Keeping drinks hot!

Does the rate of cooling of a hot drink depend upon the type of cup used?

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Hypothesis:

There will be a link between the material used in the cup and the time it takes for a drink to cool

Thermal conductivity

(the property of a material to conduct heat)

Material	Thermal
Polystyrene	0.03
Plastic	0.51
China	0.96
Metal (copper)	401

Prediction:

The drink in the copper cup will cool down the fastest because copper is a good conductor

Apparatus:

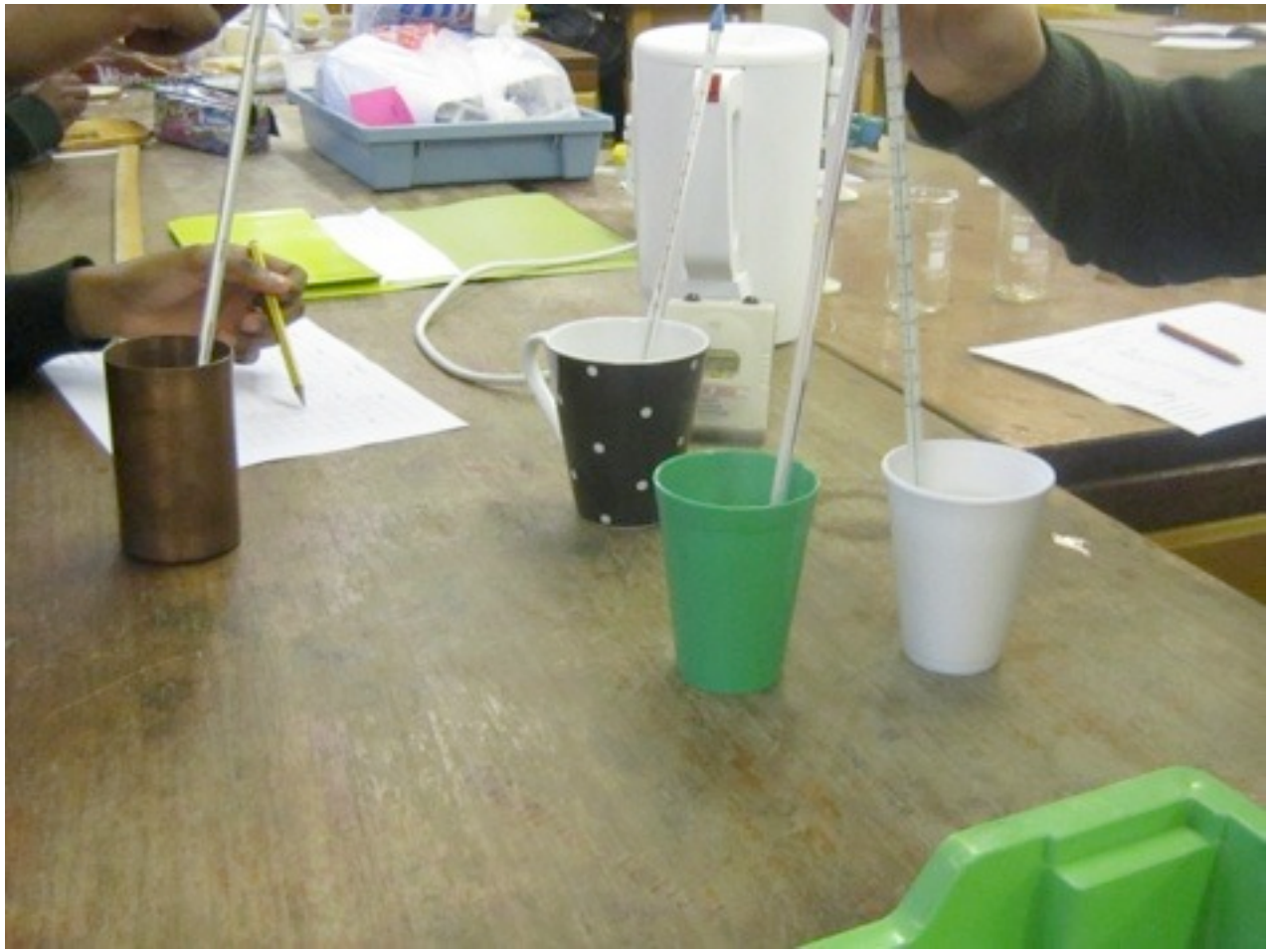
- Different types of cups
- Thermometers
- Data logger with temperature probes
- Kettle
- Beakers
- Stop watches

Method:

- We measured four lots of 50 cm^3 of boiling water
- We quickly poured the water into four cups and started the clock
- Each person then measured the temperature every two minutes for two cups

Four cups:

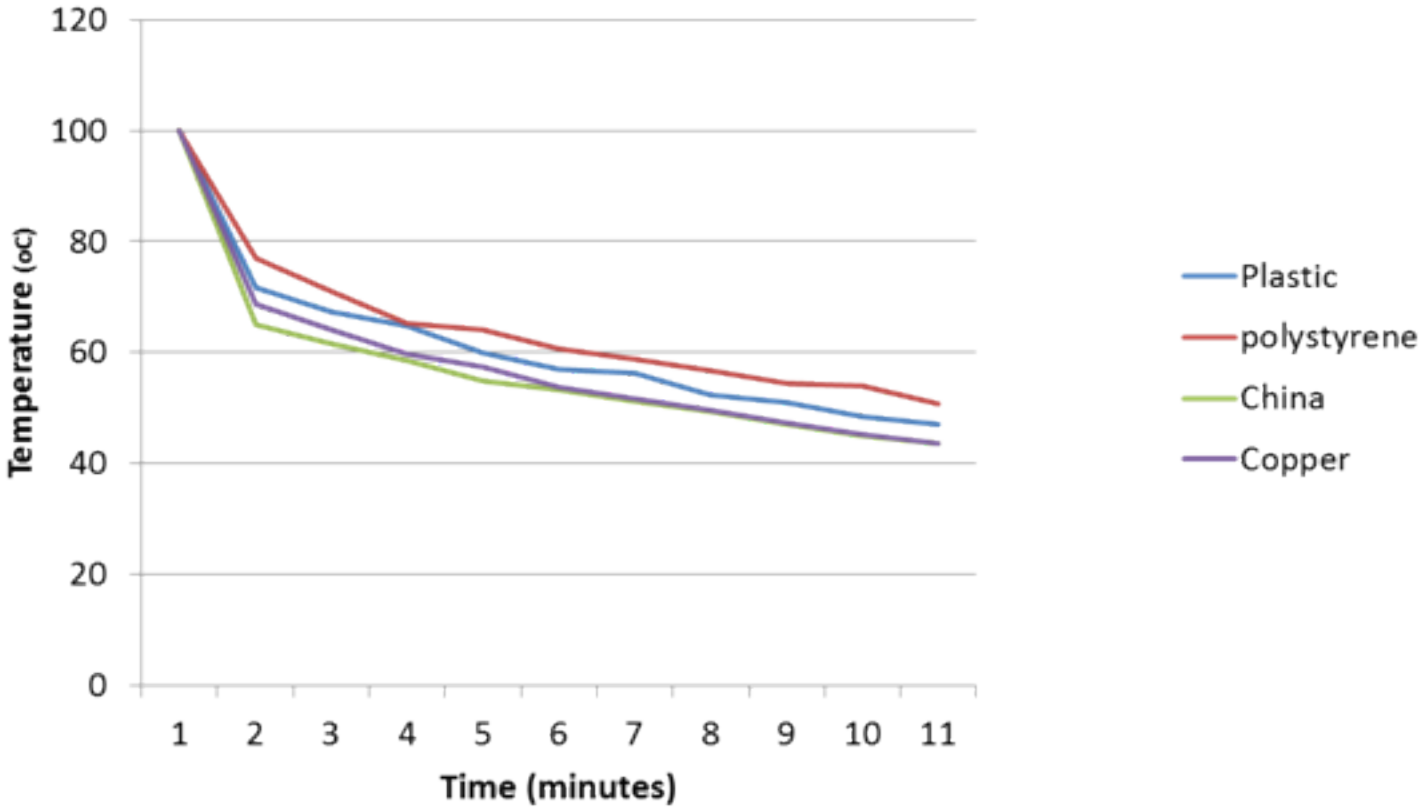
Our experiment:



Experiment series 1

	Temperature ºC			
Time	Polystyre	Plastic	China	Copper
0	100	100	100	100
2	77	71.7	65	68.7
4	71	67.3	61.5	64.0
6	65.3	64.8	58.5	59.8
8	64	60	55.0	57.5
10	60.7	57	53.2	53.7
12	58.8	56.3	51.3	51.7
14	56.8	52.3	49.3	49.7
16	54.5	51.0	47.0	47.3
18	54	48.5	45.0	45.3
20	50.7	47.0	43.7	43.7

Cooling curves for different cups:



Surprise conclusion

- Results did not match the thermal conductivity information
- Polystyrene cup drink cooled slowest
- Plastic cup drink cooled second slowest
- The china cup and copper cup were about the same

Our variables

Independent	Dependent	Control
Type of cup	temperature	Temperature at
		Volume of water
		Shape of cup
		Size of cup

Four cups were not matched:

Experiment series 2
New cups

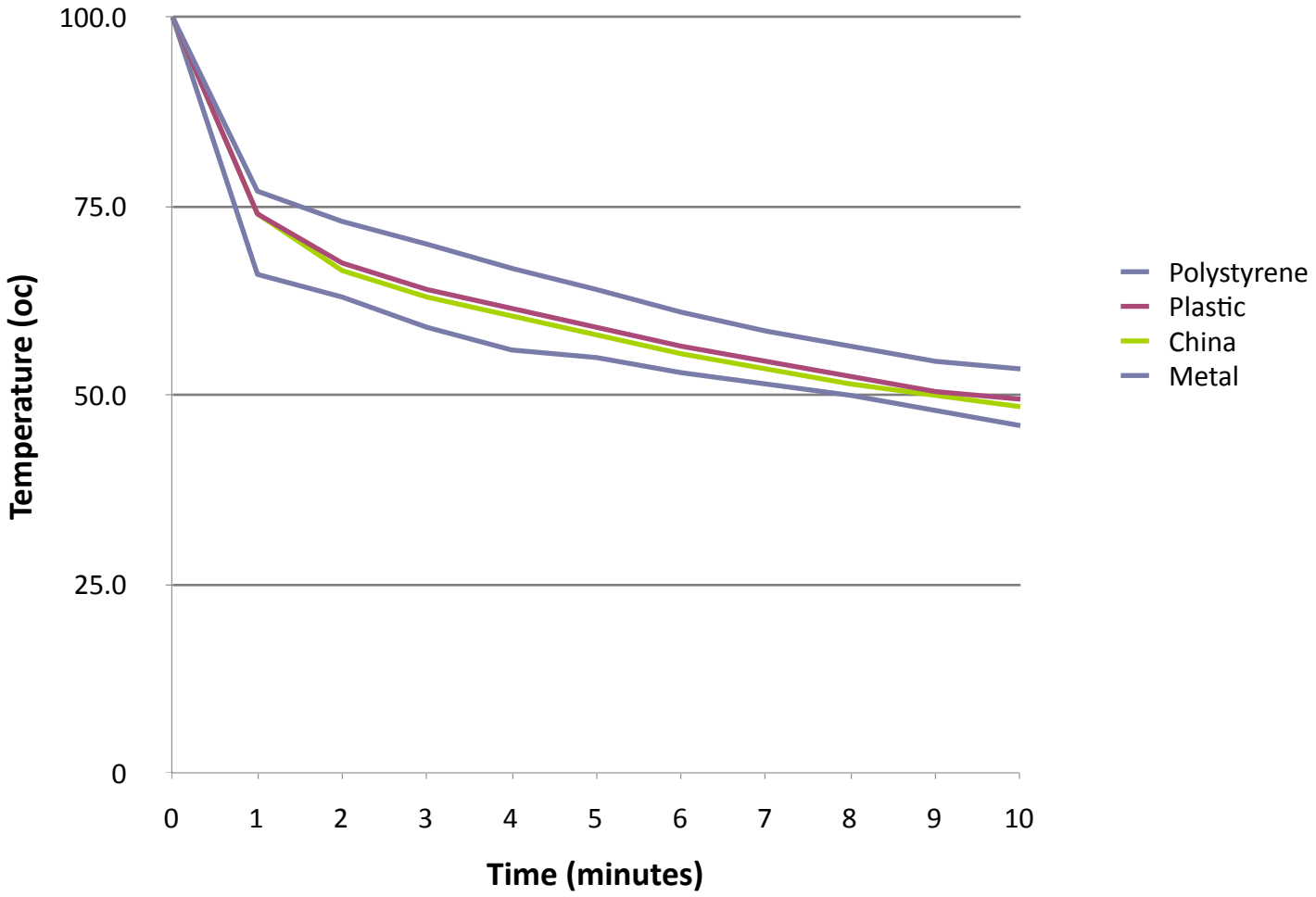
New method

- This time we worked on one cup at a time
- on Saturday 16th March

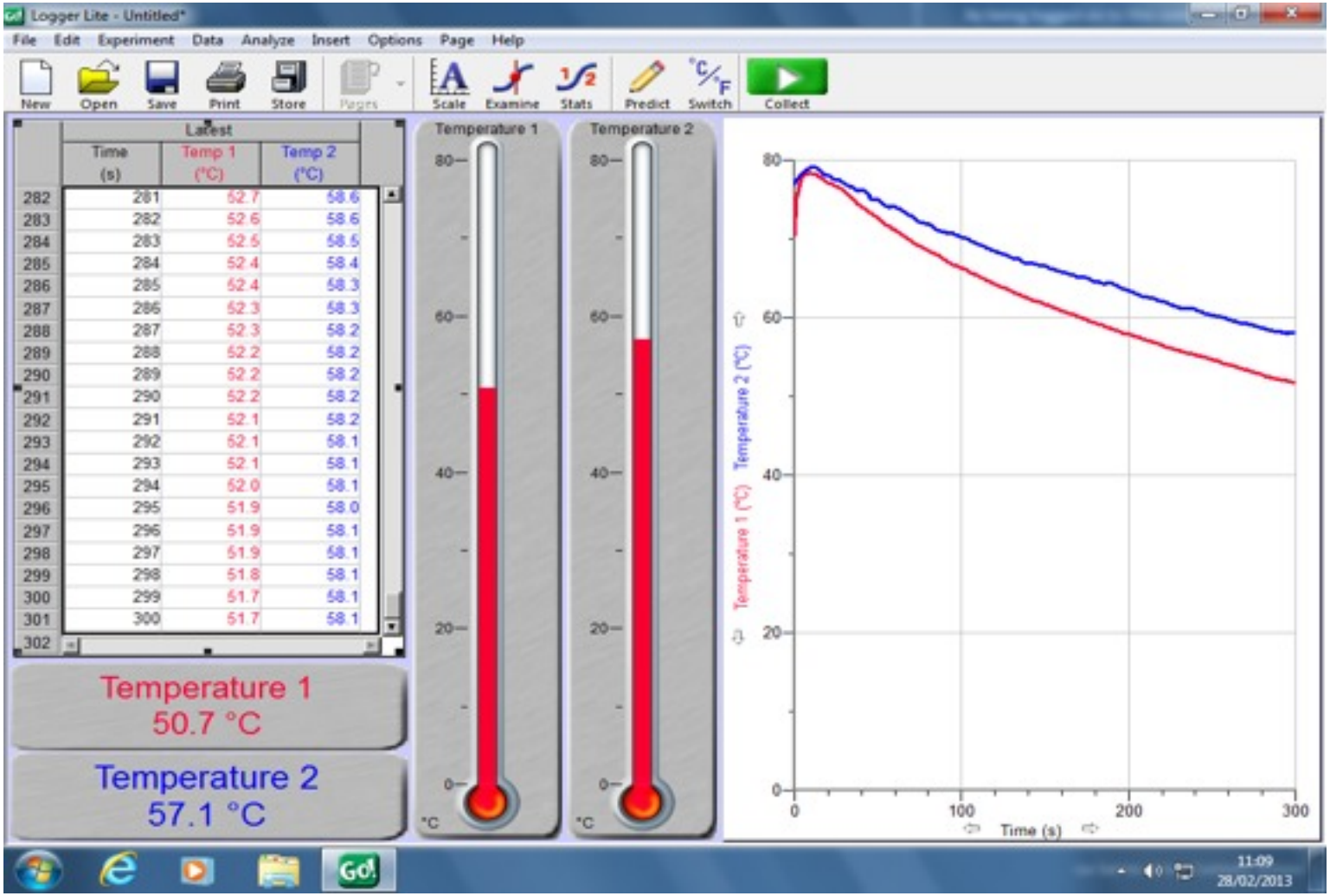
Experiment series 2

	Temperature ºC			
Time	Polystyre	Plastic	China	Copper
0	100	100	100	100
1	77	74	74	66
2	73	67.5	66.5	63
3	70	64	63	59
4	66.8	61.5	60.5	56
5	64	59	58	55
6	61	56.5	55.5	53
7	58.5	54.5	53.5	51.5
8	56.5	52.5	51.5	50
9	54.5	50.5	50	48
10	53.5	49.5	48.5	46

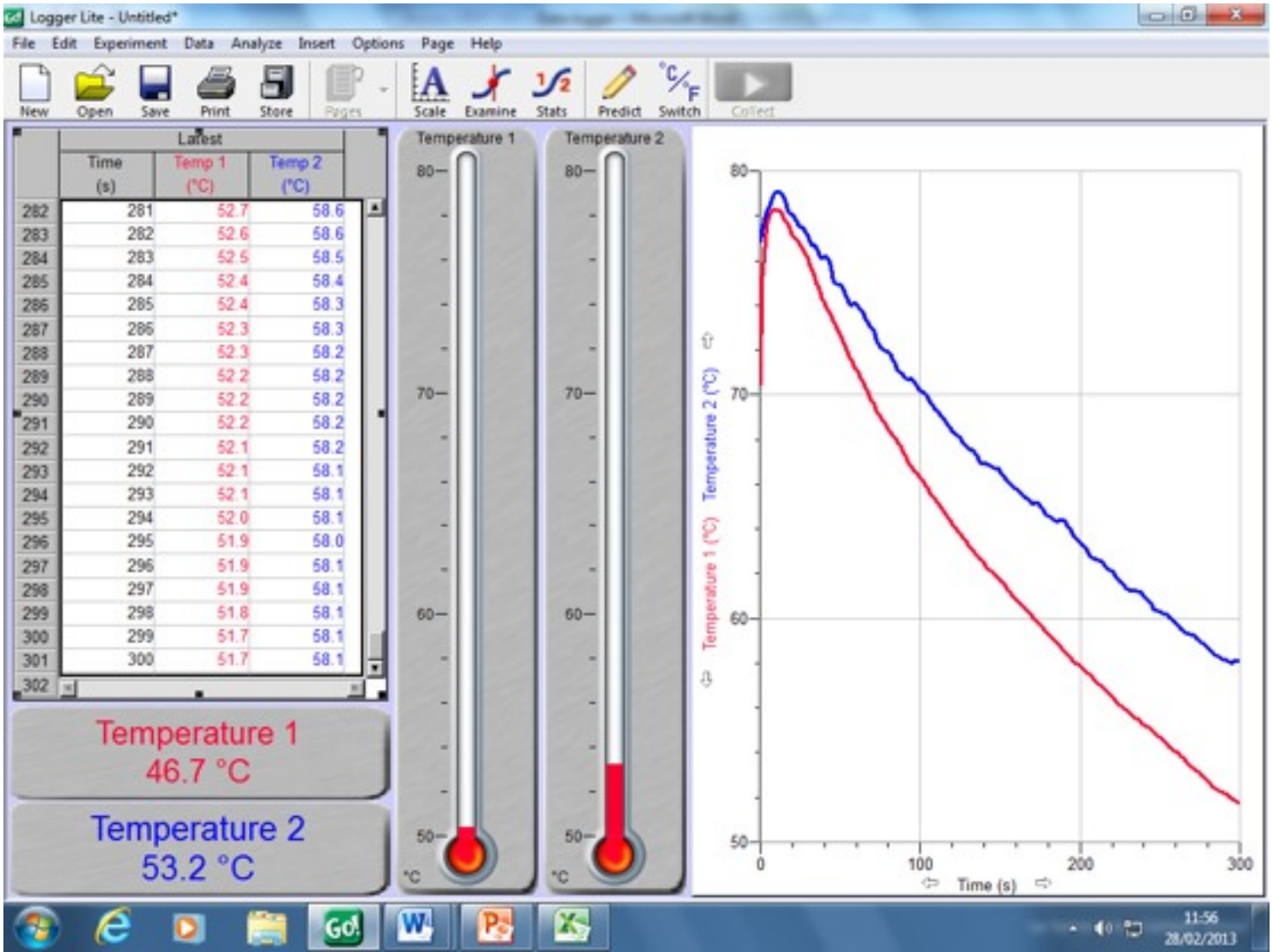
Cooling curves for different cups:



Comparing a copper cup with a plastic cup using data loggers



Comparing a copper cup with a plastic cup using data loggers



New conclusion

- Results did not match the thermal conductivity information – the difference between the cups were not huge
- Polystyrene cup drink cooled slowest
- Plastic cup and china cup drink cooled second slowest
- The copper cup drink cooled fastest

Explanation

- Conduction is important for heat loss
- BUT convection and evaporation are also very important and these will occur in cups made of all materials

Heat energy travels from a hotter area to a colder area

The coffee is hotter than its surroundings. The coke is colder than its surrounding.

Drinks warming up

So next we investigated drinks warming up rather than cooling down

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Method

- We weighed 4 ice cubes separately
- We put one ice-cube in each cup and started the clock
- After 5 minutes, we removed ice cubes from the cup. We quickly dried the cubes and weighed them.
- We repeated this again after 10 minutes

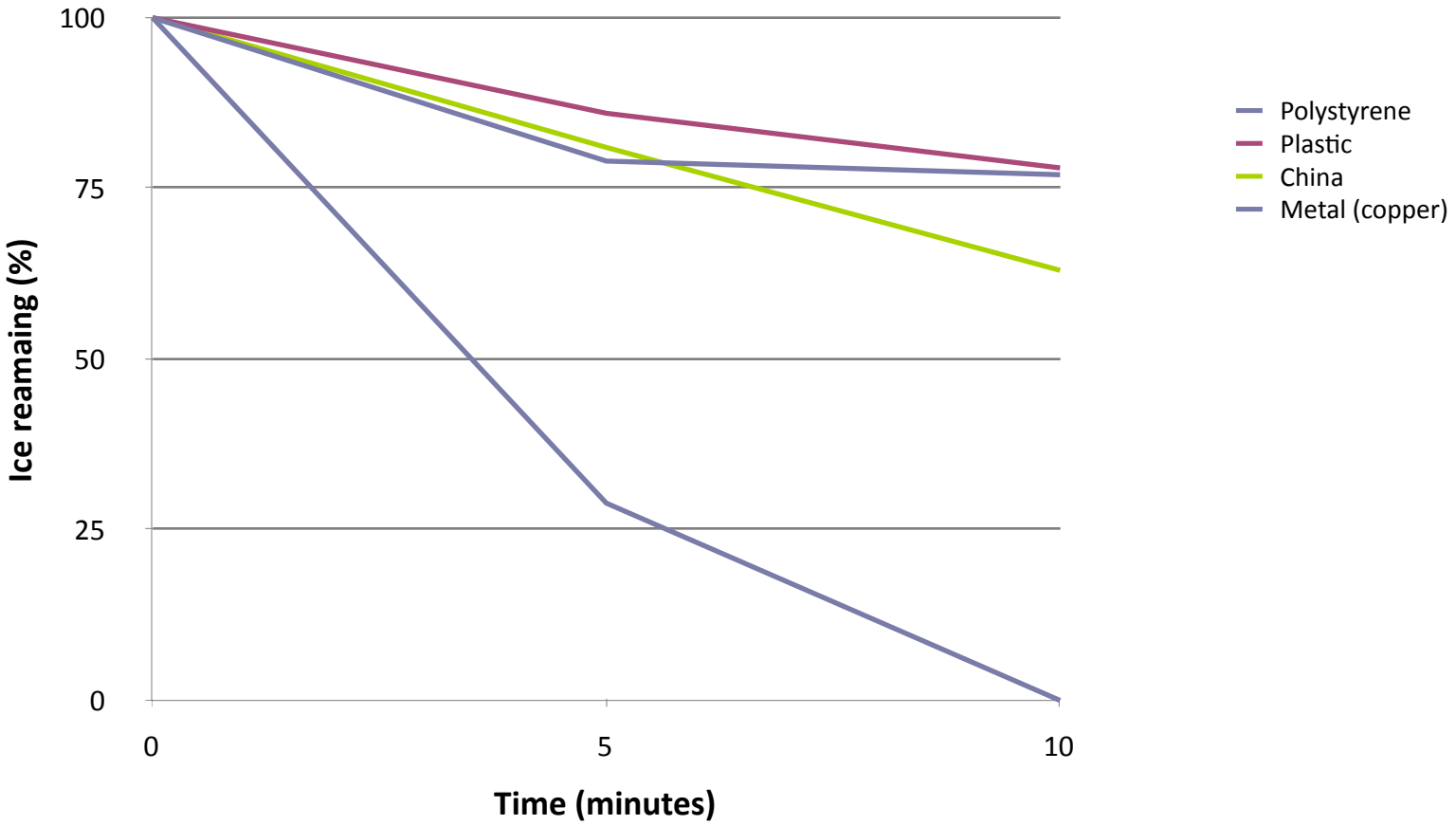
How quickly does ice melt?

	Mass of ice remaining (g)			
Type of cup	Polystyrene	Plastic	China	Metal (copper)
0 minutes	6.50	7.31	7.56	8.73
5 minutes	5.14	6.32	6.15	2.52
10 minutes	4.98	5.71	4.77	0

How quickly does ice melt?

	Mass of ice remaining (%)			
Type of cup	Polystyrene	Plastic	China	Metal (copper)
0 minutes	100	100	100	100
5 minutes	79	86	81	28.9
10 minutes	77	78	63	0

How quickly does ice melt?



Conclusion

- Polystyrene, plastic and china were very good at keeping ice cold
- Copper was very poor at keeping ice cold
- This time results did match the thermal conductivity information – the differences between the cups were big. Copper was very different to the other cups

Thermal conductivity
(the property of a material to conduct heat)

Material	Thermal Conductivity
Polystyrene	0.03
Plastic	0.51
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Metal (copper)	401

Problems

It was difficult to control:

- colour of cup
- size of cup
- shape of cup

Further work

- Put lids on cup and repeat experiment
- Compare cups from takeaway shops

Final Conclusion

- The polystyrene, plastic and china cups kept a hot drink longer than copper cup

- The polystyrene, plastic and china cups were even better at keeping ice cold when compared to the copper cup

Thank you for listening!