Promotion of modelling for 12 year old students in chemistry

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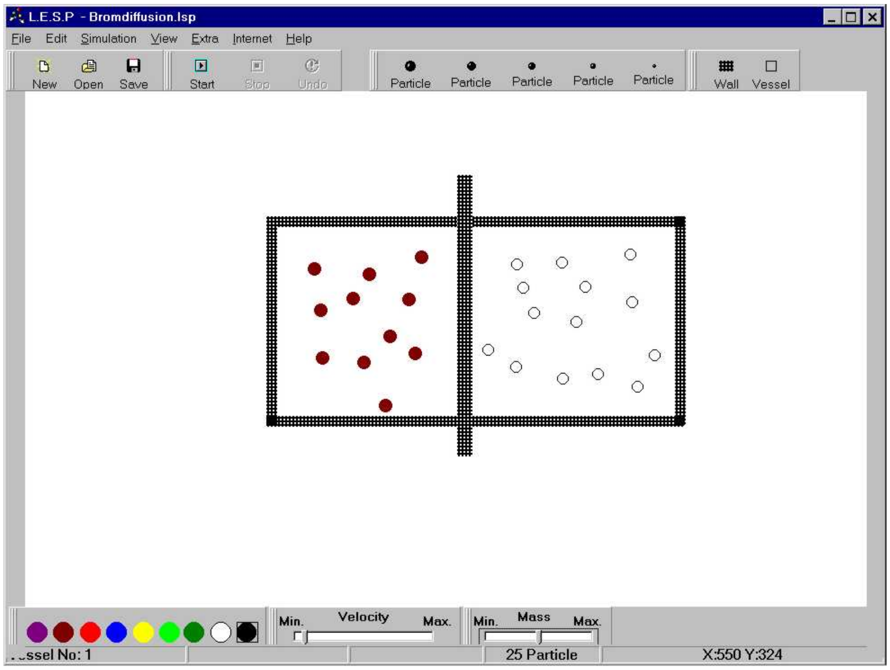
Introduction

In an earlier paper in this conference Oversby (2000) explained features of modelling in chemical education. Many of the difficulties that students have when they begin to learn chemistry in schools are concerned with the conversion between macroscopic observations and sub-microscopic models used in explanations. Inappropriate mapping between a phenomenon and models used to represent it is thought to be one cause of the creation of misconceptions.

The CoSim project is a European innovation funded by the EU and designed by colleagues in universities in Heidelberg and Essen in Germany. Trials have taken place in two secondary schools in Germany, two in Poland and one in England.

The software is based on a particle dynamic modelling framework. Its main features are:

- Up to 100 particles can be placed.
- Each particle can be represented as one of five different circles in a variety of colours or no colour at all.
- Other attributes of particles such as mass, initial velocity, gravity on or off, can also be represented.
- Other features such as boxes, walls, syringes, can be represented.
- The initial models can be stored, loaded, modified and sent to others by email.
- The software is available in three languages, German, Polish and English. He models are language independent.
- The dynamic motion of the particles when the models are run is similar to that expected for ideal gas particles.
- Short videos depicting typical experiments can be displayed.
- A pre-test and post-test on understanding of models was available but is not discussed in this report.



The experiments

- Brownian motion of smoke in air observed through a microscope
- Bromine diffusion in air in gas jars
- Potassium manganate(VII) diffusion into hot and cold water

The students had a short teaching session covering the main features of the software. In each lesson, they experienced the phenomenon from the list above, either by demonstration or group practical work. They created their personal models to behave as the experiment, speaking out loud as they did so. Their thoughts were recorded on tape or in writing as data. Each student stored their model which was then passed to another student for discussion and modification. The modified models were stored. In Germany, the models were shared between the two schools involved. As a final trial, they were asked to model bromine diffusion along a narrow tube connecting two flasks. These models were sent to all the schools in the trials and will form the focus of an international study of collaboration.

Process and content

It seems to be common in secondary schools in England to treat models as content, that is, students are required to learn consensus models a they would learn any other area of chemistry. Models are also used to develop conceptual understanding. It seems to be rare for teachers to explain the processes of modelling. Matters such as the limitations of the models in comparison with the original, its strengths and weaknesses in explanations are omitted from much teaching. It is almost as though modelling is too obvious to be taught. Although no rigorous survey has been carried out, this may also be the case in higher education too, with the proviso that the models being learned are more abstract, more detailed, and more mathematical. Given the actions of research and applied chemists in creating, testing and using models in extending explanations of chemical change, such an omission may give a distorted view of real chemistry.

One of the purposes of the CoSim project has been to see if it is possible to teach modelling to students in lower secondary schools.

Outcomes - the learners' voice

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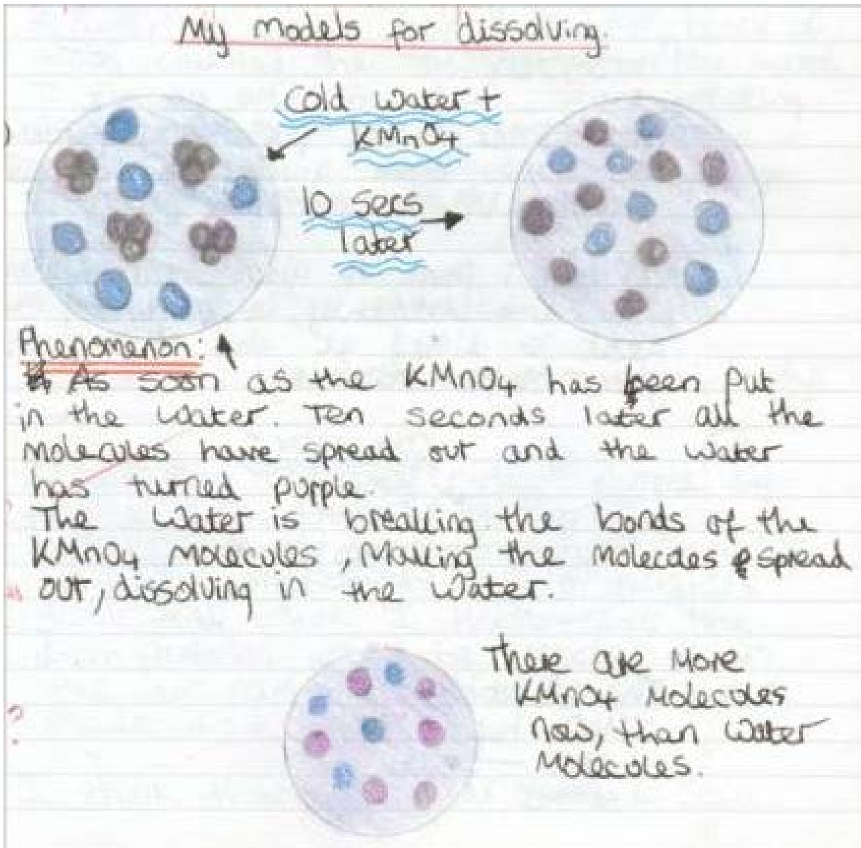

$KMnO_4$ diffusion

- Why have you chosen different sized particles for $KMnO_4$?
  I chose different sized particles because the $KMnO_4$ (purple) expands gradually so I did a small particle in the middle with rings or bigger particles round the outside representing the expansion. I did large particles all the same size for water (blue) though.

- Does your model fit what you saw on the video or in class?
  I think my model does fit what I saw on the video because it showed the purple substance gradually expanded which is what I did on my representation.

- Was it important that the particles were in a vessel? Explain your answer.
  It was quite important because the $KMnO_4$ was in water which was put in a jar. So you need the particles enclosed in something so they can only move in a set area.

- Did you set the particles at different speeds? Why?
  I did, I put them slower in the middle going outwards and then the water was put at a fairly fast speed.

Evaluation

- What is a particle?
  A particle is something that builds together to form a solid or liquid or gas. It is a group of atoms all joint together. They move at different speeds. Particles are everywhere in the air in water. Tiny size.

- How do particles move?
  Particles move through the air, water and cannot pass through solids, most of them are in groups joined together.

- How can you use your knowledge of particles to explain how a smell moves across a room?
  A smell moves around a room slowly in groups, it goes forward so gradually everyone smell it no matter where they are and after a while the smell fades away because the particles are gone, they have moved somewhere else.

LH

$KMnO_4$ diffusion

I used purple medium sized particles to represent the $KMnO_4$ and big blue particles to represent the water. To begin with all the $KMnO_4$ particles were together in a small clump and then when I pressed play on the video they all spread out. I put all my particles in a vessel because I think that normally all the particles are actually together when they are in a beaker. The vessel acts like the glass or beaker as a barrier stopping the particles escaping.

Does your model fit what you saw on the video or in class?

I think my model is a bit like the actual $KMnO_4$ diffusion as the $KMnO_4$ particles spread out, as the time goes on, mixing with the water particles but I think the particles are going too fast and normally they would spread out slower.

Did you choose to use more than one type of particle? Why?

I used two different particles: big blue ones and middle sized purple ones. I used bigger particles for the water particles because I think the water particles would be larger than the $KMnO_4$ particles.

Discussion

The two examples given are typical of those provided by the students in England. They clearly show the ability of students to describe how their models are representative and of their conceptions and misconceptions in making these correspondences. They have not provided evidence of the limitations of their models. The method of think aloud, or writing down their assumptions as they create the models appears to be an effective way of discovering their modelling capability in some respects. There is more work to be done in finding out how effective this could be with explicit requirements to consider both correspondences and non-correspondences of the models they make.

The methodology is also very effective in pointing to the major problems of relating macroscopic and sub-microscopic. Water and air particles appear still to move within a continuous matrix of water and air. The use of the modelling software has not shifted ideas totally to a submicroscopic model. Further investigation of whether a different use of the software could alter these ideas would be useful. It would also be interesting to use the software with older students to see if it is more effective at modifying these well-established ideas.

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