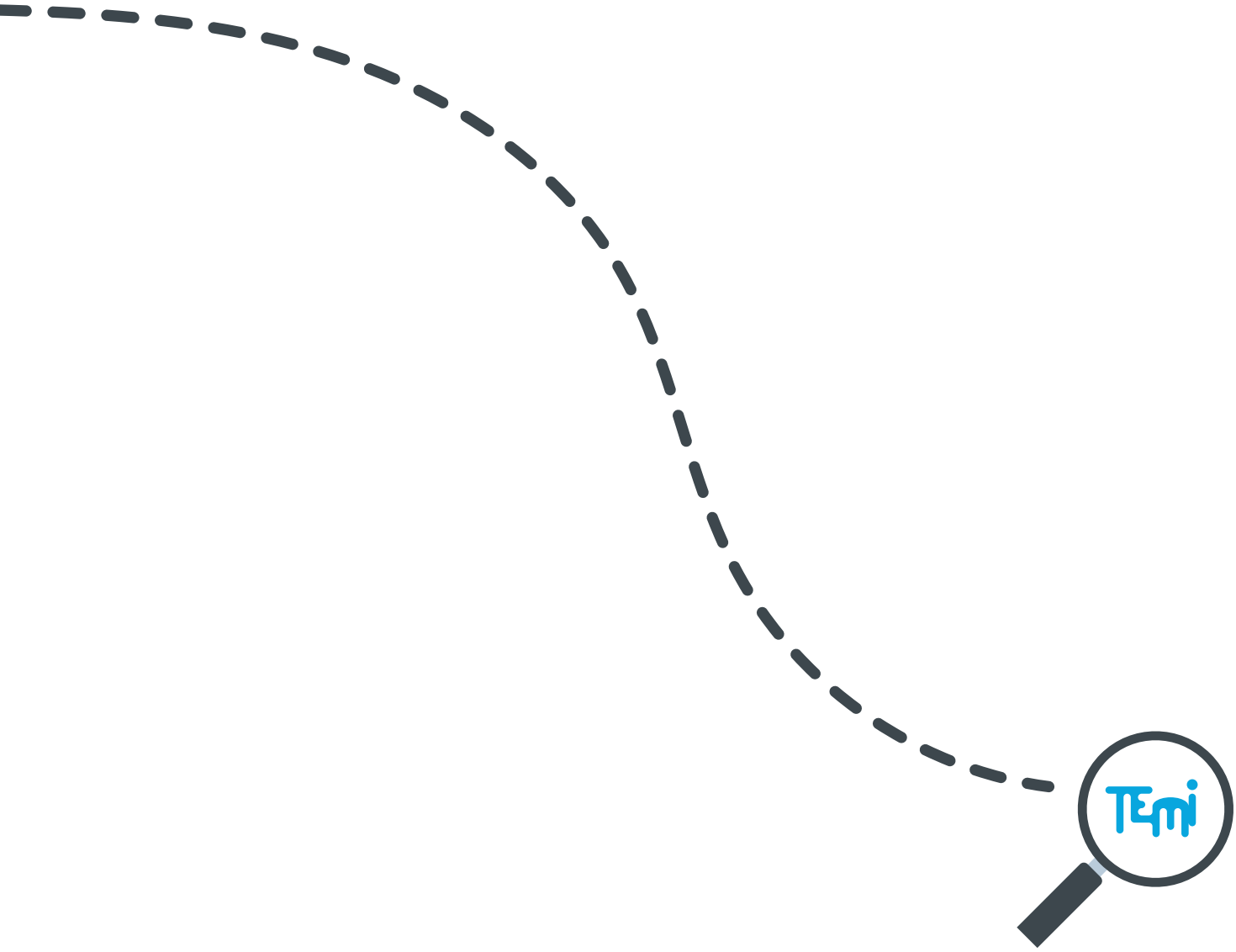
To dissolve or not to dissolve...

CLASSROOM SCIENCE ACTIVITY TO
SUPPORT STUDENT ENQUIRY-BASED LEARNING



This classroom-tested teaching plan uses the four innovations of the TEMI project, as detailed in the Teaching the TEMI Way (TEMI, 2015).

You should read this companion book to get the most from your teaching. The **TEMI** techniques used in this teaching plan are: **1)** productive science mysteries, **2)** the **5E model** for engaged learning, **3)** the use of presentation skills to engage your students, and **4)** the apprenticeship model for learning through gradual release of responsibility. You might also wish to use the hypothesiser lifeline sheet (available on the **TEMI** website) to help your students document their ideas and discoveries as they work.

To know more about **TEMI** and find more resources **www.teachingmysteries.eu**

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To dissolve or not to dissolve...

What's the mystery?

Two glasses are half full of clear liquid. When a teaspoon of salt is added to both and stirred, it dissolves in one but not in the other. When the two liquids are mixed together, they dissolve in each other to form a solution. When salt is added, the solution separates into two layers.

DOMAIN(S)

Chemistry.

SUBDOMAIN KEYWORDS

Solubility, ionic salts, polarised and non-polarised liquids.

AGE GROUP

Junior secondary (**11** to **15** years) or senior secondary (**16** to **18** years), depending on the level of explanation.

EXPECTED TIME FOR THE MYSTERY

Approximate time for teacher preparation:
15 min.
Approximate time in classroom:
One double lesson (**70** to **90 min.**).

SAFETY/SUPERVISION

The chemicals used are safe. One liquid is flammable, so there should be no naked flames. The solvent should be disposed of as an organic solvent. Eye protection should be worn.

Disclaimer: the authors of this teaching material will not be held responsible for any injury or damage to persons or properties that might occur in its use.

PREPARATION AND LIST OF MATERIALS

- 2 x 250 ml beakers, water (200 ml).
- Propan-2-ol (isopropyl alcohol) (200 ml) (also known as rubbing alcohol)
- Sodium chloride (3 x 5g)
- Stirrer
- Measuring spoon
- A large 400 ml beaker
- Access to other common ionic salts and solvents and laboratory equipment.

LEARNING OBJECTIVES

The importance of the nature of the solvent in solubility. The solubility of ionic salts like sodium chloride in water compared to its solubility in an organic solvent. What factors affect solubility of a salt in a solvent.

Guidance notes for teachers

THE 5E MODEL

Engage

CAPTURE STUDENTS' ATTENTION

The teacher sets up two beakers, each half full with a clear liquid. One contains water and the other beaker contains propan-2-ol (isopropyl alcohol, rubbing alcohol). A teaspoon of sodium chloride (salt) is added to both and stirred. The salt dissolves in one liquid (water) but not in the other (propan-2-ol). Why is there a difference? Why does salt dissolve in water? Why does salt not dissolve in the other liquid? The two liquids look the same but are they?

When mixed separately, the two liquids dissolve in each other and form one layer, a solution. However, when salt is added and shaken, the liquids separate out into two layers. They mix and then they separate.

Explore

COLLECT DATA FROM EXPERIMENTS

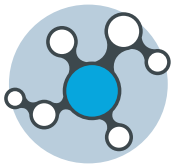
How much salt will dissolve in the water? Working in pairs, the students can repeat the above experiment while also seeing how many teaspoons of salt will dissolve in a fixed volume of water. Does the other liquid dissolve a small amount of salt or none at all? How can they tell that the two liquids are not the same?

They could smell them: water has no smell while the other liquid has a distinctive smell. They could measure the density of each by weighing equal volumes of each liquid. One liquid satisfies the characteristic test for water (anhydrous copper sulphate). One liquid does not burn and the other does. When the mixture separates into layers, how can you tell which layer is which?

Explain

WHAT'S THE SCIENCE BEHIND THE MYSTERY?

Why does salt dissolve in water and not in the organic solvent? Salt is an ionic substance composed of a lattice of sodium and chloride ions. Water molecules are strongly polarised and can pull the positive and negative ions into solution by bonding to them (use diagrams or animation to explain this). The organic liquid is less polarised (how could you show this?) and does not bond strongly enough to the ions to break the ionic bond in the solid. Use molecular models to show where the polarity comes from (the –OH groups). The polarity of water and the organic solvent can be compared by using a charged plastic comb or pen to see how much a stream of liquid from a burette is deflected. Polar liquids are attracted to the charged comb or pen: the greater the polarity, the greater the deflection. Water is more polarised than the organic solvent.



Extend

WHAT OTHER RELATED AREAS CAN BE EXPLORED?

Is this behaviour shown by other ionic salts? Try some other salts in water and the propan-2-ol. Sucrose (sugar) dissolves well in water, but it is not an ionic substance. Does it dissolve in propan-2-ol or not? Does sucrose dissolve in water in a similar way to sodium chloride? Sucrose molecules are also strongly polarised and so they bond to water molecules. Propan-2-ol is not polarised enough to do this. Is sodium chloride soluble in more polarised alcohols like methanol or ethanol? Using salt to separate two miscible liquids is known as 'salting out'. Salting out is used in the production of soap.

Water and propan-2-ol mix with each other to form a solution. When salt is added and the mixture is stirred or shaken, it separates into two layers. Why does this happen when salt is added?

Evaluate

CHECK THE LEVEL OF STUDENT SCIENTIFIC UNDERSTANDING

Either in their own words, by using a diagram, or by making a short animation using a mobile phone, the students should describe how water molecules break up the structure of sodium chloride and bring the ions into the solution. Why do some ionic salts dissolve in water while others do not? The bonding energy of water molecules to the ions has to be stronger than the bonding energy between the ions in the solid; otherwise, the water cannot pull the ions into solution.

Propan-1-ol molecules are less polarised than water molecules and do not bond as strongly to ions; thus, they cannot break up the sodium chloride structure.

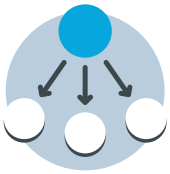
THE 5E MODEL

Showmanship

TIPS ON HOW TO TEACH AND PRESENT THIS MYSTERY

What would a universal solvent be like? What would you put it in? Do all liquids behave in the same way as water? I have two clear liquids here (use the same volume of each), one of which is water. What happens when I add a teaspoon of sodium chloride (salt) to each and stir? Which one do you think is water?

When I mix the two liquids together separately, they mix with each other and form a solution. Add some food colouring to colour the solution (mixture). What happens now when I add salt to the solution and shake or stir? Wow! Now why did that happen? Is that what you expected? What do you think is in the two layers? If more salt is added, does this affect the degree to which the liquid separates into layers?



GRR

TEACHING SKILLS USING GRADUAL RELEASE OF RESPONSIBILITY

Demonstrated enquiry (level 0): the teacher does it.

The teacher introduces the mystery and asks questions. Why do some substances dissolve in water and not others? Why do some substances dissolve in water and not in another liquid (solvent)? What would a universal solvent look like? What would you put it in?

Structured enquiry (level 1): 'we do it'.

How much salt dissolves in a fixed amount of water? What sorts of substances dissolve in water? Sucrose dissolves in water: does it dissolve in the other solvent? How could you test for and identify the two solvents (smell, density, burning)? Do all organic solvents behave like the first one? Is there anything in common in the structures of those substances that dissolve in water and those that don't? How could we measure the solubility of different substances in water and other solvents? How can two liquids mix to form a solution and then separate out into two layers when salt is added? Which liquid is at the top and why? Can you explain what is going on in terms of molecular and crystal models and the charges or polarity of the particles involved? How useful is the maxim 'like dissolves like' in explaining your results?

Structured enquiry (level 2): 'they do it'.

Devise experiments to investigate which liquids dissolve in each other and how this relates to their chemical nature. How could you compare the polarity of these liquids? Investigate how the nature of the solvent affects the solubility of different solids, such as sodium chloride, sucrose, urea, and paraffin wax. What generalisations can you make about solubility and the natures of the solvent and solute?

Resources

There are a number of YouTube videos showing how the addition of salt causes the two liquids to separate out. TEMI Youtube Channel:
www.goo.gl/tUDaq5
playlist> separation of ethanol and water with salt

There are many animations of the solubility of salt in water. TEMI Youtube Channel:
www.goo.gl/tUDaq5
playlist> how water dissolves salt

The polarity of liquids can be shown using a charged plastic comb or pen and a stream of water or the other liquid. TEMI Youtube Channel:
www.goo.gl/tUDaq5
playlist> polar and non polar molecules static electricity demo

To dissolve or not to dissolve...

STUDENT WORKSHEET

You are familiar with how sodium chloride (salt) and sucrose (sugar) dissolve in water. However, not everything dissolves in water: flour doesn't and neither does chalk (limestone). Do salt and sugar dissolve in other liquids or is water special? Why doesn't everything dissolve in water?

Engage

WHAT'S INTERESTING?

Task: Why does salt dissolve in one clear liquid but not the other, although they look the same? The two liquids also dissolve in each other to form a solution (one layer). But when salt is added and shaken, it dissolves and the solution separates into two layers. Which layer does the salt dissolve in? Why does this happen?

Explore

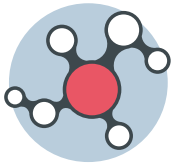
WHAT'S HAPPENING?

Task: Are the two liquids the same? How do they differ? How would you identify them? How much salt can dissolve in the first liquid? What sort of liquid is the second liquid? Does salt dissolve in other similar liquids? Why does the salt cause the two liquids to separate out? How much salt is needed to do this? Does the amount of salt added affect to extent to which the liquids separate?

Explain

WHAT'S CAUSING IT?

Task: The teacher will give you the structure of the molecules in the two liquids. Make models of them or draw diagrams. Which part of the molecules will be negative and which positive? Draw a diagram of a sodium chloride crystal or make a model of it. How will the molecules interact with the solid (hint: opposite charges attract). Show how bonding between the solvent molecule and the ions in the crystal can break up the crystal and bring the ions into solution. Why is the first solvent better than the second at doing this? Set up two burettes: fill one with water and the other with the other liquid. Rub a plastic comb or pen on your hair or on a jumper to charge it. Open the burette to let a steady flow of liquid out: how is the stream affected when you bring the charged comb or pen near? Do the two liquids behave in the same way?



Extend

WHAT'S SIMILAR?

Task 1: The separation of the two liquids when salt is added is a process known as 'salting out'. Look up where this is used to make an everyday product (which you may have done already). Do other solvents behave in the same way? Does the solubility of sodium chloride depend on the type of solvent or are they all the same? Do other salts (e.g. copper (II) sulphate or sodium carbonate) behave in the same way?

Evaluate

WHAT'S MY UNDERSTANDING?

Task: Explain in words and by using a model or an animation made on your smart phone the process involved when a salt like sodium chloride dissolves in water. Explain why the nature of the solvent affects the solubility of salts. Why does sucrose dissolve in water but flour doesn't? If 'like dissolves like', why do some ionic salts (like limestone) not dissolve in water? Why does the addition of salt cause the water and organic solvent to separate out? If you have made soap in chemistry class before, how does today's lesson explain the 'salting out' of soap (if you haven't already done this, look it up)?