**ACTIVITY: Relative humidity and thermal comfort**

**Activity idea**

In this activity, students measure the relative humidity in their classroom and in a sheltered playground location and relate the relative humidity and temperature in the classroom to thermal comfort levels.

By the end of this activity, students should be able to:

* explain the meaning of the terms relative humidity and dewpoint
* describe the evaporative cooling effect that lies behind the wet bulb/dry bulb temperature differences
* relate evaporative cooling present in this setting to the latent heat of vaporisation of water
* give a simple explanation of the role relative humidity and temperature play in establishing satisfactory thermal comfort levels in classrooms.

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**Introduction/background**

Thermal comfort in classrooms is dependent on numerous factors such air temperature, relative humidity, air movement, radiant heat, physical activity and clothing. This activity focuses on air temperature and relative humidity.

One way of measuring relative humidity is through the use of wet bulb/dry bulb temperature differences. The wet bulb/dry bulb thermometer instrument is called a psychrometer. These come about due to the evaporative cooling effect present at the wet bulb thermometer.

Evaporative cooling in this setting is directly related to the latent heat of vaporisation of water. The drier the air for a given temperature, the greater the difference between the dry bulb and wet bulb temperatures will be. Very humid air at a given temperature will result in a small wet bulb/dry bulb temperature difference.

Thermal comfort in classrooms is dependent on numerous factors with the key ones being relative humidity and air temperature. Guidelines and regulations for acceptable thermal comfort levels in workplaces have been set by the Ministry of Business, Innovation and Employment Health and Safety Group.

In this activity, students will firstly view a PowerPoint presentation that explains the terms ‘relative humidity’ and ‘dewpoint’. They will then set up their own psychrometer (wet bulb/dry bulb thermometer) and measure the relative humidity in their classroom and in a sheltered playground location outside of the classroom. To complete the activity, students will then relate the relative humidity and temperature in the classroom to thermal comfort levels.

**What you need**

* Access to the PowerPoint presentation Understanding Relative Humidity and Dewpoint –

<http://regentsearth.com/Powerpoints/Tutorials/RelHum.ppt>

* Two stirring rod thermometers (spirit filled) or a psychrometer if available
* Clean dry cotton gauze (some science lab spirit burners use this as the wick)
* Small plastic bottle (10–20 mL)
* Copies of the student handout: [Temperature and humidity observations](#handout)
* Small beaker (50 mL)
* Methylated spirit (10 mL)
* Soft drink straw
* Copies of [Relative humidity (%) and dewpoint temperature (°C) charts](#charts)
* Copies of [Thermal comfort guidelines](#guidelines)

**What to do**

1. Set up the psychrometer or the two thermometers as shown and leave in a safe, central position in the classroom for 20 minutes. 
2. As a class, view the PowerPoint presentation Understanding Relative Humidity and Dewpoint (<http://regentsearth.com/Powerpoints/Tutorials/RelHum.ppt>).
3. Have students note the dry bulb/wet bulb temperature readings and record these on the student handout [Temperature and humidity observations](#handout).
4. Remove the wet bulb/dry bulb arrangement to a sheltered outside setting and leave in place for a further 20 minutes.
5. Whilst waiting for the wet bulb/dry bulb arrangement to equilibrate, set up an evaporative cooling demonstration as follows:
* Place 10 mL of methylated spirit in the small beaker.
* Arrange the beaker such that it sits on a small film of water on the lab bench.
* Use the soft drink straw to blow a steady stream of bubbles through the methylated spirits to speed up its rate of evaporation.
* Have students note what happens to the thin film of water under the beaker on the handout.
1. Note the new thermometer readings from the thermometer and have students record this on the handout.
2. Hand out copies of the [Relative humidity (%) and dewpoint temperature (°C) charts](#charts) and have students read off the relative humidity values and dewpoint values for inside the classroom and outside the classroom and record these on the handout.
3. Hand out copies of the [Thermal comfort guidelines](#guidelines). Have students read these, then answer questions 4–11 on the handout.

**Student handout: Temperature and humidity observations**

1. ***Dry bulb/wet bulb temperatures***

|  |  |  |
| --- | --- | --- |
| Classroom | Dry bulb temperature | °C |
| Wet bulb temperature | °C |
| Difference in temperature | °C |
| Outside | Dry bulb temperature | °C |
| Wet bulb temperature | °C |
| Difference in temperature | °C |

1. ***Evaporative cooling observations:*** On bubbling a steady stream of air bubbles through the methylated spirits, it was noted that:
2. ***Relative humidity and dewpoint***

|  |  |  |
| --- | --- | --- |
| Classroom | Relative humidity | % |
| Dewpoint | °C |
| Outside | Relative humidity | % |
| Dewpoint | °C |

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1. How do the classroom and outside relative humidity results compare? Can you account for any differences?
2. Using the outside dewpoint results you have recorded, if the outside temperature in the area you selected fell to 5°C during the night following your experiment, what would you expect to see early next morning on objects such as seats, plant leaves and metal pipes in the outside area you selected?
3. During the course of your investigations, was the classroom environment thermally comfortable? Justify your answer using temperature and humidity results you recorded.
4. Explain why it is that, for humidity values less than 100%, the wet bulb temperature is always less than the corresponding dry bulb temperature.
5. Why is it that: “Achieving personal thermal comfort for everyone is a difficult issue”?
6. Define the term ‘thermal comfort’.
7. List the disadvantages that can result from working in a thermal environment that causes discomfort.
8. Using ideas from the kinetic theory of gases and the concept of latent heat, explain why the evaporative cooling activity produced a layer of ice under the beaker containing the methylated spirits.

**Relative humidity (%) and dewpoint temperature (°C) charts**

**Relative Humidity (%)**

|  |  |
| --- | --- |
| **Dry-Bulb****Temperature****(°C)** | **Difference between Wet-Bulb and Dry-Bulb Temperature (°C)** |
| **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |
| **-20** | 100 | 28 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-18** | 100 | 40 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-16** | 100 | 48 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-14** | 100 | 55 | 11 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-12** | 100 | 61 | 23 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-10** | 100 | 66 | 33 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-8** | 100 | 71 | 41 | 13 |  |  |  |  |  |  |  |  |  |  |  |  |
| **-6** | 100 | 73 | 48 | 20 |  |  |  |  |  |  |  |  |  |  |  |  |
| **-4** | 100 | 77 | 54 | 32 | 11 |  |  |  |  |  |  |  |  |  |  |  |
| **-2** | 100 | 79 | 58 | 37 | 20 | 1 |  |  |  |  |  |  |  |  |  |  |
| **0** | 100 | 81 | 63 | 45 | 28 | 11 |  |  |  |  |  |  |  |  |  |  |
| **2** | 100 | 83 | 67 | 51 | 36 | 20 | 6 |  |  |  |  |  |  |  |  |  |
| **4** | 100 | 85 | 70 | 56 | 42 | 27 | 14 |  |  |  |  |  |  |  |  |  |
| **6** | 100 | 86 | 72 | 59 | 46 | 35 | 22 | 10 |  |  |  |  |  |  |  |  |
| **8** | 100 | 87 | 74 | 62 | 51 | 39 | 28 | 17 | 6 |  |  |  |  |  |  |  |
| **10** | 100 | 88 | 76 | 65 | 54 | 43 | 33 | 24 | 13 | 4 |  |  |  |  |  |  |
| **12** | 100 | 88 | 78 | 67 | 57 | 48 | 38 | 28 | 19 | 10 | 2 |  |  |  |  |  |
| **14** | 100 | 89 | 79 | 69 | 60 | 50 | 41 | 33 | 25 | 16 | 8 | 1 |  |  |  |  |
| **16** | 100 | 90 | 80 | 71 | 62 | 54 | 45 | 37 | 29 | 21 | 14 | 7 | 1 |  |  |  |
| **18** | 100 | 91 | 81 | 72 | 64 | 56 | 48 | 40 | 33 | 26 | 19 | 12 | 6 |  |  |  |
| **20** | 100 | 91 | 82 | 74 | 66 | 58 | 51 | 44 | 36 | 30 | 23 | 17 | 11 | 5 |  |  |
| **22** | 100 | 92 | 83 | 75 | 68 | 60 | 53 | 46 | 40 | 33 | 27 | 21 | 15 | 10 | 4 |  |
| **24** | 100 | 92 | 84 | 76 | 69 | 62 | 55 | 49 | 42 | 36 | 30 | 25 | 20 | 14 | 9 | 4 |
| **26** | 100 | 92 | 85 | 77 | 70 | 64 | 57 | 51 | 45 | 39 | 34 | 28 | 23 | 18 | 13 | 9 |
| **28** | 100 | 93 | 86 | 78 | 71 | 65 | 59 | 53 | 47 | 42 | 36 | 31 | 26 | 21 | 17 | 12 |
| **30** | 100 | 93 | 86 | 79 | 72 | 66 | 61 | 55 | 49 | 44 | 39 | 34 | 29 | 25 | 20 | 16 |

**Dew-Point Temperatures (%)**

|  |  |
| --- | --- |
| **Dry-Bulb****Temperature****(°C)** | **Difference between Wet-Bulb and Dry-Bulb Temperature (°C)** |
| **0**  | **1**  | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |
| **-20** | -20 | -33 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-18** | -18 | -28 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-16** | -16 | -24 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-14** | -14 | -21 | -36 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-12** | -12 | -18 | -28 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-10** | -10 | -14 | -22 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **-8** | -8 | -12 | -18 | -29 |  |  |  |  |  |  |  |  |  |  |  |  |
| **-6** | -6 | -10 | -14 | -22 |  |  |  |  |  |  |  |  |  |  |  |  |
| **-4** | -4 | -7 | -12 | -17 | -29 |  |  |  |  |  |  |  |  |  |  |  |
| **-2** | -2 | -5 | -8 | -13 | -20 |  |  |  |  |  |  |  |  |  |  |  |
| **0** | 0 | -3 | -6 | -9 | -15 | -24 |  |  |  |  |  |  |  |  |  |  |
| **2** | 2 | -1 | -3 | -6 | -11 | -17 |  |  |  |  |  |  |  |  |  |  |
| **4** | 4 | 1 | -1 | -4 | -7 | -11 | -19 |  |  |  |  |  |  |  |  |  |
| **6** | 6 | 4 | 1 | -1 | -4 | -7 | -13 | -21 |  |  |  |  |  |  |  |  |
| **8** | 8 | 6 | 3 | 1 | -2 | -5 | -9 | -14 |  |  |  |  |  |  |  |  |
| **10** | 10 | 8 | 6 | 4 | 1 | -2 | -5 | -9 | -14 | -28 |  |  |  |  |  |  |
| **12** | 12 | 10 | 8 | 6 | 4 | 1 | -2 | -5 | -9 | -16 |  |  |  |  |  |  |
| **14** | 14 | 12 | 11 | 9 | 6 | 4 | 1 | -2 | -5 | -10 | -17 |  |  |  |  |  |
| **16** | 16 | 14 | 13 | 11 | 9 | 7 | 4 | 1 | -1 | -6 | -10 | -17 |  |  |  |  |
| **18** | 18 | 16 | 15 | 13 | 11 | 9 | 7 | 4 | 2 | -2 | -5 | -10 | -19 |  |  |  |
| **20** | 20 | 19 | 17 | 15 | 14 | 12 | 10 | 7 | 4 | 2 | -2 | -5 | -10 | -19 |  |  |
| **22** | 22 | 21 | 19 | 17 | 14 | 14 | 12 | 10 | 8 | 5 | 3 | -1 | -5 | -10 | -19 |  |
| **24** | 24 | 23 | 21 | 20 | 18 | 16 | 14 | 12 | 10 | 8 | 6 | 2 | -1 | -5 | -10 | -18 |
| **26** | 26 | 25 | 23 | 22 | 20 | 18 | 17 | 15 | 13 | 11 | 9 | 6 | 3 | 0 | -4 | -9 |
| **28** | 28 | 27 | 25 | 24 | 22 | 21 | 19 | 17 | 16 | 14 | 11 | 9 | 7 | 4 | 1 | -9 |
| **30** | 30 | 29 | 27 | 26 | 24 | 23 | 21 | 19 | 18 | 16 | 14 | 12 | 10 | 8 | 5 | 1 |

**Thermal comfort guidelines**

From ***Designing Quality Learning Spaces: Heating and Insulation***(New Zealand Ministry of Education, 2007) <http://www.education.govt.nz/assets/Documents/Primary-Secondary/Property/School-property-design/Flexible-learning-spaces/HeatingInsulation.pdf>

The comfort of students and teachers depends on:

* good indoor air quality
* adequate ventilation
* appropriate thermal comfort resulting from an acceptable air temperature and relative humidity.

Air quality, ventilation and temperature are interdependent and must always be considered

together. Adequate cooling for thermal comfort (whether active or passive) is closely related to heating and ventilation. Students and teachers need to be comfortable in their learning/teaching environments to reach their full potential. Achieving personal thermal comfort for everyone is a difficult issue because it is so subjective. A space may be within the normal temperature comfort band, but high humidity may make the occupants feel thermally uncomfortable. Thermal comfort also depends on such factors as personal metabolism and the amount of physical activity underway.

From ***What you need to know about temperature in places of work***
(New Zealand Department of Labour, 1997)
[www.business.govt.nz/healthandsafetygroup/information-guidance/all-guidance-items/temperature-in-places-of-work-what-you-need-to-know-about/temp-s.pdf/view](http://www.business.govt.nz/healthandsafetygroup/information-guidance/all-guidance-items/temperature-in-places-of-work-what-you-need-to-know-about/temp-s.pdf/view)

**What is thermal comfort?**

Thermal comfort has been described as “a condition of the mind which expresses satisfaction with the thermal environment”. A person can be described as being “thermally comfortable” when they are not conscious of being either too hot or too cold.

A “thermally comfortable” environment is the ideal thermal environment for people to work in. Not only do people perform their work more efficiently, but they are less likely to make mistakes that could result in an accident. Thermal comfort can be very subjective. Conditions that are very comfortable to one person can be uncomfortable to another.

**What is thermal discomfort?**

Thermal discomfort is the uncomfortable place between a thermal environment that is ideal, and one that will cause a person to be harmed. A person feeling thermal discomfort will feel either too hot or too cold. However, a person will not suffer harm as a direct result of the thermal environment.

**Should people be allowed to experience thermal discomfort at work?**

While a thermal environment that causes discomfort may not directly cause harm, it does have many disadvantages. People can feel tired and irritable. They may be less productive and make more mistakes with their work. There’s a greater risk of someone making a mistake that could result in an accident.

It’s therefore not desirable for people to work in thermally uncomfortable conditions.

In many work situations, it may not be possible to avoid some thermal discomfort. The thermal environment obviously cannot be controlled for people working outdoors, although clothing, physical activity and the timing of the work can be. If people experience discomfort for only a few days a year, it may not be practicable to spend a lot of resources to control the thermal environment. Administrative controls may be more appropriate.