FaSMEd

Raising Achievement through Formative Assessment in Science and Mathematics Education

Insulation: Graphing a cooling curve

Subject:	Science
Age of students:	12-13 years
Hardware:	Surface or iPad, temperature probe
Software:	*LoggerPro* software
Functionalities:	Identifying and Responding to Conceptual Difficulties
Time:	10 minutes before the lesson, two 40-minute classes (or one double class) and 10 minutes in a following class (or homework).
FaSMEd partner:	Maynooth University
Short Abstract:	In this lesson teachers explore student misconceptions and how these might impact a science lesson. Students carry out a pre-assessment. Teachers use this pre-assessment to plan for the following lessons to carry out an insulation activity with students using temperature probes, data logging software and *Schoology*. This activity adapted from materials from Discover Sensors Ireland www.discoversensors.ie . Students set up an experiment to graph a cooling curve using the logger software. The students then to record their analysis of their graphs within groups.

1. Content

Identify good and bad conductors of heat and compare insulating ability of different materials.

2. Activity

2.1 Aims

Learning Outcomes:

Content Knowledge:

- Temperature is a measure of the hotness of something.
- Metals are poor insulators.
- Materials that are good insulators.
- A conductor lets heat through it easily.
- An insulator is a bad conductor of heat.

Process:

- Students will learn how to carry out a fair test.
- Students will become familiar with using *LoggerPro* and temperature sensors[1].
- Students will interpret graphs in real time as they collect data.
- Students will associate the slope of the graph with the rate of cooling.

Skills:

- Information processing- recording, presenting information.
- Critical and creative thinking – examining evidence and reaching conclusions. Communicating
- Working with others

OBJ

2.2 Structure / Methodology

Introduction:

This lesson unit is structured in the following way:

- Before the lesson, students' work on a pre-assessment task designed to reveal their current understanding and difficulties. You review their work and create questions for students to answer in order for them to improve their solutions.
- Students will be introduced to the Go!temp technology (you may use the videos listed below) and will install software on their laptops/iPads.
- Students will participate in group work to get familiar with temperature probes.
- A whole class discussion provides students with an opportunity to discuss the technology and any problems/comments they may have about it.
- The teacher will then introduce the insulation experiment and discuss safety regulations.
- Students will carry out the insulation experiment in groups.
- Students will gather and interpret their data and post results on *Schoology*.
- Teacher will analyse results on *Schoology* and give group feedback to the class.

[1] Temperature Sensors available at:
http://www.vernier.com/products/sensors/temperature-sensors/

- Finally students return to the pre-assessment task and try to improve their original responses.

Pre-assessment Task (10 minutes)

Set this task, in class or for homework a few days before this formative assessment class. This will give you an opportunity to assess the work, and to find out the kind of difficulties students are having with it. You will then be able to target your help more effectively in the follow up lesson.

Give each student a copy of the pre-assessment task. Briefly introduce the task and help the class to understand the problem and its context.
Read through the task and try to answer it as carefully as you can.
It is important that as far as possible, students are allowed to answer the questions without your assistance.

Explain to students that by the end of the next class(es) they should be able to answer questions such as these confidently. This is their goal.

Assessing students' responses:

Collect students' responses to the task. Make some notes on what their work reveals about their current levels of understanding and their different problem solving approaches.
We suggest that you do not score students' work. The research shows that this will be counterproductive, as it will encourage students to compare their scores and will distract their attention from what they can do to improve their mathematics. Instead, help students to make further progress by summarizing their difficulties as a series of questions.
We suggest that you write a list of your own questions, based on your students' work, using the ideas that follow. You may choose to write questions on each student's work. If you do not have time to do this, select a few questions that will be of help to the majority of students. These can be written on the board at the end of the lesson.

Suggested Lesson Outline

Technology Introduction (30 minutes)

Begin the class by introducing the temperature probes and *LoggerPro* software. You may use the videos listed above to familiarise the students with how the probes work. Allow students time to install the software on the laptops. Teachers should supervise this activity closely so that students are familiar with the technology for the next activity.
Organise students into groups for the next activity, make sure groups are mixed ability or chosen using the 'lollipop stick' method. Assign group roles and emphasis that every student has a part to play in the experiment as well as contributing to the group activity.
Students are going to test out their temperature probes and the *LoggerPro* software using beakers of hot and cold water. Remind students that data needs to be gathered on their computer while they are testing out the probes. Show students how to adjust the time scale on the *LoggerPro* software.

- *Now we are going to test out our temperature probes by placing them in the beakers of water.*

- *Make sure that you are collecting data on the laptop/iPad while you are carrying out the experiment.*
- *Make a list of any problems that you are having with the laptop programme or the temperature probe.*
- *Write down 3 comments that you have about this activity, we are going to have a group discussion after this.*

Following on from this you should lead a whole class discussion or brainstorm about the first activity, making sure that all groups understand how to use the technology accurately.

Activity Introduction: Insulation Experiment (20 minutes)

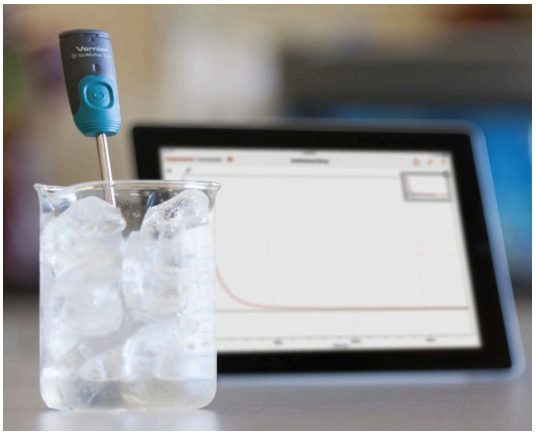
It will be important that you lead into this experiment by linking it with the previous one. Make sure to discuss any safety issues that may arise during the experiment. Again assign group roles and emphasis the importance of sticking to the role as well as participating fully in group work.
The following method can be used for this activity:

Introducing the investigation (sample questions):

- Why do cafés and garages sell coffee "to go" in cardboard or polystyrene cups?
- Why do hot water bottles have woollen covers?
- Why are we told to put a lagging jacket on the hot water cylinder in our house?
- If we were to carry out an investigation on how good of an insulator a material was what would we do?
- How could we make sure our experiment was a fair test?

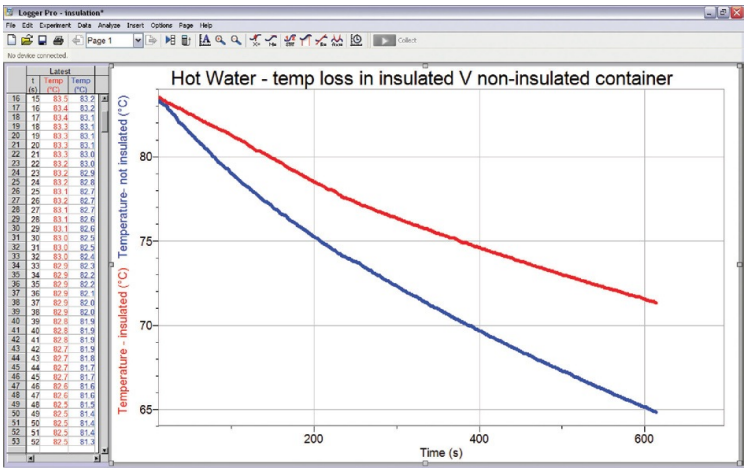
Procedure

1. Boil the kettle.
2. Get two cans and wrap a thick wad of kitchen paper around one of the cans.
3. Place exactly 100 cm3 of the boiled water into both containers.
4. Place a coffee cup lid on each of the containers.
5. Place the temperature sensor through the hole in each lid so it reaches the hot water.
6. Set the timer on the *LoggerPro* software to collect for 10 minutes (600 seconds)
7. Start collecting temperature data.
8. Stop and autoscale the graph.
9. Save the graph.



Results

This is the data collected by the two temperature sensors, and the graph generated by the software. Each time the experiment is repeated; the trend in the results is the same.



Sample Graph

Questions arising from the experiment

- What was the initial temperature of the water in each container? (And if the kettle was just recently boiled, why was the water temperature not 100 ° C?)
- What was the temperature loss in each container after 10 minutes?
- Can you express this as a percentage loss in each case?
- Was this a fair test?
- What was the only variable we changed, and why?
- What was kept constant – why was this important?
- Would it matter if the lids were left off?
- What would happen if the layer of insulation was (i) thicker (ii) thinner (iii) a different material?
- Can you predict if the trend in results would be the same for larger bodies of hot water?
- What makes a material a good insulator against heat loss?
- Why are we always advised to wear layers of clothing in cold weather?

Analysing and Interpreting the Data: (10 minutes)

There is a definite trend – we can see the temperature is falling in both containers of water. The temperature is falling more quickly in the 'bare' container, more slowly in the 'wrapped' container. This must be because the layer of kitchen paper (or whatever material used) is preventing the heat energy from leaving the water as quickly as in the 'bare' container.

Students should now have a graph with all of their experiment results on the *LoggerPro* programme. Encourage students to analyse and interpret this data.
Now students we are going to look at our graphs and see if we can draw up any conclusions from this experiment.
I want you to upload your graph to the Schoology group page and leave a comment about what your group concluded about insulators.
This activity may take time as students may find it difficult to upload the graphs. You should practice this yourself before coming into class so that you are familiar with the process.

Student responses on Schoology

Once all graphs are uploaded, you should analyse the results yourself after the class and pick the key conceptual difficulties that groups are having and discuss them in to following class.

Improving individual solutions to the assessment task (10 minutes)
Return to the students their original pre-assessment task, as well as a second blank copy of the task.
Look at your original responses and think about what you have learned this lesson.
Using what you have learned, try to improve your work.
If you have not added questions to individual pieces of work then write your list of questions on the board. Students should select from this list only those questions they think are appropriate to their own work.
If you find you are running out of time, you could set this task for homework.

2.3 Technology

- Video Clips: Bluetooth Device: http://vnr.st/v190: USB Device: http://vnr.st/v19
- Each student will need two copies of the pre-assessment task and access to their individual *Schoology* account.
- Each group will need a temperature probe, kettle, water, two plastic containers with lids, thick wad of kitchen paper and elastic band
- Each group will need access to a laptop, Surface or iPad for the LoggerPro software.

2.4 Aspects of Formative Assessment

The formative assessment strategies of note during this series of lessons included engineering effective classroom discussions and learning tasks such as group based insulation investigations, which elicit evidence of student understanding, providing feedback that moves learners forward, and activating students as instructional resources for one another. This was facilitated through the following formative assessment practices:

- Assessing prior knowledge using a pre-assessment task.
- Co-operative learning.
- Higher order questioning.
- Using technology to gather information on student understanding to inform feedback practices.

3. Further Information

- Establishing where the learners are in their learning.

The teacher made use of a pre-assessment task to assess prior knowledge around insulation before the lesson began. He analysed student responses and used this to build structured feedback to the group before the investigation began.

During the graphing activity the teacher made use of effective questioning to establish were the learners are in their learning. He did this at the beginning of the lesson when he engaged students in a brainstorm activity about their investigation. Field notes illustrated how he was asking students higher order questions throughout the entire lesson. Toward the end of the lesson when students were beginning to draw up conclusions to their experiments video data showed how the teacher was moving around the classroom and engaging different groups in discussion. He probed students for understanding by asking them for their reasoning behind their conclusions and he asked students about what they learned from their graphs.

- Establishing where they are going.

The aim of the lesson was for students to explore graphing and alleviate any misconceptions students may have around the concept. It was also important for pupils to understand how a graph works and how they can draw conclusions about an experiment using graphs.

- Establishing what needs to be done to get them there.

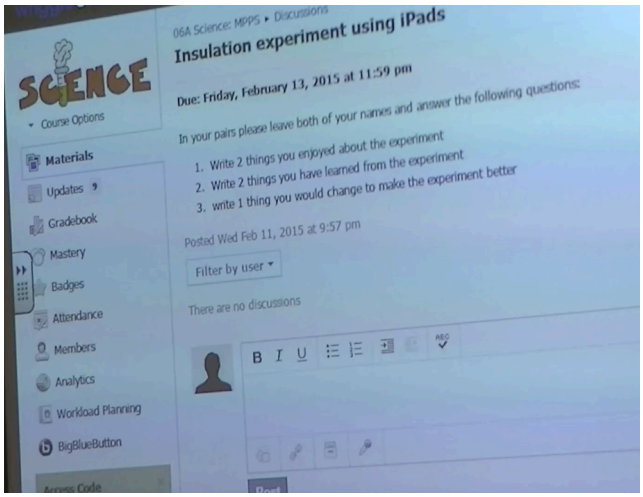
Throughout the lesson the teacher activated students as resources for one another to help them understand the concept of graphing. Video data demonstrate that the students worked in co-operative groups of four during the lesson with each student assigned a specific task. The students were assigned number and were not informed as to what task each of them would be completing until after the numbers were assigned. This meant that all students had the opportunity to have any role in the group in contrast with the more outgoing students taking over group work. Students were engaged in co-operative work for the entire lesson.

During co-operative work the teacher activated students as owners of their own learning by getting them to work on individual tasks. This helps students to build on their self-regulatory skills. Within the task the students were asked to answer the questions “what are we doing”

and “why are we doing it?” This was aided by technology, as students were able to work on these higher order questions while simultaneously gathering data on their iPads. This would not have been possible without technology, as student’s time would have been taken up with gathering data to create a graph. During the lesson the teacher also encouraged the students to draw conclusions about the experiment without help from other groups and without approval from the teacher. They could share these on the shared space (*Schoology*) and look for feedback. Again this is highlighting how the teacher was trying to encourage self-assessment among students and not to look to him for guidance.

Technology played a crucial role in the teacher’s feedback processes in the lesson. The students were to come up with their own conclusions to the experiment after analysis of data, and post them to the class *Schoology* page. After the lesson the teacher commented on how he would analyse this information prior to the following lesson and use the data gathered to build structured feedback for the students in the next class. At the end of the lesson, students were also asked to complete an *Exit Ticket* whereby students were asked to complete the following:

1. Write two things you enjoyed about the experiment.
2. Write two things you have learned from the experiment.
3. Write one thing you would change to make the experiment better.



This was a means for the teacher to diagnose what impacted the students during the activity and use this feedback to inform his future lessons. It also provided students with the opportunity to self assess their own work and decide on how they would improve. Using technology for the *Exit Ticket* meant that the teacher could access this information at any time and students in the class could also access this information in their own time and learn from their peer’s comments. This would be of benefit to students as it provides them with the opportunity to engage with science outside of the classroom to aid them in their learning. The teacher communicated to the students why he was asking them to complete the *Exit Ticket* so that the students could understand the rationale for completing the task.

Teacher and/or students comments

Pre-Assessment: Insulation

What material do you think would make a good insulator?

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_____

How would you test this in the lab?

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How would you make sure that your test a fair one?

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You have made a snowman. You think it is the best one you have ever made. What could you do to make it last for a while when the weather starts to get warmer?

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_____

4. References

Schoology www.schoology.com	Any device with a modern web browser – smart phones, tablets, PC's, laptops etc. (available as an iPad app)	Online learning environment that allows teachers to create and manage academic courses for their students. It provides teachers with a method of managing lessons, engaging students, sharing content, and connecting with other educators.
Logger software used in conjunction with hand held sensor technology www.vernier.com	Any device that is Bluetooth compatible or has a USB port	For example temperature probes. Used to gather data in real time to facilitate in depth analysis of graphs created via the logger software (LoggerPro).

Bell, B., & Cowie, B. (2001). The characteristics of formative assessment in science education. *Science Education*, 85(5), 536-533.

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in education*, 5(1), 7-74.

http://www.discoversensors.ie