrooms (N), grouped by building types: portable and permanent classrooms.

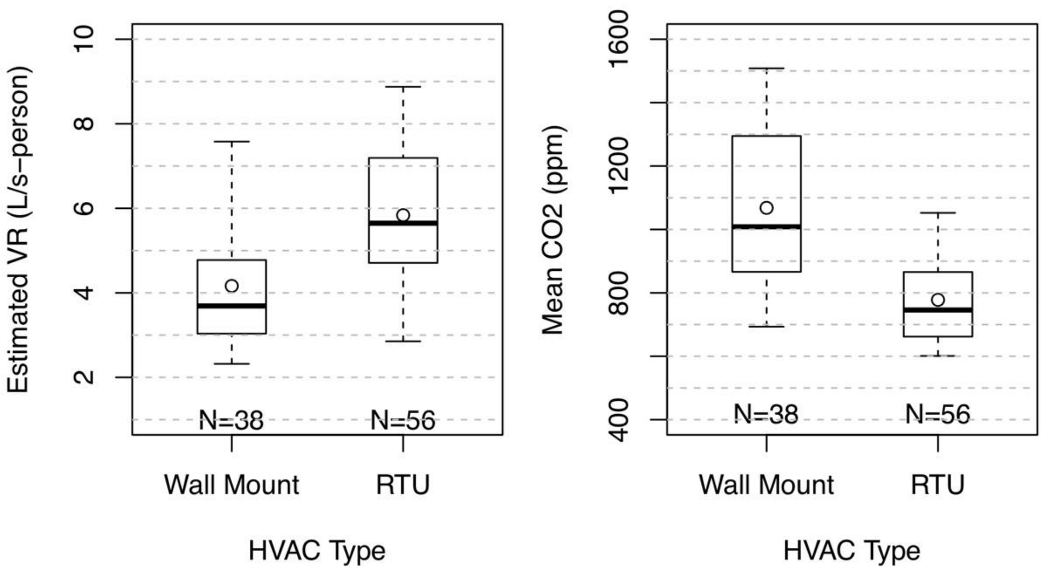



Figure A-5 Boxplots of estimated VR and mean $CO_2$ across classrooms (N), grouped by HVAC type: wall-mount and rooftop units (RTUs).

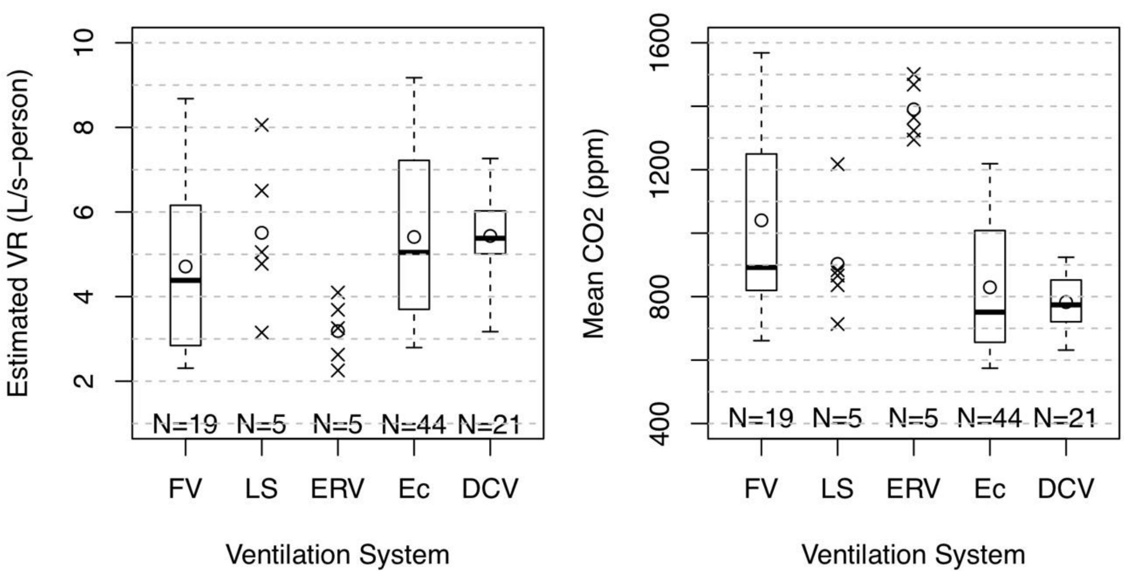



Figure A-6 Boxplots of estimated VR and mean $CO_2$ across classrooms (N), grouped ventilation system types: FV = fixed position ventilator; LS = low airflow spring damper; ERV = energy recovery ventilator; Ec = economizer; DCV = demand control ventilation (with economizer). Individual data points are shown instead of boxplot for LS and ERV because of the small number of classrooms (N=5).

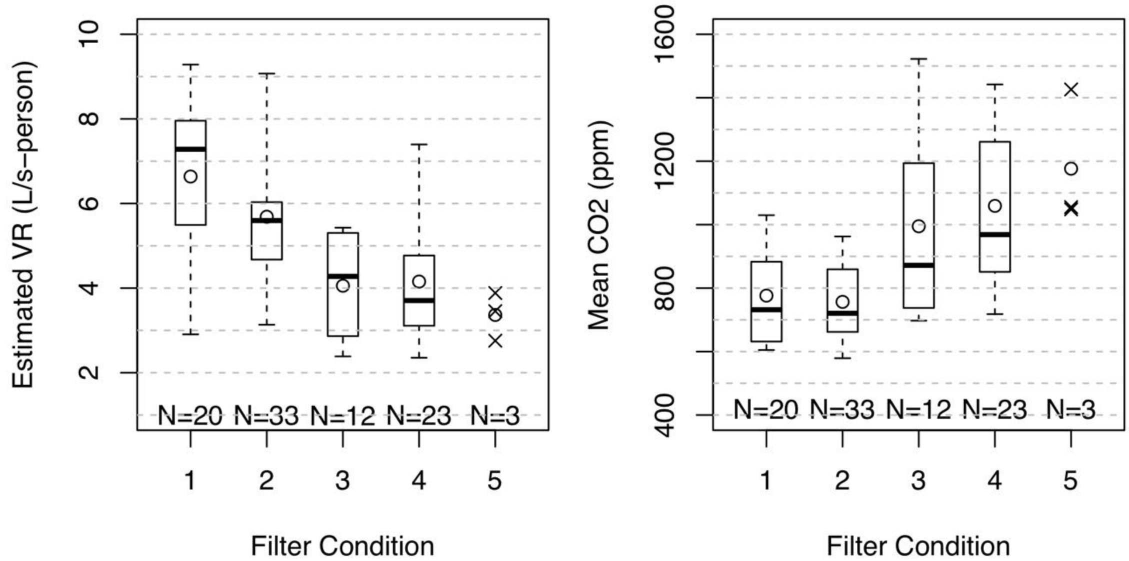



Figure A-7 Boxplots of estimated VR and mean $CO_2$ across classrooms (N), grouped filter condition: 1 = like new; 2 = lightly used; 3 = used; 4 = time to change; 5 = past service life. Individual data points are shown instead of boxplot for condition 5 because of the small number of classrooms (N=3).

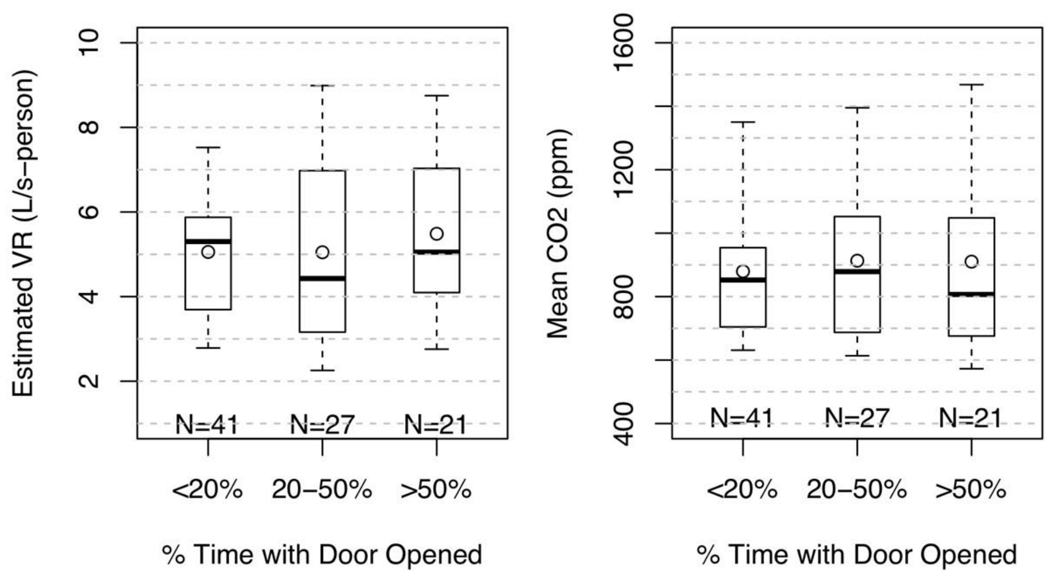



Figure A-8 Boxplots of estimated VR and mean $CO_2$ across classrooms (N), grouped by the percentage of time when door was opened during school hours.

## 6. Summary Statistics of Classroom Air Temperature and Relative Humidity

Table A-6: Summary statistics for classroom temperature and humidity during school hours, by school.

| School ID | Measured Period | Mean Air Temperature (°C) | | | | Mean Relative Humidity (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Median | SD | Range | Mean | Median | SD | Range |
| 1 | 2016: 09/29–11/03 | 24.3 | 23.9 | 1.1 | 23.1-26.0 | 44.8 | 45.4 | 3.0 | 39.6-47.6 |
| 2 | 2016: 10/13–11/11 | 24.9 | 24.7 | 0.8 | 23.6-25.9 | 50.9 | 50.6 | 2.5 | 47.3-55.4 |
| 3 | 2016: 11/26–12/18 | 22.4 | 22.3 | 0.9 | 21.6-23.8 | 44.3 | 43.8 | 1.8 | 42.5-47.2 |
| 4 | 2016: 11/26–12/18 | 24.5 | 24.9 | 1.3 | 21.2-26.1 | 42.0 | 41.3 | 3.1 | 37.8-50.0 |
| 5 | 2017: 01/03–02/01 | 21.4 | 21.2 | 1.7 | 19.3-25.6 | 40.8 | 41.8 | 3.6 | 33.0-45.4 |
| 6 | 2017: 02/22–03/22 | 22.9 | 22.6 | 1.5 | 20.9-26.4 | 42.3 | 43.1 | 2.4 | 36.9-44.9 |
| 7 | 2017: 04/21–05/18 | 23.8 | 23.8 | 0.4 | 22.9-24.4 | 42.4 | 42.9 | 1.4 | 40.2-45.3 |
| 8 | 2017: 04/28–05/25 | 22.4 | 22.3 | 0.9 | 21.1-24.2 | 50.3 | 50.1 | 2.6 | 46.2-55.6 |
| 9 | 2017: 05/27–06/23 | 23.0 | 23.2 | 0.5 | 21.8-23.7 | 59.8 | 59.5 | 1.9 | 56.9-63.9 |
| 10 | 2017: 06/07–06/20 | 23.3 | 23.2 | 0.5 | 22.5-23.9 | 55.1 | 55.6 | 2.2 | 52.4-58.3 |
| 11 | 2017: 06/07–06/20 | 22.0 | 22.4 | 1.1 | 19.7-23.1 | 56.3 | 56.1 | 2.9 | 51.3-60.5 |
| All classroom | | 23.2 | 23.2 | 1.5 | 19.3-26.4 | 47.7 | 45.6 | 6.9 | 33.0-63.9 |

## 7. Teacher Survey

The objective of the teacher survey was to describe occupant experience as an alternative means of characterizing HVAC performance. Data was collected on classroom characteristics and teachers' experiences with their classroom HVAC controls, temperature, air quality, and HVAC system noise. One hundred-eleven teachers were invited to participate in the online survey, which exceeded the number of classrooms (N = 104) because seven classrooms were shared by two teachers and both were invited to participate. Eighty-six teachers completed a majority of the survey and made it to the end, a response rate of 77%. The response rate for individual questions was at times lower than this because respondents were able to skip questions.

The following summarized responses from the teacher survey on two questions about classroom temperature:

- How satisfied are you with the temperature in the classroom?
- Does the temperature in your classroom interfere with the learning environment?

The survey asked for separate responses for times during the colder months when the heater is running, and times during the warmer months when the air conditioner is running. There were additional questions on classroom temperature (e.g., how often is classroom too hot or too cold) that are not discussed here.

Figure A-9 shows that about half the teachers reported satisfaction with their classroom temperature during each cooling and heating season and just under 30% reported dissatisfaction (about 20% were neutral). Considering individual responses across both seasons, 18% of teachers reported dissatisfaction with classroom temperature year-round.

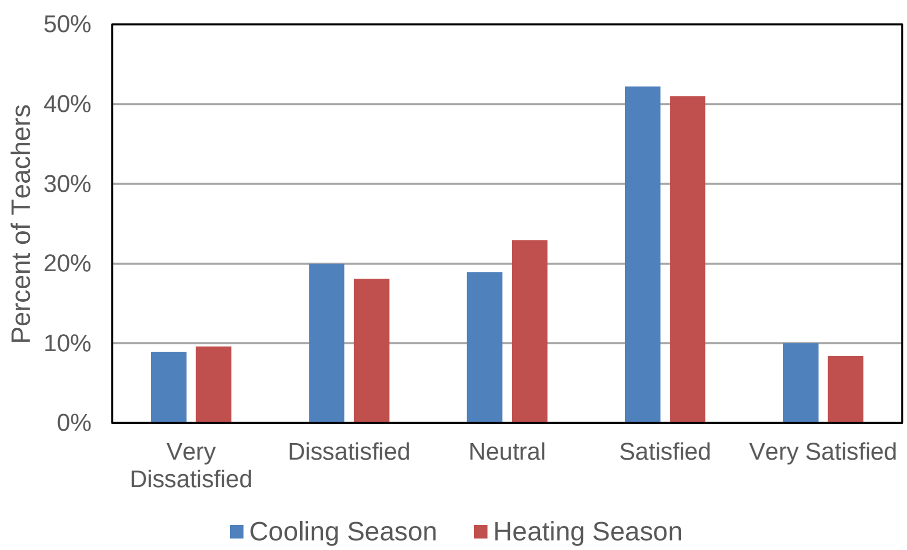



Figure A-9 Teachers' satisfaction with classroom temperature in cooling and heating season.

Roughly half the teachers reported that classroom temperature interfered with the learning environment in either the heating or cooling season, and 41% said it interfered year-round (Figure A-10). However, a large majority of these respondents said it interfered 'a little' rather than 'a lot.' Unsurprisingly, perception of temperature interfering with the classroom environment strongly correlated with less satisfaction with temperature (cooling season: $r = -.69$, $p < .001$; heating season: $r = -.63$, $p < .001$).

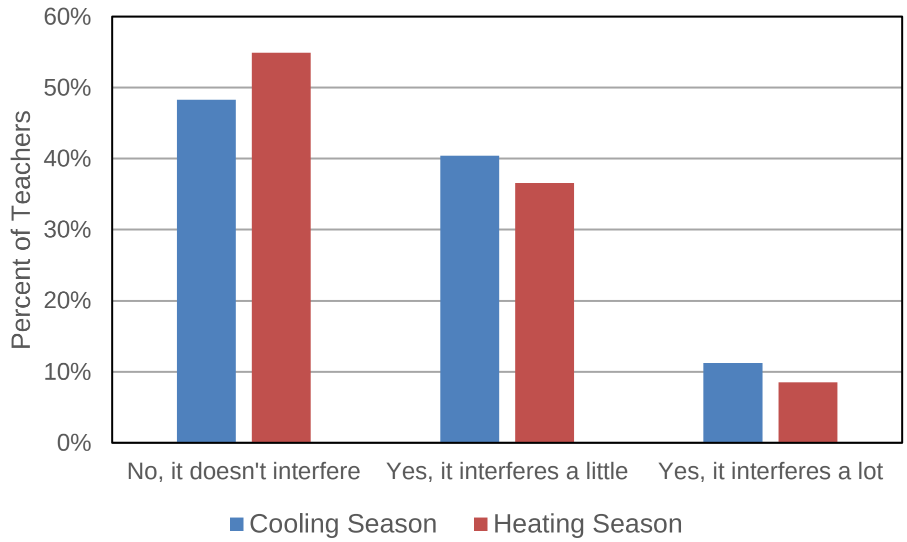



Figure A-10 Teachers' opinion on interference of classroom temperature on the learning environment.

Teachers reported using various strategies to adapt to uncomfortable temperatures, and to help their students adapt. Numerous teachers reported that such activities interfered with the classroom environment, as these quotes illustrate:

> *The kids are constantly putting on and taking off their jackets. It is very distracting.*
>
> *I must adjust the settings every hour or so, which interrupts lessons and teacher/student interactions.*
>
> *The constant interruption of turning it on and off, adjusting temp[erature], and student complaints distracts from the job at hand.*

Some teachers reported hacking their thermostat, despite disapproval from facilities departments and energy managers. For example, four teachers reported "tricking the system" to activate additional cooling using the following strategies: putting a lamp near the thermostat, having a student put their finger on the temperature sensor, covering the sensor so the air from the fan did not hit it, or microwaving a towel and placing it over the thermostat. Strategies to call for additional heating were less common, but included placing an ice pack on the thermostat (2 respondents), or drinking something cold and blowing on the thermostat (1 respondent).