



Improving our Classroom Environment v3

Internet of Things: CfE Science 2nd Level

Lesson Activities



THE UNIVERSITY
of EDINBURGH

Improving our Classroom Environment



Data-Driven
Innovation



CITY
REGION
DEAL

Edinburgh
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Scotland



Activity 1 The Class that Kept Falling Asleep

1.1 The teacher presents the short introductory story (*The Class that kept Falling Asleep*) which sets the scene for the topic.

1.2 As a class, or in groups, learners discuss possible causes of the situation described in the story.

Learners may propose a variety of causes:

- the teacher is boring
- everyone hates maths
- a magic spell or potion
- children aren't getting enough sleep at home
- children are dehydrated

1.3 With direction, learners explore the possible contribution of environmental factors:

- the room is too warm
- there isn't enough fresh air (oxygen)
- classroom lighting is inadequate

1.4 Time should be spent establishing what is meant by each of these 4 variables - CO₂, temperature, humidity and light - and their units of measurement. This can be done using the PowerPoint slides, or by learners carrying out research online.

UNITS OF MEASUREMENT

- Room temperature: Degrees Celsius
- Carbon dioxide: parts per million (ppm)
- Light level: Lux
- Humidity: % water in air

1.5 Learners discuss the following introductory questions.

- What are the sources of CO₂ within the classroom?
- Is CO₂ harmful?
- What causes increases and decreases in classroom temperature?
- How is classroom temperature controlled?
- What are the sources of light in the classroom?
- How is the level of light controlled?
- What causes increases and decreases in classroom humidity?

1.6 Learners discuss/research aspects of each environmental variable within their classroom setting. Drawing on their own experiences learners discuss whether

classroom temperature, air quality and level of lighting affect the quality of their learning. Are there particular times of day when they are less alert and ready to learn, or when learning can be a struggle? (Note: This is described as their 'Learning State' and its important establish early in discussion since this will be the metric for learners' self-evaluation in Activity 4).

The Class That Kept Falling Asleep

Abbie tried hard to concentrate. Her teacher Mr Prentice was showing the class how to do a complicated maths calculation. She tried to focus but her eyelids felt heavy and the numbers on the whiteboard seemed to be jumbled. Abbie yawned and looked at the clock on the classroom wall. There was still 20 minutes to go until lunch. She rubbed her eyes and sat up in her chair to try to stop herself from falling asleep.

Mr Prentice suddenly stopped writing. "Ryan," he said in a loud voice. All the pupils looked over to where Ryan was sitting, next the classroom window. Ryan had his head on his hands and he was fast asleep. Mr Prentice shouted "Ryan . . . wake up!" but it was no use, Ryan kept on sleeping.

"It's not just Ryan," said Kimberly. "Look at Jamil . . . he's asleep too."

"I don't know what's happening with this class," Mr Prentice said, shaking his head. "What on earth's the matter with you?" Then the teacher yawned and rubbed his eyes.

There's something strange happening, Abbie thought. Every day she came to school feeling bright and energetic. But as the morning wore on, she became more and more tired and the last half hour before lunch always seemed to be a struggle. It was the same towards the end of the school day. By 3 o'clock she was always drowsy and heavy-eyed. It wasn't just Abbie. Everyone seemed to be tired in Mr Prentice's class. Yesterday, Zac had fallen asleep in the middle of a spelling test and Abbie's friend Poppy had nodded off three times.

Abbie gazed out of the classroom window. It was a dull, cloudy day, which made it quite dark inside the classroom, and Mr Prentice hadn't put any lights on. Abbie couldn't wait to get out into the playground at lunch break. Only twenty minutes of maths to go, she thought. Hope I can manage to stay awake.

Activity 2 Investigating Environmental Factors

Learning intention

- We are learning how environmental factors, such as temperature, light and CO₂ can affect children's learning.

Success criteria

- We can find evidence that shows how environmental factors affect learning
- We can share and present our findings
- We can work well in groups

2.1 The class (working in groups) carries out Internet research to find out how environmental factors such as CO₂, temperature, humidity and light affect the ability to learn.

Links may be suggested to support this activity for example in relation CO₂ We are still looking for so level 2 learner resources for this activity.

<https://hepell.net/byop/>

<https://thinkprogress.org/exclusive-elevated-co2-levels-directly-affect-human-cognition-new-harvard-study-shows-2748e7378941/>

2.2 Learners share and present their findings.

Activity 3 How Sensors Capture Data About Buildings

Learning intention

- We are learning how sensors can record environmental data about a building.

Success criteria

- I can describe types of building data recorded by a sensor.
- I can say why data about buildings is helpful.
- I can analyse environmental data about a classroom.

3.1 Recap on Activity 1 – looking at how environmental conditions can affect readiness to learn.

3.2 Learners are introduced to the use of sensors to monitor building environments such as school classrooms, offices and homes.

3.3 Learners consider the purpose of monitoring environmental conditions such as CO₂ levels in workplaces and homes. Possible considerations include health and wellbeing, safety, productivity, comfort and being eco-friendly.

3.4 Learners are presented with data from Abbie’s classroom at Cladach Primary School. The data comprises:

- Changes in classroom temperature throughout the school day
- Changes in CO₂ levels throughout the day
- Changes in light levels throughout the day
- Changes in humidity levels throughout the day

3.5 In groups, learners discuss and analyse the 4 sets of data from Cladach Primary. They should be directed to identify trends and changes during the day, eg CO₂ levels rising steadily throughout the morning, and with a similar pattern in the afternoon. They should discuss the data and develop hypotheses to explain why such changes occurred. For example:

- Classroom temperature increases from 9 am due to rising temperatures outside(eg sunshine) and falling from 2.30 pm due to cloudy, cooler weather.
- Classroom temperature increases from 9 am due to body heat of pupils and teachers, levelling off at lunchtime when pupils are out of the class.
- CO₂ levels increase from 9 am due to pupils and teachers breathing and speaking. This falls over lunchtime when pupils are outside but increases steadily again during the afternoon until 2 pm.
- CO₂ levels fall significantly between 2 pm and 3 pm. This suggests that the teacher has opened the windows to let fresh air into the classroom.

Alternatively it may be that the class is elsewhere, for example, doing PE in the school gym between 2 pm and 3 pm.

- CO₂ levels increase from 9 am due to pupils and teachers breathing and speaking. This falls over lunchtime when pupils are outside but increases steadily again during the afternoon, following a similar pattern.
- Classroom light increases steadily during the morning (as the sun rises) but falls dramatically between 12 noon and 1 pm, which suggests that the classroom lights are off during lunch break.
- Classroom light decreases significantly between 1 pm and 2 pm. This may be explained by very cloudy weather outside, or perhaps the teacher turning off the lights to use an interactive whiteboard.
- Classroom humidity levels remain fairly constant during the morning and over lunch but increase sharply between 1 and 2 pm. Perhaps it was raining over lunch and pupils have wet clothing that is drying out in the classroom.
- Humidity levels return to normal levels as the afternoon progresses. Perhaps the teacher has opened the classroom windows.

Activity 4 Investigating our Learning Environment

Learning intention

- We are learning how to plan and carry out an investigation into our classroom environment using the PPDAC model.

Success criteria

- I can identify the problem to be investigated.
- I can plan an investigation.
- I can describe how our sensor will provide us with data.
- I can rate my own learning state.
- I can work well in groups.

4.1 The main purpose of the investigation is for learners to determine how environmental conditions in their classroom affect their learning.

Learners will undertake an investigation to determine the impact of environmental factors on their learning.

The class should use the PPDAC model:

- Identify the problem
- Plan how to carry out research
- Identify/gather data required to help solve the problem
- Analyse the data
- Draw conclusions



4.2 The process may be presented to the class in this way.

Problem: We want to know how our classroom environment affects our learning.

Plan: We will plan an investigation to discover how our classroom environment affects our learning.

Data: We will identify and gather data about our classroom environment.

Analysis: We will analyse the data to understand how different environmental factors affect our learning.

Conclusion: We will draw conclusions from our investigation.

(Note: Activity 4 covers the first 2 stages of the PPDAC model – Identifying the Problem and *Planning the Investigation*).

4.3 Learners discuss the problem. How do we find out if:

- CO₂ levels in our class affect our learning.
- Classroom temperature affects our learning.
- Classroom lighting affects our learning.
- Humidity affects our learning.

4.4 How might this be achieved? Learners know that Cladach Primary used a sensor to gather this data (Activity 3) so they should request a require a sensor to generate similar data about their own classroom.

Learners find out about the *Elsys ERS Smart Building Sensor* which will be installed in their classroom to support their research.

They learn how the sensor operates; how it captures data and uploads it to Edinburgh University. They learn how they will access data about their classroom via the dashboard.

4.5 Learners discuss where the sensor should be located within the classroom. Consideration is given to where in the room data gathering will be optimised. Teachers should be aware that the sensor should be located ideally in or around an area where CO₂ is likely to be most prevalent within the room. Placing the sensor on the teacher's desk, for example, would provide more reliable CO₂ readings than if placed in the corner of the classroom.

At the outset, learners need to establish baseline readings from the sensor. This is provided by the Data Education Unit at the University of Edinburgh, which will gather and publish the data uploaded by the classroom sensor.

4.6 Learners also need to have a method of assessing their readiness or capacity to learn – Are they **ready to learn**? It is suggested that learning states are depicted using a traffic light system.

GREEN: I am able to concentrate and take in new information well.
I feel bright, energetic and positive.

AMBER: I am able to concentrate and take in new information quite well.
My energy levels and motivation are okay, but could be better.

RED: I don't feel able to concentrate or take in new information well.
I feel drowsy, a bit lazy and negative about my learning.

Evaluating their readiness to learn is an exercise that should be practised at regular times before the investigation begins, so that learners are familiar and comfortable with the traffic light rating process.

Activity 5 Recording 'Learning State' Ratings/Evaluations

5.1 For 3 weeks and using the traffic light system, each member of the class rates his/her readiness/capacity to learn at various times each school day. Ratings are carried out:

- Around 20 minutes after the start of the school day
- Around 20 minutes before lunch
- Around 20 minutes after lunch
- Around 20 minutes before the end of the school day

Activity 6 Analysing Dashboard Data

Learning intention

- We are learning how to analyse sensor data about our classroom.

Success criteria

- I can identify changes to classroom data, such as temperature, CO₂ and light levels.
- I can suggest possible reasons for changes data during the school day.
- I can make connections between classroom data and my learning state.

6.1 For 3 weeks, learners analyse the data from the sensor dashboard and discuss changes to the environmental metrics.

6.2 The class establishes baseline metrics for CO₂, temperature, humidity and light.

6.3 Learners explore how environmental metrics change during the course of the school day.

- At what times of day are CO₂ levels highest/lowest?
- At what times of day is the temperature of the room highest/lowest?
- At what times of day is light greatest/least?
- At what times of day is the humidity highest/lowest?
- What might be the cause of these changes?

6.4 As a class or in groups, learners correlate their *Learning State* ratings with the sensor data. They identify changes in levels of CO₂, temperature, humidity and light, and they consider whether (and how) these factors affect the quality of their learning.

The class could be split into 4 groups, with each groups focusing on one set of data; ie temperature, CO₂ levels, lighting and humidity. Each group could present their findings to the class.

- In groups, discuss what we've learned from our analysis of dashboard.
- Agree possible explanations for changes to sensor data during the day.
- Describe how changes to our classroom environment affects our learning.

Activity 7 Changing Our Learning Environment

Based on their findings so far, learners investigate ways of improving their classroom environment. From analysis of data they should identify optimal conditions for learning.

Learning intention

- We are finding out if making changes to our classroom improves our learning environment.

Success criteria

- I can identify optimal conditions for learning.
- I can suggest ways of changing our classroom environment.
- I can analyse data to see the effects of these changes.

7.1 Learners reflect on what they have learned about the impact of environmental factors on their learning.

- What do we know about how classroom temperature affects our learning?
- What do we know about how CO₂ affects our learning?
- What do we know about how light levels affect our learning?
- What do we know about how humidity affects our learning?

7.2 Learners should be introduced to the term 'optimal', ie the best for learning. From analysis of dashboard data and traffic light ratings, learners determine:

- An optimal classroom temperature for learning (degrees Celsius)
- An optimal air quality for learning (parts per million CO₂)
- An optimal light level for learning (lux)
- An optimal humidity level for learning (% water in air)

7.3 In groups or as a whole class, learners discuss what they would need to do or change to achieve these optimal levels. They plan and implement a range of interventions, for example:

- Opening/closing classroom windows at various times of day to maintain optimal temperature.
- Altering radiator thermostats (if possible) or other methods of heat control
- Use of window blinds to increase/decrease the impact of sunlight on classroom temperature.
- Opening windows to increase oxygen and reduce CO₂.

- Introducing plants to the classroom. (Note: there is a separate extension activity which focuses on the impact of plants on classroom environment - Activity 8).
- Use of window blinds to increase/decrease the impact of sunlight on lux levels in the classroom.
- Selective of classroom overhead lights to increase/decrease lux levels to achieve optimal lighting.
- Strategies for increasing/decreasing humidity levels to achieve optimal humidity level (above 40%). Water troughs or even wet towels on radiators can boost humidity, plant walls or just lots of plants (1 per learner) with moist soil helps raise humidity.

7.4 Over the following weeks, learners analyse sensor data regularly to see if their interventions have been successful in achieving optimal levels. They correlate the sensor data with their ongoing learning state ratings so that they can draw conclusions from their investigation.

7.5 Contact can be made with other schools doing similar research to find out the results of their investigations and compare with their own. The Data Education Team at Edinburgh University will supply details of participating schools.

Activity 8 (Extension) Can Plants Improve Our Learning Environment?

Learning intention

- We are investigating the effect of plants on air quality in our classroom.

Success criteria

- I can plan an investigation to see how plants affect air quality in our classroom.
- I can analyse data to see the impact of plants on CO₂ levels.

8.1 The introduction of plants is likely to be the most active way for children to improve their learning environment. There is evidence that even a small number of plants reduces the level of CO₂ in a learning space/classroom. Stephen Heppell's website (BYOP – bring your own plant) is a good source of information and ideas about improving air quality.

Extract from: <https://heppell.net/byop/>

Getting the CO₂ down and the learning up!

Higher than normal CO₂ levels will directly impact badly on human cognition. As more and more research comes in, we realise that the level for damage to occur is lower than was first thought. Many, many children's school performances are currently damaged. As we seek to make learning better, a simple target for improvement and for significant marginal gain is getting the CO₂ levels down.

There is much interest in plants and air quality - countless studies confirm that the right plants can have an active role in reducing CO₂ and increasing oxygen particularly in any closed space (although plants also respire and are counter effective as oxygen producers at night in the dark).

We have been encouraging schools to harness the power of plants through Bring Your Own Plant projects, which really do make things better during the school day. Better oxygen brings behaviour, engagement, wellbeing and other gains.

Ideally, the plant needs to be in a white pot - normally the school provides these for uniformity and to make sure they fit the plant pot holders. Photosynthesis uses light absorption, white pots reflect light a little more to help balance this. The data gains for white pots vs dark pots might seem very small but the impact in terms of meta cognition is significant: children think about 'Why white?' A white background behind the plants helps too.

Measuring the CO₂ at 3 points during the day, before and after the plants were added will give surprising results. It provides a good data visualisation and graphing task too. Target CO₂ is to keep below 1,000 parts per million (ppm) throughout the day, and you will all notice when levels are worse (above) than that.

Plants and humidity

The Covid pandemic has brought a number of problems to schools and working spaces. CO₂ spikes can be a useful indicator that you are not ventilating the space well enough to minimise aerosol plumes in confined spaces. But lately the role

of humidity has become increasingly clear in research: put simply, moist air (above 40% humidity) helps the body to battle infections and of course with windows necessarily open to ventilate, with dry winter air, and / or with air conditioning too, air can become very dry. Water troughs or even wet towels on radiators can boost humidity, but actually Plant Walls or just lots of plants (1 per learner) with moist soil really do help get the humidity up. Even more reasons for BYOP!

Activities

- Learners can research which plants are best for reducing CO₂ (spider plants are particularly effective).
- Each learner can bring their own plant to school with their name written on the pot and they are tasked with looking after it and monitoring moisture levels.
- Plants should be introduced gradually, so that learners can monitor and analyse the incremental changes to CO₂ levels.
- CO₂ readings should ideally be taken at 3 points during the day (before and after plants are added).
- Plant walls are available to purchase – learners may discuss ways of raising funds to enable purchase of plants or a plant wall.
- Learners may decide to grow their own plants.
- Contact can be made with other schools doing similar research to find out the results of their investigations and compare with their own. The Data Education in Schools team at the University of Edinburgh will supply details of participating schools.

Activity 9 Drawing Conclusions From Our Research

At the end of the investigation learners discuss their findings and draw conclusions.

Learning intention

- We can draw conclusions from our learning environment investigation.

Success criteria

- I can summarise the main findings of our investigation.
- I can draw conclusions from our investigation

9.1 As a class or in groups learners discuss what they have discovered about the impact of environmental factors on learning. They review and discuss the impact of their interventions on air quality, temperature, humidity and light.

They identify those interventions which resulted in the most significant changes to conditions for learning.

9.2 Learners summarise their findings and draw conclusions.

Activity 10 Making A Presentation About Our Investigation

Learning intention

- We will create a presentation about our investigation and share it with the class.

Success criteria

- I can describe the problem to be investigated.
- I can describe how we planned the investigation.
- I can describe the role of data in our investigation.
- I can describe how we analysed the data.
- I can describe the main conclusions of our investigation.

10.1 Learners create a presentation about their investigation and share it with the class. They should be directed to use the PPDAC model to show the process they followed.

- Problem
- Plan
- Data
- Analysis
- Conclusions

10.2 Each group may present the entirety of the investigation or, alternatively, each group presents only one of the PPDAC stages.

Activity 11 Extension Activities

Various activities may be undertaken to extend the lesson or create additional lessons to increase breadth/depth and promote interdisciplinary learning.

11.1 Learners discuss why data about environmental conditions in other buildings such as offices, factories and in homes might be important.

11.2 Learners develop deeper knowledge of data by reviewing all the data produced during their research; analysing, comparing, and summarising the data.

11.3 Learners use information technology to produce graphical representations of the data.

11.4 Contact is made with other schools doing similar research to find out the results of their investigations and compare with their own.

11.5 Write a blog or newspaper article about their research for a local newspaper or school magazine.