4.1 Case study 1 (CS1 Ireland)

Concept focus	Sources of light Understanding shadows
Activities implemented	Activity A, Activity C
Inquiry skills	Developing hypotheses Forming coherent arguments
Scientific reasoning and literacy	Not assessed
Assessment methods	Classroom dialogue Worksheets
Student group	**Grade:** 2nd year (lower second level) **Age:** 13-14 years **Group composition:** single sex (female); 22 students **Prior experience with inquiry:** First class with IBSE, but teacher often asks what-if questions and regularly asks students to predict outcomes.

Two activities from the **Light** SAILS inquiry and assessment unit were trialled in this case study – looking at sources of light and formation of shadows. Skills identified for assessment were *developing hypotheses* and *forming coherent arguments*. Skills were assessed through evaluation of student worksheets, using a three-level rubric to evaluate performance level. Students were given verbal feedback on arguments presented in class.

(i) How was the learning sequence adapted?

The **Light** SAILS inquiry and assessment unit was implemented in a single 80-minute lesson. Activities investigated were Activity A: What are sources of light? and Activity C: Understanding shadows. The learning sequence followed the steps described in the unit with no modifications and students individually completed worksheets during each task. Students worked in groups of 2 or 3, as set by teacher with nine groupings set up.

Students were firstly asked to identify sources of light and differentiate between objects that are sources of light and those that are not. Students completed a worksheet on the task and were given a lighted candle and torch to compare their physical properties. As the group work proceeded, the teacher asked at least one member from each group a question (from the list of possible questions suggested in the draft unit). The argument presented by the student was given a score of 1-3. Students were also given verbal feedback on their argumentation.

The second task, Activity C, involved understanding shadows and what determines the size of the shadow on a screen. Students were given a torch, cardboard square and white sheet. They set up their apparatus to answer questions posed in worksheet 3: Understanding shadows.

(ii) Which skills were to be assessed?

The main elements of inquiry that this activity addressed were *forming coherent arguments* and *developing hypotheses*. Worksheets were used to assess students understanding of each topic and the hypotheses that they formulated. The teacher also assessed key arguments outlined by students in each group on a scale of 1-3. Feedback was given on arguments and key points presented by students.

(iii) Criteria for judging assessment data

Forming coherent arguments

At least one student per group was asked a question from a prescribed list of questions. Each student's answer/key argument was awarded a score between one and three using the criteria set out below:

1. The student does not provide and/or does not explain the arguments in his/her own words (construction); key arguments aren't properly developed.
2. The student presents and explains her arguments, explaining the key arguments but not completely. In case of verbal communication, this level includes complete answers obtained only after prompting by the teacher.
3. The student presents and explains his/her arguments in his/her own words (construction), properly developing the key arguments.

Developing hypotheses

Students had to make a number of predictions that were noted on their worksheets. For example during question 8 in Activity C: Understanding shadows, students had to predict the light path they would expect to see.

(iv) Evidence collected

Teacher opinion

The topic and practical work involved engaged students from the start of the lesson. Eleven students (at least one from each group) were asked a question about light. It was judged that eight of the arguments in the sources of light activity scored a 2, as the students presented and explained their arguments but not completely without prompting. It was noted that feedback and further questioning by the teacher elicited a more comprehensive argument from students, e.g. student D in Figure 1. One of the students scored a 3 (student F in Figure 1), as she explained her arguments fully and outlined key points without prompting with scientific questions.

Teacher: ***Which of the light sources are solids, liquids, or gases?*** Student D: ***Candle a gas?*** Teacher: ***Why do you think that?*** Student D: ***It has a flame. Wax is a solid.*** Teacher: ***Can you explain that?*** Student D: ***Wax being burned is a gas.*** Student D: ***Solid battery.*** Teacher: ***Is the battery solid inside?*** Student D: ***Not sure*** Assessment: **2**	Teacher: ***If we can see walls, tables, and chairs, are they also sources of light? If not, why can we see them?*** Student F: ***No*** Teacher: ***Why not?*** Student F: ***Don't have energy to convert (to other form). Light rays reflect off them and we can see their shape.*** Teacher: ***Very good.*** Assessment: **3**, explained arguments fully and outlined key points without prompting with scientific questions

Figure 1: Examples of responses to teacher questions

At the end of Activity C: understanding shadows, the teacher posed a question to class "***If I place a green bottle in front of the light, will I create a shadow on the wall?***" and 8 hands were raised to shown agreement with this. Only a few students were directly asked to make an argument and these were noted and judgment recorded (Figure 2). Again, it was noted that with feedback and further questioning by the teacher a more comprehensive answer could be elicited.

Teacher: ***If I place a green bottle in front of the light, will I create a shadow on the wall?*** Student T: ***I think it is a shadow because it will leave an area on the screen the shape of the bottle.*** Teacher: ***Will it be a full dark shadow?*** ***S: More like a partial shadow.*** Assessment: **2**	Teacher: ***What do you think is causing the shadow?*** Student: ***Card is blocking.*** Teacher: ***What happens to the light on cardboard?*** Student: ***Light is hitting onto cardboard and reflecting back. There is no light in the shadow.*** Assessment: **3**

Figure 2: Examples of responses to teacher questions

In general, the students responded very well to both inquiry-based topics. They enjoyed the practical work and the challenge of the questions on their worksheet. They gained confidence from the experimental work during Activity C: Understanding shadows (questions 1-4) and appeared confident when answering questions 7 and 8. The majority of the students predicted the light path correctly in these final two questions on their worksheet.

Students worked in groups of three and enjoyed the interaction in each topic. The use of worksheets meant that each student's learning could be directed within an inquiry setting and could also be individually assessed. A number of class discussions also developed, the most fruitful of which took place at the end of Activity C on the question of whether or not a shadow is formed when a light is shone on a green bottle. 8 out of the 22 students agreed the green bottle would create a shadow. Other students talked about a partial shadow and the fact that the outline of the bottle would still be seen on the screen. A little more time to progress this discussion a little further would have been beneficial but class finished at this exact moment.

Students performed very well in both activities. The assessment questions to at least one member of each group was a good barometer of the understanding of the topic as it required students to use the knowledge they had gained to explain and expand on key points. The teacher made sure to cover a spectrum of students and not just the top performers.

For these second year students, *forming coherent arguments* was a relatively new skill. They are asked a variety of lower and higher cognitive questions throughout their course but as the teacher was focused on assessing this particular skill students were encouraged with feedback to develop their argument further. This led to much more comprehensive answers than would normally be experienced at this age. It highlighted to the teacher the benefits of inquiry based learning and how much can be gained by focusing on one particular skill from time to time.

Sample student artefacts

The teacher used two modes of assessment; firstly she assessed the verbal responses to questions (of at least one student per group) and assessed student artefacts after the lesson for assessment of all students.

Examples of responses to teacher questions, and their assessment, are shown in Figure 3 and Figure 4.

Teacher: ***Which of the light sources are also hot? Are all light sources hot?*** Student A: ***Candle. No torch is not hot*** Teacher: ***Can you find out?*** Student A: ***Maybe if you left it on for a while*** Teacher left and returned a few minutes later, and student confirmed that heat was given out by torch. Assessment: **2**	Teacher: ***Which of the light sources are also hot? Are all light sources hot?*** Student B: ***Candle hot because it was lit with a match*** Teacher: ***Why is the candle hot?*** Student B: ***(its) burning*** Teacher: ***Can you prove that?*** Student B: ***torch would probably get hot*** Teacher: ***How?*** Assessment: **2**

Teacher: ***Which of the light sources are also hot? Are all light sources hot?*** Student C: ***torch provides some heat but not as much as the candle*** Teacher: ***very good*** Assessment: **3**

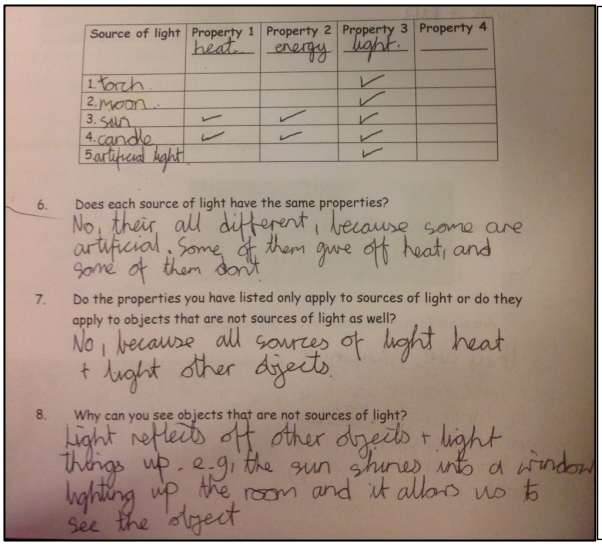
Figure 3: Examples of responses to teacher question "*are all light sources hot?*"

Teacher: ***If we can see walls, tables, and chairs, are they also sources of light? If not, why can we see them?*** Student E: ***No*** Teacher: ***Why?*** Student E: ***Not giving off light*** Teacher: ***How do you know?*** Student E: ***Don't know. Light around it*** Assessment: **2**	Teacher: ***If we can see walls, tables, and chairs, are they also sources of light? If not, why can we see them?*** Student G: ***No, don't emit light*** Teacher: ***Why?*** Student G: ***Light off other objects will relect off them*** Teacher: ***Very good*** Assessment: **3**
Teacher: ***Which of the light sources involve chemical reactions?*** Student H: ***Torch is chemical*** Teacher: ***Can you explain?*** Student H: ***Battery uses chemicals to light up the bulb.*** Teacher: ***What about the candle?*** Student H: ***No, burning more heat than the chemical reaction.*** Assessment: **2**	Teacher: ***Which of the light sources involve chemical reactions?*** Student I: ***Candle (liquid gives out heat and light), Torch is solid. Sun is gas.*** Teacher: ***Why is sun a gas?*** Student I: ***It's on fire & gives out heat*** Teacher: ***Is it all gas?*** Student I: ***No*** Assessment: **2**
Teacher: ***Is there a single physical characteristic that explains why some objects are sources of light and some are not? Does energy play a role in some way?*** Student J: ***Reflect light through objects?*** Teacher: ***Through or onto?*** Student J: ***Through*** Teacher: ***How? Can they allow us to see things?*** Student J: ***Moon is a piece of rock different from candle – allows us to see things.*** Assessment: **2**	Teacher: ***Is there a single physical characteristic that explains why some objects are sources of light and some are not? Does energy play a role in some way?*** Student K: ***They give off heat*** Teacher: ***Are there other characteristics?*** Student K: ***No*** Assessment: **1**

Figure 4: Examples of responses to teacher questions

Assessment of *forming coherent arguments* was also based on written responses of students in their worksheets. Students provided very satisfactory answers to questions 1-4 and question 8 in worksheet 1 (Activity A: Sources of light). They had covered the topics of heat and energy in the recent past and brought this knowledge into this topic. In the main, students provided right answers

with reasoning words without help. From the three samples provided (Figure 5: student R, Figure 6: student G and Figure 7: student P), it is clear that questions 5 and 6 caused some difficulties. It would have been a good idea to have a "think, pair, share" or class discussion about questions 5 and 6 to bring ideas together at this stage.



Source of light	Property 1 heat	Property 2 energy	Property 3 light	Property 4
1. torch			✓	
2. moon			✓	
3. sun	✓	✓	✓	
4. candle	✓	✓	✓	
5 artificial light			✓	

6. Does each source of light have the same properties?
No, their all different, because some are artificial. Some of them give off heat, and some of them don't

7. Do the properties you have listed only apply to sources of light or do they apply to objects that are not sources of light as well?
No, because all sources of light heat + light other objects

8. Why can you see objects that are not sources of light?
Light reflects off other objects + light things up. e.g. the sun shines into a window lighting up the room and it allows us to see the object

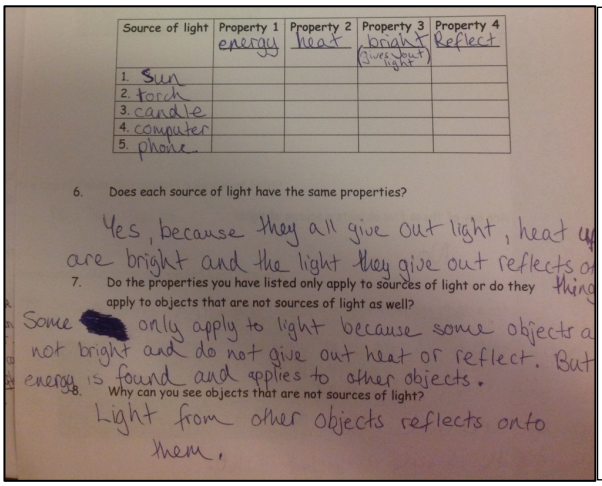
Sources of light	Property 1. ***Heat***	Property 2. ***energy***	Property 3. ***light***	Property 4. _____
1. ***torch***			✔	
2. ***moon***			✔	
3. ***sun***	✔	✔	✔	
4. ***candle***	✔	✔	✔	
5. ***artificial light***			✔	

6. Does each source of light have the same properties?
No their all different, because some are artificial. Some of them give off heat, and some of them don't

7. Do the properties you have listed only apply to sources of light or do they apply to objects that are not sources of light as well? ***No, because all sources of light heat and light other objects***

8. Why can you see objects that are not sources of light?
Light reflects off other objects & lights things up e.g. the sun shines into a window lighting up the room and it allows us to see the objects

Figure 5: Student R



Source of light	Property 1 energy	Property 2 heat	Property 3 bright (gives out light)	Property 4 Reflect
1. Sun				
2. torch				
3. candle				
4. computer				
5. phone				

6. Does each source of light have the same properties?
Yes, because they all give out light, heat up are bright and the light they give out reflects off things

7. Do the properties you have listed only apply to sources of light or do they apply to objects that are not sources of light as well?
Some [redacted] only apply to light because some objects are not bright and do not give out heat or reflect. But energy is found and applies to other objects.

8. Why can you see objects that are not sources of light?
Light from other objects reflects onto them.

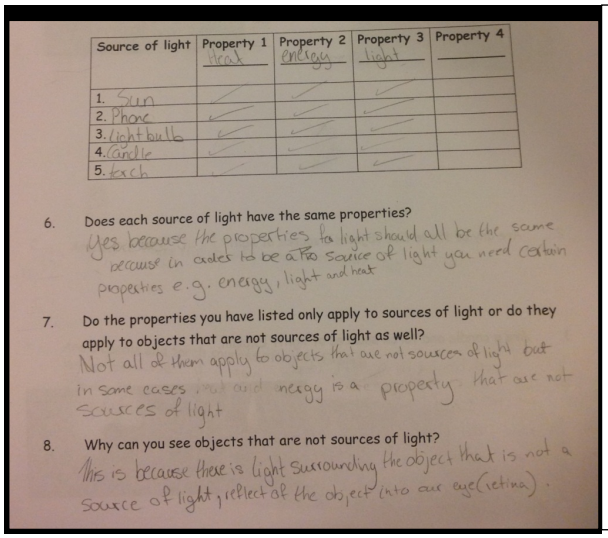
Sources of light	Property 1. ***energy***	Property 2. ***heat***	Property 3. ***bright***	Property 4. ***reflect***
1. ***sun***				
2. ***torch***				
3. ***candle***				
4. ***computer***				
5. ***phone***				

6. Does each source of light have the same properties?
Yes, they all give out light, heat up, are bright and the light they give out reflects off things

7. Do the properties you have listed only apply to sources of light or do they apply to objects that are not sources of light as well? ***Some only apply to light because some objects are not bright and do not give out heat or reflect. But energy is found and applies to other objects***

8. Why can you see objects that are not sources of light?
Light from other objects reflects onto them

Figure 6: Student G



Source of light	Property 1 heat	Property 2 energy	Property 3 light	Property 4
1. Sun	✓	✓	✓	
2. Phone	✓	✓	✓	
3. Light bulb	✓	✓	✓	
4. Candle	✓	✓	✓	
5. torch	✓	✓	✓	

6. Does each source of light have the same properties?
Yes because the properties fa light should all be the same because in order to be a source of light you need certain properties e.g. energy, light and heat

7. Do the properties you have listed only apply to sources of light or do they apply to objects that are not sources of light as well?
Not all of them apply to objects that are not sources of light but in some cases heat and energy is a property that are not sources of light

8. Why can you see objects that are not sources of light?
This is because there is light surrounding the object that is not a source of light, reflect of the object into our eye (retina).

Sources of light	Property 1. ***heat***	Property 2. ***energy***	Property 3. ***light***	Property 4. _____
1. ***sun***	✔	✔	✔	
2. ***phone***	✔	✔	✔	
3. ***light bulb***	✔	✔	✔	
4. ***candle***	✔	✔	✔	
5. ***torch***	✔	✔	✔	

6. Does each source of light have the same properties? ***Yes, because the properties fa light should all be the same because in order to be a source of light you need certain properties e.g. energy light and heat***

7. Do the properties you have listed only apply to sources of light or do they apply to objects that are not sources of light as well? ***Not all of them apply to objects that are not sources of light but in some cases [heat and] energy is a property that are not sources of light***

8. Why can you see objects that are not sources of light? ***This is because there is light surrounding the object that is not a source of light, reflect of the object into our eye (retina)***

Figure 7: Student P

Assessment of *developing hypotheses* was also based on written responses of students in their worksheets (Activity C: Understanding shadows, question 8). The question on predicting the light path (question 8) was very well answered by the majority of students (for example, student B in Figure 8), proving that the guided inquiry provided by the practical work and worksheet on questions 1-7 equipped students well to make a prediction. However, a small number of students showed a little difficulty with the concept of light travelling in straight lines, as can be seen from their responses to question 7. For example, student F in Figure 9 talks about light going around the cardboard.

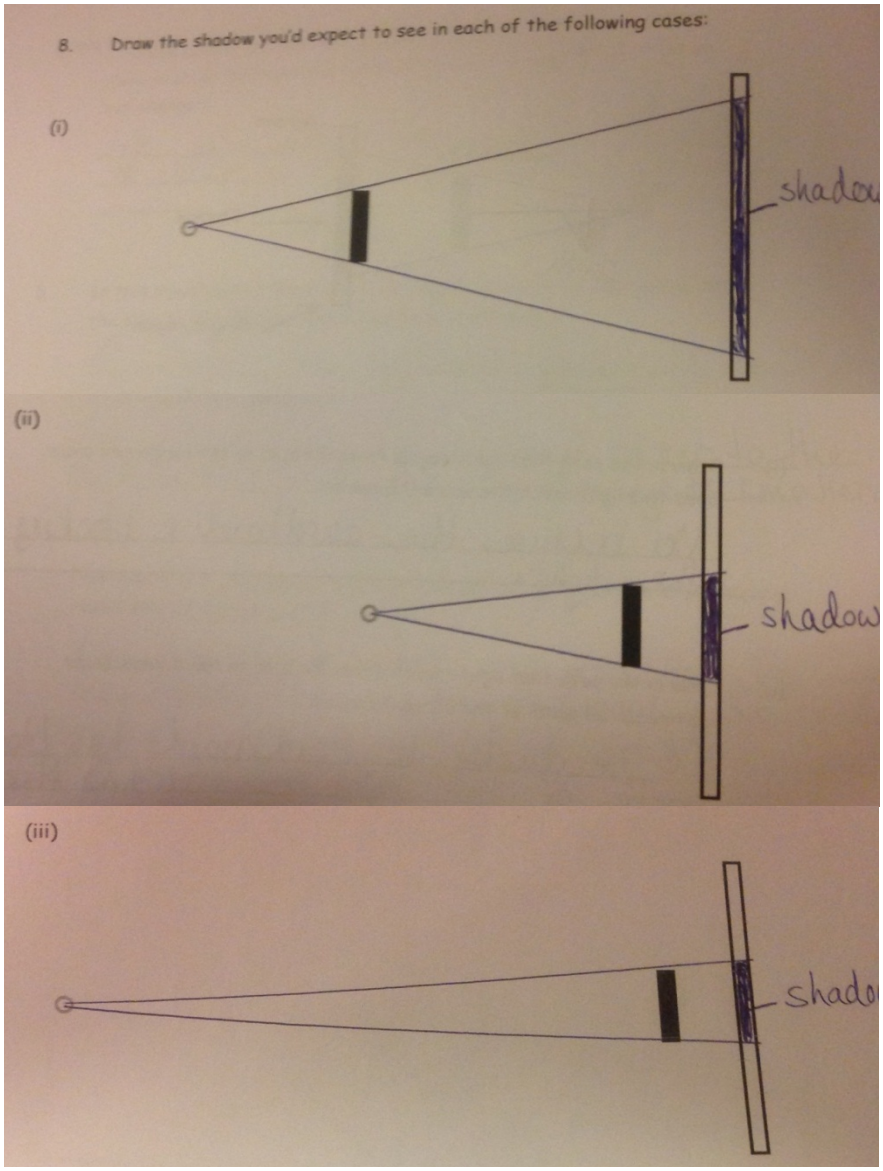


Figure 8: Student B

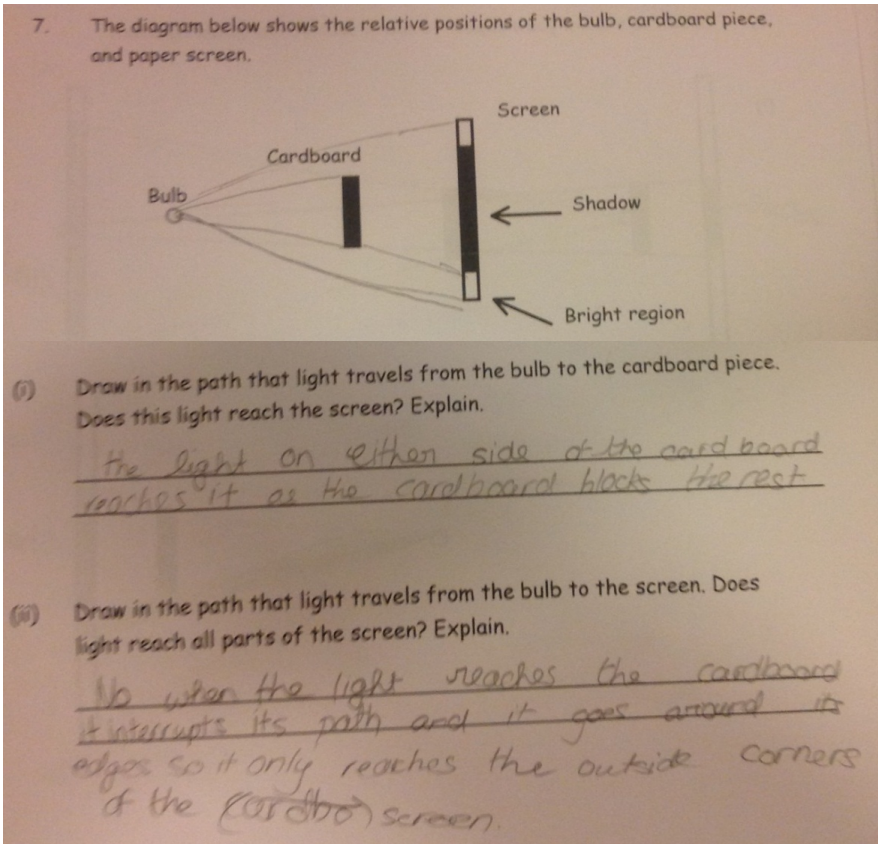


Figure 9: Student F

(v) Use of assessment data

The teacher gave feedback to the class in groups and individually as the lesson proceeded. Specific feedback was given on the skill of *forming coherent arguments*. This was the opening lesson on the topic of light to second years. The planning of the lessons that followed was altered to try to bring in some more inquiry-based learning. Students clearly enjoyed the learning experience in the first two lessons. It is clear from this lesson that it is possible to focus on certain inquiry skills and assess them within class time.

(vi) Advice for teachers implementing the unit

One particular difficulty for the teacher was trying to record and judge student answers, provide feedback and in some cases encourage students to expand on their answers within a small time frame. Videoing the lesson or use of an observer would help with the difficulty of recording in this instance. On an on-going basis, experience with recording such information and tailoring rubrics to a particular class or topic would help with this difficulty.

On completion of Activity A: Sources of light, it is clear from written responses that questions 5 and 6 caused some difficulties. It would have been a good idea to have a "think, pair, share" or class discussion at this stage in class to bring ideas together.

The teacher felt that 80 minutes of class time was appropriate for these two activities with this age group of students. It required the teacher to carry out more focussed planning and pre-work so that the activities could be carried out through group work and to allow time for student teacher dialogue. Overall, the teacher was surprised at how much more could be achieved by using these activities and felt this approach gave a better balance between learning content and assessment of learning.