4.3 Case study 3 (CS3 United Kingdom)

Concept focus	Introduction to IBSE
Inquiry skills	Planning investigations Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (drawing conclusions) Scientific literacy (presentation of scientific data)
Assessment methods	Classroom dialogue Teacher observation Peer-assessment Self-assessment Student devised materials (experimental plan, graph, documentation of inquiry)
Student group	**Grade:** Year 7 (lower second level) **Age:** 11-12 years **Group composition:** mixed gender and ability (small groups of students (4 from Y7/8) from the 'designated special provision' which works with autistic students joined the class.) **Prior experience with inquiry:** Very experienced; 10 weeks at second level, varied experience in primary school

In this case study, mixed ability students engaged in an *open inquiry* as an introduction to inquiry skills, in particular *planning investigations*. Assessment included self- and peer-evaluation of student-devised materials using a student-generated "arrow rubric" as an assessment tool. Students also self-assessed their performance in other transferrable skills, using a "learning landscape" guide.

(i) How was the learning sequence adapted?

The **Collision of an egg** SAILS unit was implemented in full in this case study. Students had recently studied the concept of variables. The unit was implemented over five lessons (45-60 minutes each), as detailed below.

Learning sequence

Lesson 1

1. Students in groups of 4 were shown buckets of different materials (sand, vermiculite and flour) and eggs (rubber and real) as a prompt for them to plan together an open-ended investigation.
2. Students were given a worksheet that broadly described the challenge, but gave little extra detail (Figure 1).
3. Students were allowed 20 minutes to produce a basic hypothesis and outline plan in groups of 4 (they had recently been taught about variables).
4. Students were given the opportunity to generate a "wish-list" of resources they wanted to use in their investigation – this encouraged addition of extra materials (like jelly and cooking oil) and tubing/clamps to make egg delivery mechanisms. These additional resources were provided for them for use during the second lesson.
5. Students discussed within their groups what qualities are important for each skill being addressed. These ideas were then used to generate a basic rubric for assessing their plan. Ideas from all the student rubrics were included as appropriate in the final draft rubric to ensure students understood what the rationale was behind the words written in the rubric. This not only meant they understood the rubric, but it also showed their views were respected and they were expected to take more responsibility for their learning. This final rubric was compiled by the teacher for the students to use for self-assessment and for teacher assessment.

6. Students then carried out preliminary experiments in groups of 4, discussing possible variables. Hypotheses were shared on mini-white boards and the class circulated around the room to evaluate these hypotheses. Judgement based on the question "Is this hypothesis a testable statement?" was fed back to peers.

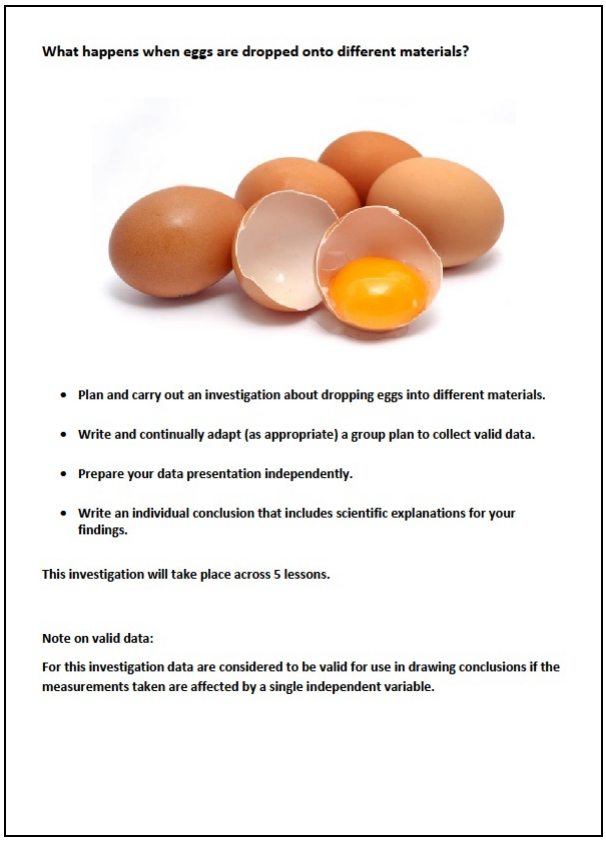


Figure 1: Student worksheet for CS3

Lesson 2

1. Students formalised their plan for homework, as teams or as individuals, and brought it to the second lesson.
2. They were given the final arrow rubric for *planning investigations*, then used it to self- and peer-assess their plans. They were encouraged to share any adaptations they had made as a result of the preliminary experiment. Students wrote on their own arrow rubric to indicate where they thought they were at present in the skill of *planning investigations*, and then thought how they might improve. They wrote this down so they would not forget and could check.
3. The teacher used the same arrow rubric in checking over their peer-assessment and to agree/disagree with the students' judgements/comments using "what went well…" and "Even better if..." feedback statements.
4. Students then carried out their experiments in groups of 4 and collected evidence (data) for their inquiry.

Lesson 3

1. Each group sent one member as an envoy to carry out a critical audit of the way another group had gone about the process thus far. Students spent 10 minutes engaging in simple discussion, question and share approaches. Envoys returned to their own group with any information gained and adjustments were made to their own ideas having learned from each other.
2. Groups completed their experimental investigations.

3. Students presented their data as a table group – this was judged by their peers against the criteria (arrow rubric) for drawing tables and handling repeated results, from a previous experiment (a tick-list students had been involved in designing).
4. For homework each student had to produce a graph of his or her results; no teacher guidance was given.

Lesson 4

1. Students peer-assessed each other's graphs against given criteria. They discussed continuous versus categorical data (information on this had been made available to the class through the Year 7 virtual learning environment, VLE). The students in this class had only recently arrived from a number of different primary schools with very different experiences. As a result, some students chose to draw histograms, some chose line graphs, but very few students chose according to any rationale about which was the most effective for the job. They chose because of their preference for one over the other.
2. Each of the groups discussed together then told the rest of the class what they thought might make a good conclusion.
3. They used this advice from the group discussion to analyse data and write conclusions.

Lesson 5

1. Students had made a first attempt at writing conclusions for homework.
2. They were given the arrow rubric to peer-assess the conclusions.
3. The teacher also used the arrow rubric in preparing their written feedback to students and check on the quality and accuracy of the peer-assessment. The teacher either agreed or disagreed with student judgements and comments using the strategy "What went well was…" and "Even better if …"
4. The students were then given the opportunity to redraft, focussing on what they have missed out and improving their original thoughts and ideas.
5. The students were given four anonymised final versions of their peers work and asked to put then in order (rank) by quality. They were then asked to look again and reconsider their judgement using the rubric. Because they had all been involved in creating the rubrics and understood what quality was, there was very little adjustment to their first ranking.

(ii) Which skills were to be assessed?

The students were assessed on their inquiry skills in *planning investigations* (writing plans), and on their *scientific reasoning* (drawing conclusions) and *scientific literacy* (presenting scientific data). Two arrow rubrics were used – one for *planning investigations* and one for *scientific reasoning* (drawing conclusions from data). A checklist on data presentation was also used for drawing graphs and tables. In each case peer-assessment was followed by teacher evaluation of the peer-assessment. Mini-white boards were also used for peer-assessment between groups.

Planning investigations

- Plan was peer-assessed against class-created arrow rubric.
- Plan reassessed after adaptations using information from preliminary experiment.

Presentation of data (scientific literacy)

- Data presentations by the groups were assessed against tick-lists designed by the class (Table 1).

Table 1: Peer assessment checklist for presentation of data

Success criterion	Peer comments
Correct graph/chart selected?	
X- axis and labels	
Y-axis and labels and units	
Bars the same width	
Bar height accurately drawn	

Writing conclusions (scientific reasoning)

- Peer-assessed using a class-created arrow rubric (Figure 2).
- Peer-assessed using a checklist (Table 2)

Note: In each case where peer assessment was utilised, teacher moderated the results afterwards to ensure quality control.

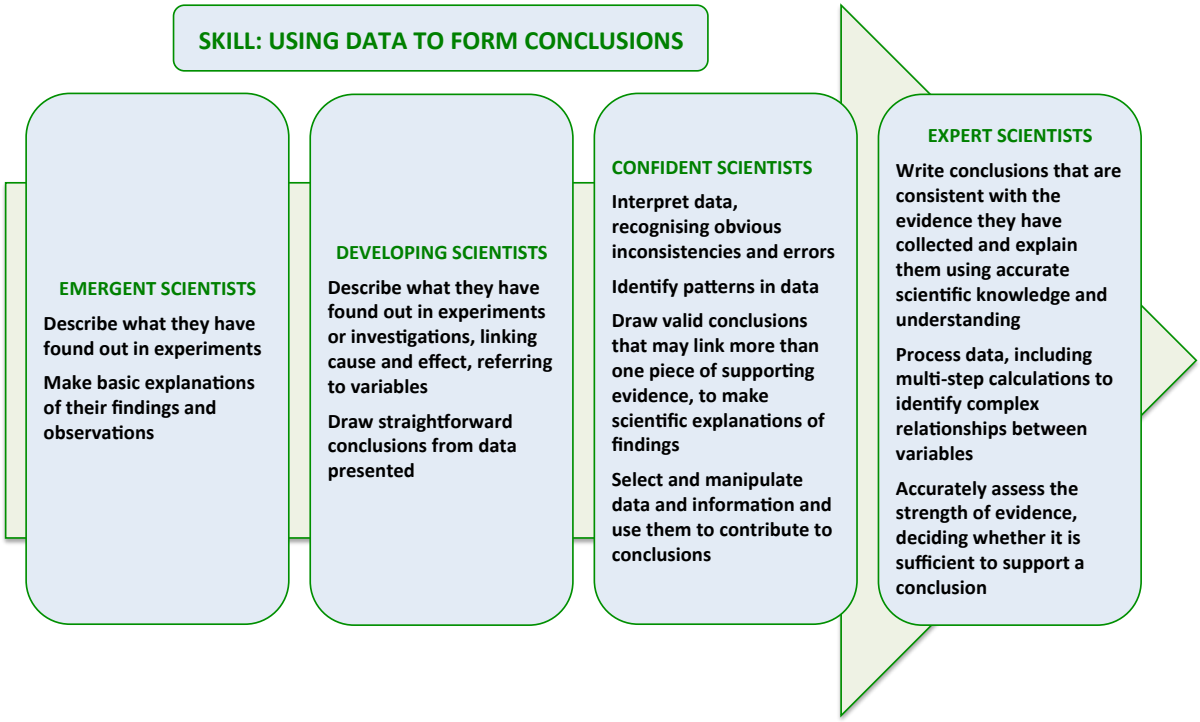
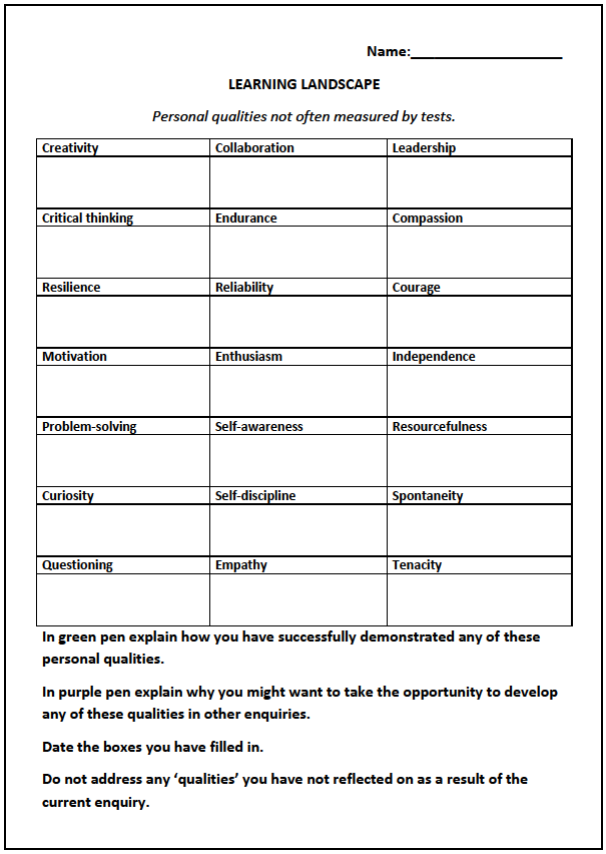


Figure 2: Arrow rubric for peer-assessment of forming conclusions

Table 2: Peer-assessment form for writing conclusions

Success criterion	Peer comments
Averages calculated correctly	
Reference to data	
Reference to repeatability	
Suggested reasons for findings	
Use of paragraphs	

After the investigation a "learning landscape" was used to allow students to consider non-testable skills (Figure 3). This is an opportunity for students to engage in reflection and identify skills that they wish to develop further.



Name:_____

LEARNING LANDSCAPE

Personal qualities not often measured by tests.

Creativity	Collaboration	Leadership
Critical thinking	Endurance	Compassion
Resilience	Reliability	Courage
Motivation	Enthusiasm	Independence
Problem-solving	Self-awareness	Resourcefulness
Curiosity	Self-discipline	Spontaneity
Questioning	Empathy	Tenacity

In green pen explain how you have successfully demonstrated any of these personal qualities.

In purple pen explain why you might want to take the opportunity to develop any of these qualities in other enquiries.

Date the boxes you have filled in.

Do not address any 'qualities' you have not reflected on as a result of the current enquiry.

Figure 3: Learning landscape

During the experimental phase various feedback opportunities were organised for the students to share understanding and improve – "envoys" joined other groups briefly to hear and feedback on plan updates. At this point "informal and ad hoc" assessment and feedback was on-going and continuous during the practical part of the inquiry. This was done by the students and the teacher. However the teacher tried hard to stand back and observe and listen, more than intervene.

After the experiment was completed and written up by the individual students, four anonymised whole investigations were given to each group – making sure their own were not in the sample. They were asked to "put in order" with reasons for their order chosen. These reasons were written on the

mini white boards that each group had on their table. This enabled them to articulate and justify their reasoning.

(iii) Criteria for judging assessment data

In this activity, it is possible to select a number of independent variables to investigate. Students had been learning that ensuring there was only one independent variable made the test more likely to produce valid results, so this was an opportunity to apply that learning. "Fair tests" were planned that used only one independent variable. The expectation was that this would represent a challenge since the variables of height and material the egg was dropped into could be varied. Groups not yet able to grasp the idea of isolating an independent variable would develop this concept as the investigation went on.

A second learning intention to be developed as the inquiry progressed were to be able to present data as a table and to select a suitable way to present data, which had been identified as continuous or categorical.

Assessment was generally formative and took place as part of the lesson, although summative judgments as to which part of the rubrics were being achieved were also made by the students themselves and the teacher. The first arrow rubric presented criteria on planning through selecting variables. Students judged the point to which they had achieved using the words on the arrow rubric to help them make that judgment. They then were able to consider what else they needed to do to be fully confident for the next step. They then set themselves personal realistic goals for the next inquiry to develop their specific area so that they could achieve the next stages or consolidate new learning. This process helped them to recognise how they can take a stronger and more positive role in their own learning. The second arrow rubric presented criteria on drawing conclusions based on isolating variables. Again students judged the point to which they believed they had progressed to on the class formulated arrow rubric and then set themselves a personal goal for the next inquiry to develop to the next stages.

The checklists for drawing tables/graphs also referenced conventions. This time students were asked to make a judgement based on a tick-list and also to consider how they could draw a graph next time. A homework task was created following this inquiry. This gave the students an immediate opportunity to present data in graph form to demonstrate how they might improve on their first efforts. This was good as things were still fresh in their minds.

(iv) Evidence collected

Teacher opinion

Students were very well engaged and were excited by the task. They wanted to carry out the experiments with real eggs immediately. The autistic students were also very engaged and worked well as part of a team. The specialist staff member who worked with one autistic boy commented that this collaboration and motivation represented a significant positive change as previous "animosity" seen in some group work had been completely ignored. This was due to the fun challenge and the curiosity generated during the inquiry.

Students were allowed to act freely and make choices for themselves through much of the inquiry and were able to refocus back to the learning intentions with ease. Formal assessment was not allowed to get in the way of the inquiry. The teacher made mental notes and tried to stand back and observe and mediate through carefully questioning rather than through direct instruction. Students were given plenty of time to experiment and work as groups and retry out ideas and explore equipment until they felt they had collected enough relevant data to address their hypotheses. Students worked independently of the teacher and were happy to problem solve for themselves and

work as part of a group. However, many students were sometimes preoccupied with designing a mechanism for delivering the egg (more a design element than science per se) and needed encouragement to refocus on the science inquiry aspect not the design technology aspect.

Students were suitably challenged by the possibility of more than one independent variable. The height of dropping before the egg broke was generally chosen as the most common output. Students were happy to investigate the different materials into which the egg could drop into and so redesigned their investigation a number of times before they were finally happy with the variables they wanted to focus on. Interestingly two groups investigated the shape of 'craters' formed by the eggs that didn't break. This showed the creative aspect of the inquiry and their creative approach to science.

The planning process was successful, because students discussed and shared their ideas in a meaningfully collaborative way before having to commit to an approach. There was the opportunity for them to adjust their thinking and ideas as part of the inquiry approach. They stayed focussed on generating a set of realistic data that was based around a developing understanding of fair-testing/valid data. Students could make basic differentiations between categorical and continuous data after the inquiry and present data appropriately. This was confirmed by teacher observation and evaluation of final student artefacts.

All students commented that they enjoyed the open-ended approach. As more experience is gained in inquiry-based approaches, issues with teamwork and time-management (the students identified these difficulties during reflection and self-assessment) are being successfully and independently addressed.

Measuring precision was not addressed by the rubric but might be in the next teaching sequence because the teacher and students recognised errors after the experiment, but not often during it (because there was deliberately little teacher intervention on this at the time). This recognition of the errors in measurement formed part of their conclusion.

Notes on rubrics used in this case study

The rubrics used here are an amalgamation of ideas from students and teachers. The students could generally suggest content for "emergent, developing and crafting scientists", while teachers added to the "extending box" Some of the language and much of the thinking came from Assessing Students Progress (APP) statements.

Students had been involved in development of a "planning" arrow rubric before and were happy to develop their work using it. The conclusion rubric was new to them and time was needed for them to engage with what each statement meant, as they started to learn new terminology. It was generally used well but will become an even better tool as students become familiar with it. Students have generally enjoyed the use of arrow rubrics and are in the routine of using them in a number of ways (guidance, judgement, as a route-map for improvement). A number of students commented that they benefit from "seeing the big picture" and understanding not just where they are but how to improve as they can recognise what quality really means to them. Although a few students do go to the "right-hand side of the arrow rubric" and say they are already able to do these things consistently, most students are very good self-reporters and quite realistic about their own position on the continuum. This is why peer discussion and peer assessment are helpful, as they have to justify their reasons ad this process helps them to understand better.

The planning rubric refers quite heavily to a "fair testing" approach and might improve by omitting that element. However the context of the inquiry in this school was that the Year 7 students had

come from a variety of primary backgrounds – some of which had "drilled" the students in fair testing and others of which had done little of it. In order to teach that element of inquiry in a way that got everyone to the same point it became part of the focus in this planning rubric.

The rubric that develops the skill of drawing conclusions using data omits "the criticism of data" and methods and the idea of "limitations of data." This is because we were working with a Year 7 group who were not found to be able to link data to conclusions particularly well. This rubric might be refined as required, or, more likely, a separate rubric addressing evaluation (of data/methods) might be written.

Notes on other documents
The criteria for peer-assessing presentation of data and drawing of conclusions came wholly from the students and might be of interest!

The "learning landscape" was used as a way to chart how the inquiry allowed us to reflect on skills we had used that might not be so easily measured. Students wrote in green for those things they felt they had done well, giving a brief explanation, and in purple for those things they wanted to address during the next investigation, explaining why. This was purely reflective and done on an individual basis. They will be given their learning landscape to add to after all inquiries. How that is practically managed through the document will develop with time!

(v) Use of assessment data

The teacher observed that different groups of individuals moved at different rates through the learning (particularly noticeable after redrafting of experimental plans). Therefore activities or tasks were provided to address their needs in developing understanding of planning with variables. An example of this "differentiated goals" approach was the homework task assigned to improve students' graphing skills. This involved choosing a suitable graph for presentation based on the type of data and conventions used when drawing graphs in general. The assessment of these skills during the inquiry informed the next learning objective. Another example was that during their next investigation they were given opportunities to respond to their written feedback by their peers, so they wrote another conclusion based on data they had collected.

Feedback was important throughout the inquiry and, as detailed above, peer-assessment was the most common feedback mechanism. There was a lot of opportunity for the students to discuss and share work and ideas, with moderation by the teacher.

(vi) Advice for teachers implementing the unit

The teacher had several pieces of advice for others implementing this unit, in particular looking at practical and pedagogical aspects.

Practical

- Use rubber eggs first so there is less mess as they refine their thinking! Be aware that students might become pre-occupied with the 'delivery mechanism' not the hypothesis and inquiry approach.
- Have appropriate supplies of cleaning materials as there will be mess – black refuse sacks and old newspapers underneath the experimental equipment avoids the need for a massive clean-up of surfaces. This can be a very messy set of experiments. Remind students they will be leaving the area clean and tidy.
- The materials the eggs are dropped in can also be difficult to clean – so think about lining with newspapers.

- Risk assessments need to be done using the schools policy. Remember that the height of the egg drop can be quite high – students can be supplied with stepladders for example – eggs can sometimes be dropped relatively long distances without cracking.

Pedagogical

- Limit formal learning intentions and too much teacher intervention. The teacher needs to stand back and observe the learning, but constantly check for safety, and guide the individuals and the groups by carefully considered questions. A lot of learning can occur, so keeping a close eye on the focus of the selected goals and reminding the students is useful.
- At the start of each lesson, it is beneficial to communicate a clear view of what is required over the full inquiry. This can be detailed readily using a student worksheet.