4.3 Case study 3 (CS3 United Kingdom)

Concept focus	Factors influencing rates of reaction
Activities implemented	Activity A, Activity C
Inquiry skills	Planning investigations Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (trouble-shooting) Scientific literacy (critiquing experimental design)
Assessment methods	Classroom dialogue Teacher observation Self-assessment Student devised materials (investigation plan)
Student group	**Grade:** Year 7, lower second level **Age:** 11-12 years **Group composition:** Co-ed; range of attainment and ability; 22 students (8 girls, 14 boys) from a private fee paying secondary school with entrance exam **Prior experience with inquiry:** The group is used to doing practical work and has had a number of fairly open-ended inquiry tasks this term.

Two activities from the **Reaction rates** SAILS inquiry and assessment unit were implemented in two lesson periods. Students' skills in *planning investigations* and *working collaboratively* were assessed formatively through in-class observation, evaluation of students' written work and a student survey on teamwork. *Scientific reasoning* and *scientific literacy* were also evaluated, looking at students' ability to critique experimental design, identify potential problems in experimental plan and critical thinking.

(i) How was the learning sequence adapted?

This group of year 7 students started with a very simple science task to build on their existing science knowledge (Activity A: Design an investigation). The teacher implemented this activity using an *open inquiry* approach, as detailed in the lesson sequence. The second activity (Activity C: Altering reaction rate) was implemented as a *bounded inquiry*, as the teacher was limited by curriculum pressures and wanted the students to become familiar with collecting gases using a bung and delivery tube. Not all aspects of the activity were implemented, due to time constraints.

Lesson sequence

1. Students were shown a vitamin C tablet reacting in water and then asked how they could find out which gas was being produced. They were given a few minutes to discuss in groups of four, and most groups decided that they needed to collect the gas in order to test what it was.
2. They were then given about 10 minutes to plan their collection method as a group. They were told that they could use any of the equipment in the classroom, or anything they thought they could easily get hold of. These students often find visual stimulus helpful in sparking ideas so I went around the classroom lifting up a range of different pieces of equipment, some that could easily be used, some that probably could not be used (the possibly useful equipment included a bung and delivery tube, boiling tube, balloon and bottle).
3. Each group then had to present their idea as a picture and or set of instructions. At this point they had not used the equipment or tried out any ideas. They were thinking through how the inquiry method might be undertaken. Each group was then asked to critique each other's methods. They were given the explicit instructions to comment on possible problems that they thought might arise with that method and explain this to the other group. It was explained to

them that as scientists they needed to be able to spot possible problems or errors before starting an experiment, sometimes of their own experiment and sometimes of a colleague. It was made very clear to them that this was a natural part of planning and was not any reflection on their ability to plan an experiment. This came with comments such as "Write down things that you can't see evidenced in the method, even if you think it is something they thought of but haven't written down".

4. In an ideal world I would have allowed them to conduct the experiment that they had designed. However due to time and curriculum pressures it was necessary to ensure that each group used the same method and practiced collecting gas from the reaction between marble chips and acid, using a bung and delivery tube. Due to this fact, it was emphasised that there were many different correct ways to collect the gas, and that each group had produced a valid collection method.
5. At the end of the second lesson, each student completed a self-reflection questionnaire. Homework task was to write up the practical.

(ii) Which skills were to be assessed?

In the first lesson, the teacher identified *working collaboratively*, *planning investigations* and *scientific literacy* (creative thinking, ability to spot possible problems in experimental design, critiquing experimental design) as key skills for assessment. In the second lesson, *scientific reasoning* and *scientific literacy* (creative thinking and being able to spot possible problems) were evaluated. In addition, *working collaboratively* was assessed, looking at student engagement, offering of ideas and support, challenging with respect to others, turn-taking and peer feedback.

The assessment was formative, and conducted through in-class observation (listening to conversations and looking at written artefacts), assessment of written artefacts and through student survey at the end of the inquiry activities. A rubric was not used on this occasion, although rubrics have been used before.

Groups of 3-4 students were deliberately arranged so that they were mixed gender, although this meant that some girls were on their own within the boy group. I didn't consider ability particularly in this grouping, as I was focusing on ensuring a mixed gender in each group, so each group was in the main mixed ability as well as mixed gender. The class had just one child (boy) from a non-white European background. I did use my knowledge of the individual students and their personalities and prior performance in class, to actively avoid putting together people who I knew would really struggle to get on as well, or those friendships that had previously proved a hindrance to productive working. The result of this was that some students had worked together before, but some had not worked together before. I tried to ensure that my questioning wasn't gender biased, such as only asking the boys or the confident students or the students who put their hands up, by using the "lolly sticks" strategy. This is a way to select at random a person who answers the question as each lolly stick has one person's name on it and all the lolly sticks go in a pot together. The teacher selects one lolly stick and reads the name of the person, who then attempts to answer the question. This way everyone is ready to think of an answer just in case they are asked. The students in this class are used to this way of working.

At the end of the experiment, the students were each given a questionnaire on how they had worked with the others in their group. This required them to reflect on themselves and in this way start to recognise that they had a responsibility to consider others as individuals who might require different approaches to help them work better. This group had a large number of boys compared to girls: 8 girls and 14 boys. However, good collaborative and helpful behaviour was a normal class expectation, regardless of gender, but their practice was still underdeveloped and they tended to group into friendship groups if not reminded.

(iii) Criteria for judging assessment data

The teacher outlined three expectations for lesson 1:

- Each group would manage to produce a possible method.
- Most groups would be able to make a verbal comment on another group's method
- A few groups would also manage to make at least one helpful written critique comments.

The assessment was formative and gave students an opportunity to adjust their first plans having had feedback from their peers. It also gave the teacher the opportunity to observe students working and look at their plans, allowing the teacher to adjust the next session to address and gaps in their process skills or understanding. No written feedback or verbal feedback was given to the students on their written plans. They did not self-reflect on how their group worked or have the opportunity in this session to consider for themselves what aspects of their group collaboration they did well and which aspect should they try to develop next time.

In the second lesson, assessment during the lesson was generally formative. The teacher went around groups and asked them questions and gave advice. The teacher did not make any written notes about the skills students used or their understanding during the session. The teacher's assessment criteria were informal and the teacher tended to notice those who were struggling more than those who were achieving the aims of the activity. The teacher kept observations in mind, as they knew the students well. At the end of the session each student was asked to type up their method for homework and were given a set of extra questions as guidance for them to structure their written report. This written report was assessed. The teacher used their knowledge of the students to help guide their formative feedback.

(iv) Evidence collected

Teacher opinion

In the first lesson, the students responded well to the task and enjoyed it. They were focused throughout and actively engaging with their group and the things presented to them. They definitely seemed to enjoy the fact that they were working with a substance that they come across in their everyday lives (vitamin C tablets). It was a shame that the set experiment we did afterwards was not a particularly effective one for them to engage with. This was possibly because the acid had been inadvertently diluted too much (prior to the session, so this was not caused by the students) and as a result very little chemical reaction happened. It made it even more useful having the vitamin C tablets and limewater to bubble it through. This in my opinion has the potential to be a good activity, although two sessions were required to do the planning and the activity.

There was a range of responses. Most groups, as expected, chose to use the equipment that was most familiar to them, namely the balloon with either a beaker or a boiling tube. However, two groups (those containing two of the higher achieving students in the class) were able to envisage what the bung and delivery tube could be used for, despite never having used them before. They did inform their groups. No rubric used for assessment, due to the fact that I find the rubric takes a large amount of time to create. However, I do find rubrics are helpful.

The second lesson did not go as well as I hoped. It was the last lesson of the day before a holiday. The students were tired and eager to go on holiday soon. This meant it was going harder to run this lesson and keep their attention. It was very disjointed lesson. One student became ill, one child got upset because of home life and everyone was very tired and needed to be constantly reminded about basic lab rules and cooperation. Despite these things they seemed to enjoy what they did.

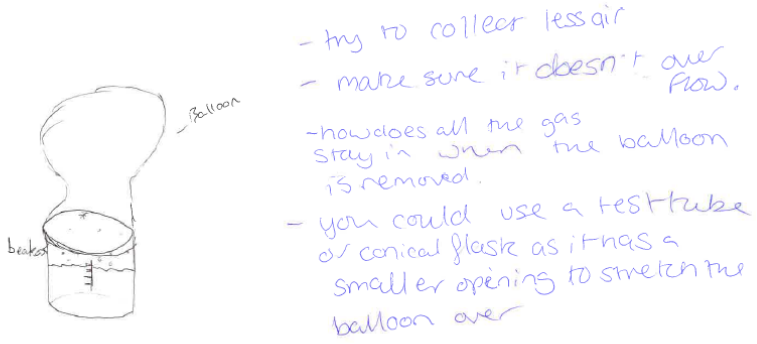
Prior to starting this we reviewed the previous lesson, where we had used an inverted water filled test tube and delivery tube to collect the gas. We talked through the good parts of what they had

done last lesson, and some of the things that they had missed. We also briefly discussed the important things that need to be in a method, the variables and the numbers associated with them. In this lesson, I had expected that at least some of the groups would decide to take numerical measurements and some would use the water filled test tube method. However, none of the groups did either of these things, which was disappointing. They are capable of doing this.

It was perhaps over ambitious to try and do all the reviewing, planning, feeding back and the experiment in one lesson. This possibly contributed to the lack of the careful measurement of controls that I was hoping for. The students were tired as it was the end of a half term. It was too much in one session

Sample student artefacts

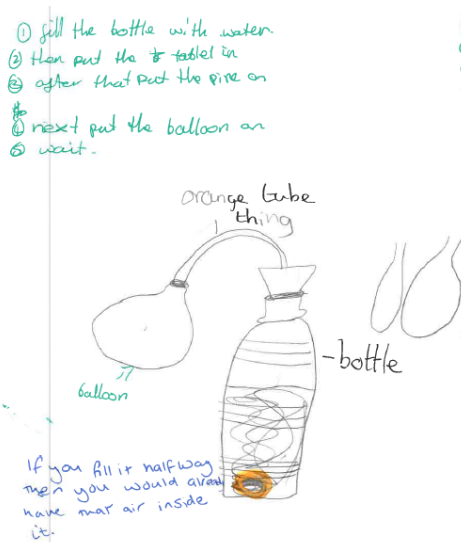
Figure 1 outlines a student's proposed method for collection of a gas, and peer-review that critiques the method. The teacher commented that "The group that critiqued this method have produced some very helpful pointers for the original group, spotting a number of possible problems that are not only about making the experiment easier to run, but also make comments about the purity of the sample collected."



- Try to collect less air
- make sure it doesn't over flow
- how does all the gas stay in when the balloon is removed
- you could use a test tube or conical flask as it has a smaller opening to stretch the balloon over

Figure 1: Student artefact 1, featuring peer-review of method

Further examples are shown in Figure 2 and Figure 3. The teacher noted, "Both of these groups have made an attempt to use the unfamiliar equipment of the bung and delivery tube (or orange tube thing as is labelled). It is probably through coincidence, rather than design, that the group using the bottle would end up collecting their gas more easily."



1) Fill the bottle with water
2) Then put the tablet in
3) after that put the pipe on
4) next put the balloon on
5) wait

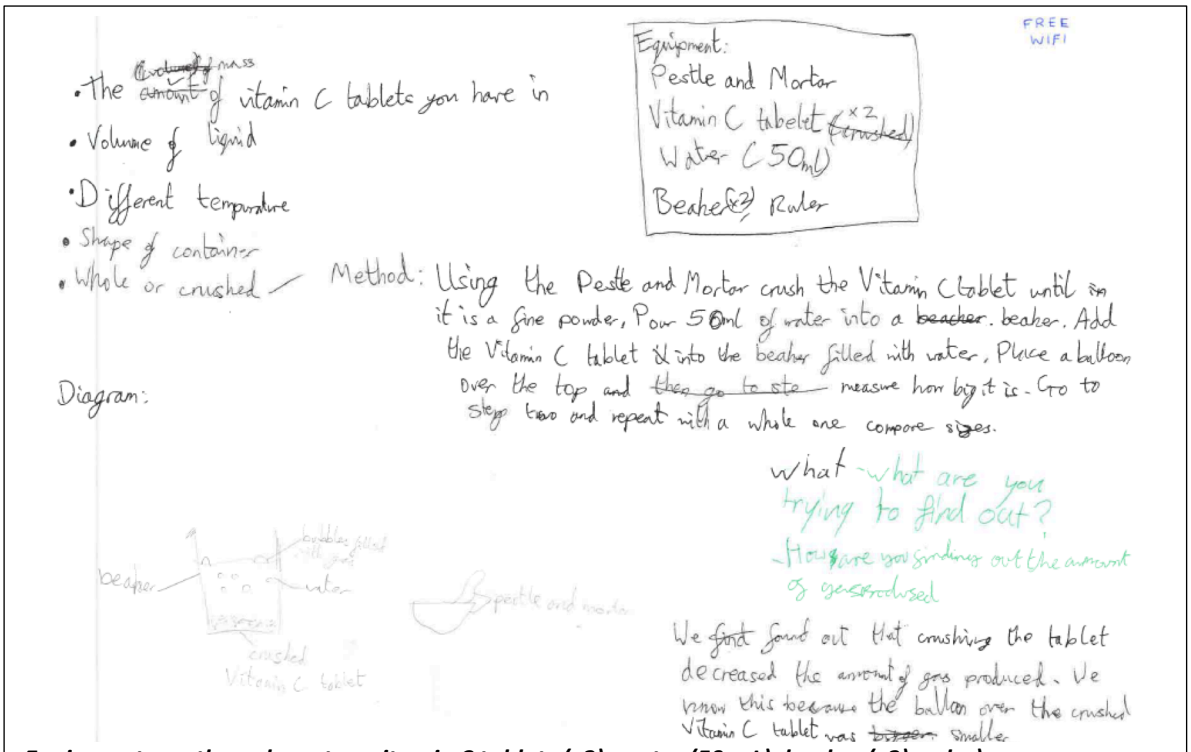
If you fill it halfway then you would already have that air inside it

Figure 2: Student artefact 2, featuring peer-review of method

Make sure it is secure or the gas will escape. May collect too much oxygen. May overflow

Figure 3: Student artefact 3, featuring peer-review of method

During the second lesson, students were asked to detail their experimental method, which was subsequently critiqued by their peers. In student artefact 4 (Figure 4), the group listed factors that affect the rate of reaction and detail an experiment to measure the effect of one of those.



Equipment: pestle and mortar, vitamin C tablets (x2), water (50 mL), beaker (x2), ruler)

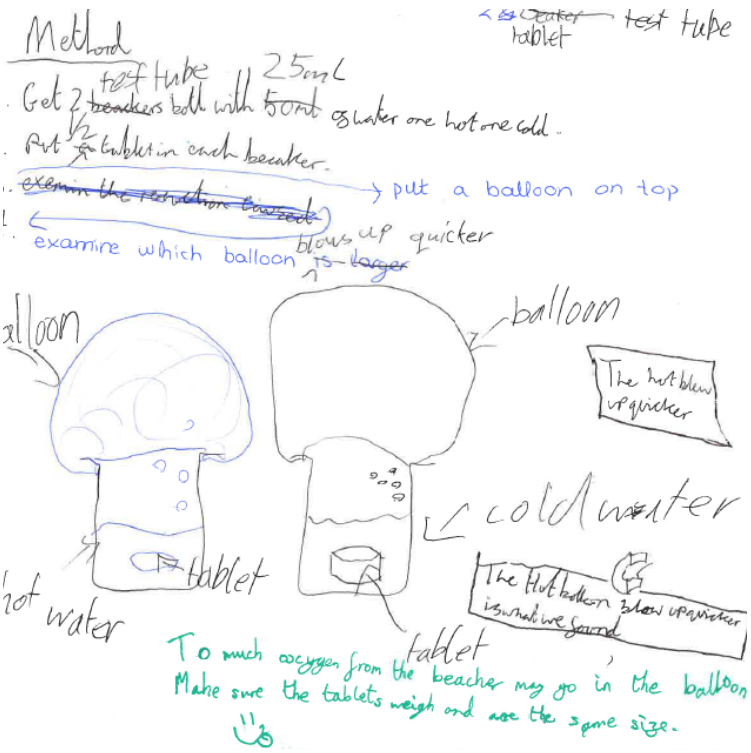
Variables that affect rate of reaction: ***the amount of vitamin C tablets you have in, volume of liquid, different temperature, shape of container, whole or crushed.***

Method: Using the pestle and mortar crush the vitamin C tablet unti it is a fine powder. Pour 50 mL of water into a beaker. Add the vitamin C tablet into the beaker filled with water.Place a balloon over the top and then ~~go to ste~~ measure how big it is. Go to step two and repeat with a whole one. Compare sizes.

Figure 4: Student artefact 4: example of experiment plan. Peer-review provided in green

The peer-review in this example asks, "what are you trying to find out? How are you finding out the amount of gas produced?" The group provide a response "we found out that crushing the tablet decreased the amount of gas produced. We know this because the balloon over the crushed vitamin C tablet was smaller." The critiquing of this method is the only one who actually raised the question of how they were going to quantify the amount of gas that was collected. The critiquing group however, were not able to bring this thought process into their own method and quantify their own gas collection.

A second example is shown in Figure 5, in which the both the original writing group and the group who critiqued the method did well at thinking about control variables. Peer review (in green) suggests, "too much oxygen from the beaker may go in the balloon. Make sure the tablets weigh and are the same size."



test tube, tablet

Method:
Get 2 ~~beakers~~ test tube, both with ~~50 ml~~ 25 mL of water one hot one cold
Put ½ tablet in each beaker
Put a balloon on top
Examine which balloon blows up quicker

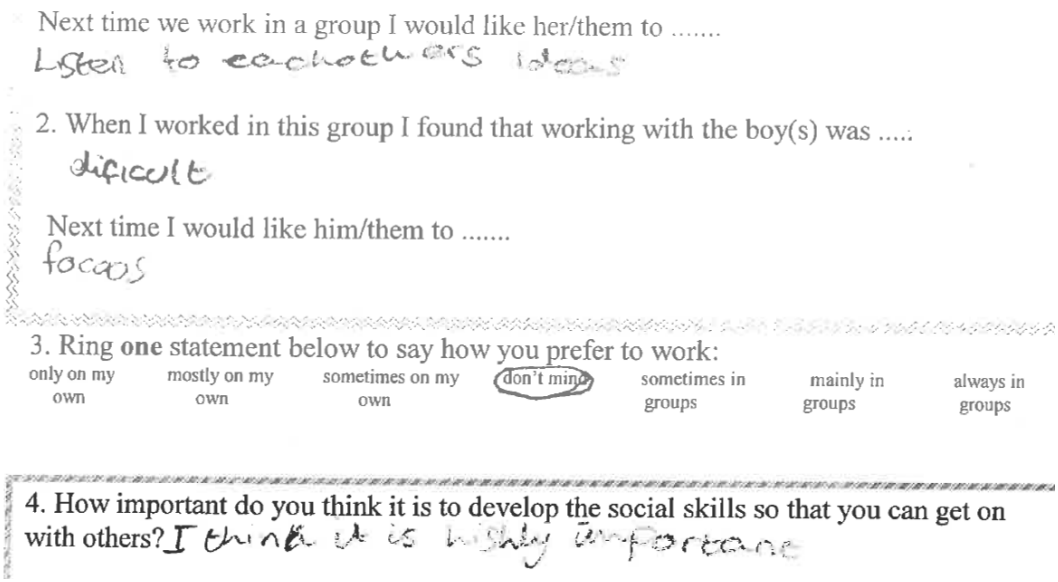
The hot blew up quicker

The hot balloon blew up quicker is what we found

Figure 5: Student artefact 5: example of experiment plan. Peer-review provided in green

In addition to teacher assessment, a student questionnaire was used at end of the two lessons, to help students to think more deeply about group working and the necessary skills and attitudes. One example shows the responses of girl who was with one other girl within a group of mainly boys (Figure 6). She states she does not mind working on her own or in a group. However she did state earlier that she found working with this group of mainly boys very difficult and next time she would like them to "focus." She thinks developing social skills is highly important. She was unable to recognise her own areas for development and suggested that maybe she should listen more.

A second example features responses from a boy in a mixed gender group (Figure 7). He likes to mainly to work in groups. He says it is very important to develop social skills. The advantages are "you get to talk in class but when you are on your own you don't get to do that." The skills he thinks he needs to develop: "don't talk about experiments which are not relevant." He thinks he can get better at his skills by "Working on the task a bit more than others (get better at them)." In an earlier section he acknowledged that he tended to do the most listening.


Next time we work in a group I would like her/them to .....
Listen to eachothers ideas

2. When I worked in this group I found that working with the boy(s) was .....
difficult

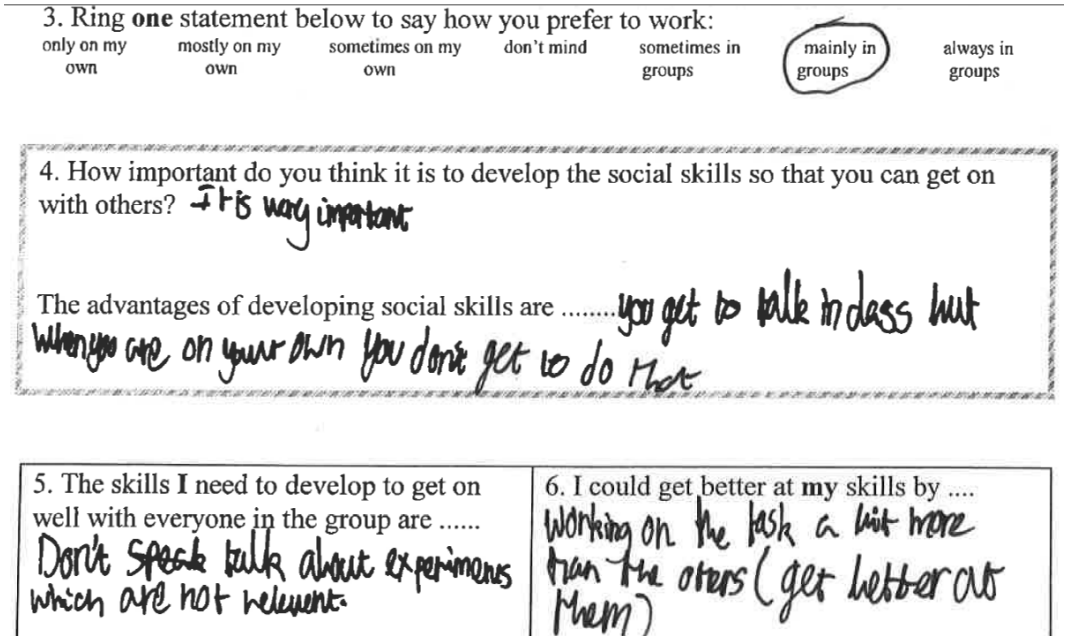
Next time I would like him/them to .....
focus

3. Ring **one** statement below to say how you prefer to work:

only on my own	mostly on my own	sometimes on my own	don't mind	sometimes in groups	mainly in groups	always in groups

4. How important do you think it is to develop the social skills so that you can get on with others? I think it is highly important

Figure 6: Student questionnaire example 1


3. Ring **one** statement below to say how you prefer to work:

only on my own	mostly on my own	sometimes on my own	don't mind	sometimes in groups	mainly in groups	always in groups

4. How important do you think it is to develop the social skills so that you can get on with others? It is very important

The advantages of developing social skills are .....you get to talk in class but when you are on your own you don't get to do that

5. The skills **I** need to develop to get on well with everyone in the group are .....
Don't speak talk about experiments which are not relevent.

6. I could get better at **my** skills by ....
Working on the task a bit more than the others (get better at them)

Figure 7: Student questionnaire example 2

(v) Use of assessment data

The first lesson led on to a second lesson on rates of reactions lesson, looking at the same skills, but experimenting with things that affect the rate of the reaction (rather than simply looking at the collection and identification of the gas).

As a result of the second lesson I will definitely be doing more work with this class on the value and importance of qualitative data (taking accurate measurements). I want them to get to a point where they choose to gather qualitative data as a matter of course. They will need much more experience in recognising which measurements are necessary as well as how to gather accurate measurement and organise these in the most effective way for them to use n their investigations. They still struggle to identify variables with confidence.

(vi) Advice to teachers implementing this unit

I thought the unit was good, I wish I had made more time to do all the different aspects of the group. It was a shame that due to time and pressures on covering the school's entire science curriculum I was not able to let them carry out their own plans. Ideally I would have planned in one lesson and carried out the experiment the next, allowing me to get the equipment for each of their methods. If I had the time I might do a trial and let them see how it worked and allow them to re-write their method before then doing it.

Sometimes I like to get groups to carry out each other's method so they can comment on the clarity of the instructions. During lesson 1, using the acid and magnesium we produced almost no gas, certainly not enough to either fill a balloon or to displace water, however the vitamin C tablets were fantastic and produced plenty of gas.

During the second lesson, as a class we discussed all the ideas of things that might affect the rate of reaction. Unfortunately I made the mistake of adding an idea of my own on to the board which no one in the class had thought of. However, this made nearly every group choose to test the variable I had mentioned. This meant I had accidently persuaded them to go with my idea. This lost the range and variation that I might have had if I had kept quiet. They did not seem to have the confidence to do their own ideas once they saw mine. I would say; help them to arrive at ideas themselves but don't add anything to the ideas that they have about things that will affect the rate.

Also, make sure they have plenty of time discuss and to write their ideas down, especially with younger or less experienced students or those writing in a language different to one they use at home. Avoid putting too much into a session. Give them time to try out their ideas and change their first thoughts.