4.2 Case study 2 (CS2 Ireland)

Concept focus	Introduction to the concept of speed
Activities implemented	Activity A
Inquiry skills	Planning investigations Developing hypotheses (generating questions)
Scientific reasoning and literacy	Scientific reasoning (identification of variables)
Assessment methods	Classroom dialogue Teacher observation Worksheets
Student group	**Grade:** 1st year (lower second level) **Age:** 13 years **Group composition:** mixed ability and gender; 24 students (multidenominational school) **Prior experience with inquiry:** Limited experience in *planning investigations*, but experience in inquiry questions (challenging students to think for themselves)

In this inquiry activity, students worked individually to plan two experiments, which enabled assessment of each student's skill in *developing hypotheses*. Students engaged in "think-pair-share" classroom dialogue to discuss their ideas. The teacher provided both formative and summative assessment of students' skill in *planning investigations* and their *scientific reasoning* capabilities, as well as their engagement with the tasks. The teacher identified criteria on a five-point scale for assessment of skills.

(i) How was the learning sequence adapted?

The **Speed** SAILS unit was implemented in a single 80 minute lesson. The learning sequence for Activity A: How fast can you go followed the steps described in the unit with no modifications. The science teacher participated in a supervisory capacity only, acting as a facilitator. Students worked individually in the planning of the experiment and discussed ideas at the end of each session. Space was left on worksheets for students to complete the task outlined at the top of the worksheet. For the practical application of the experimental plan students worked in pairs. The students were not prepared in advance; no introductory material was covered and care was taken not to use the term "speed" in any class discussion.

As suggested in the draft SAILS document, students were asked to plan two separate experiments. In the first task, students were required to plan an experiment to measure how far they would walk in 5 seconds. Students were asked to include as many questions as they could in their plans. The second task asked students to plan an experiment to measure how long it would take to walk 5 metres. Students were required not to carry out experiments until they had finalised their experimental plans. A flow chart showing the planned sequence (asking a question⇒construct a hypothesis⇒test with experiments⇒analyse the results⇒formulate a conclusion) was added to the left margin of each page to help students along to reinforce expected experimental practice and sequencing.

(ii) Which skills were to be assessed?

The main elements of inquiry that this activity addressed were *planning investigations* and *scientific reasoning*. These skills developed through diagnosing problems, as well as raising relevant question at each step of the experimental plan, identifying variables, and planning/sequencing the experiment. Within these elements, the main skills that were looked at were the generation of questions and the identification of variables. The teacher assessed three aspects of skill development: (1) engagement with task, (2) experimental plan and design and (3) level of relevant questioning and identification of variables.

In this case study high levels of achievement were recorded, this was assessed by analysing the quality of planning and questioning of the final worksheets and by field observation. The teacher did not ask any leading questions or prompt students in any way through these activities. Students with specific learning difficulties were helped in experimental planning through conversations and probing, because field observation showed them struggling with the task.

(iii) Criteria for judging assessment data

The skills of identifying variables and generating questions were assessed in terms of both quality and quantity. The teacher particularly looked at questions that were relevant to the investigations, or that highlighted issues such as accuracy or variables, sources of error, etc. It was difficult for the teacher to assign a grade to this task. As a performance indicator the teacher felt it only fair to judge not only the questioning and planning, but also the students' engagement with the task in class. However, it was difficult to assign a numerical value to this. The teacher felt that a comment-only marking system based on a continual assessment of experimental planning would be a better form of assessment here (e.g. "two stars and a wish" approach, where feedback comments are written on student scripts – the first and third comment are positive and highlight what the teacher liked about the work, the second comment allows the teacher to state what could improve). The teacher wished to give the students some formal assessment as well, which gives important numerical feedback to students. A five point scale was used for evaluation of each of the three criteria – (1) engagement with task, (2) experimental plan and design and (3) level of relevant questioning and identification of variables – represented as 5= excellent, 4= very good, 3= good, 2= fair, 1= struggling.

Table 1: Assessment criteria

Marks	Criteria
13-15 Excellent	Student has demonstrated excellent knowledge of experimental design, planning and sequencing; has shown the ability to pre-empt and solve potential problems in experimental planning; shows exceptional logic and problem solving skills
10-12 Very good	Student has demonstrated a very good knowledge of experimental design, planning and sequencing; has shown the ability to question decisions made in experimental design however could improve by exploring sequencing more carefully; shows very good problem solving skills.
8-9 Good	Student has demonstrated a good knowledge of experimental design and planning, however student must think more carefully about the sequence of steps to be taken in experimental planning. Student also needs to think more about problems that could occur in the experiment they designed and how they would solve these problems.
6-7 Fair	Student while designing and planning experiment gave a list of apparatus and suggested some steps for an experiment. Student needs to think more carefully about how the experiment is planned by asking questions and answering these same questions.
< 6 Struggling	Student showed little to no engagement with task.

Teacher comments

I was shocked by the lack of engagement of some students in the task especially students with specific learning difficulties (SLD). This is reflected by the very low mark these students obtained, 6/15 = 40% being the lowest (we have a policy in the school not to fail students). Even when prompted and questioned these students did not engage in the task. I thought they might do better in the second task (ii), since they may by then have felt more familiar or comfortable with the ideas of the investigation, but the lack of engagement remained the same.

The second shock came in the form of a student who underperforms in class tests (scoring on average 65%) and does not engage in class discussion. The performance of this student was excellent, demonstrating a clear understanding of the activities, experimental planning, fair and unbiased experimentation. On further investigation, this student scores in the upper percentile ranges on entrance tests and is in the gifted and talented category. This environment seemed to provide safety for the student to show his talents. I am unsure if the covert nature of this inquiry task allowed this student to excel or if it was the inquiry based technique that appealed to his style of learning but either way this is a positive outcome.

After Activity A (ii), I asked students a series of simple questions in relation their feelings about this inquiry based learning teaching methodology.

- "How do you feel?" The students felt happier, more confident, calmer, creative, imaginative and scientific.
- "Will you be able to complete your experiments next week?" 18/24 students (75%) felt they would be able to complete their experiments the following week.
- "If you have problems next week will you change your experiment and if you have ideas during the experiment will you test them?" 18/24 students (75%) also felt that they could adapt their experiments the following week and would be confident to test their ideas.
- "Do you think it is important to plan experiments and how does it make you feel?" All students felt that it is important to plan experiments; when asked why their answers were as follows: "You have to use your noggin [*you need to think]*," "Feel like a scientist," "Get experience and be better next time," "Do something for yourself," "Show creative side," "Sense of satisfaction."

(iv) Evidence collected

Teacher opinion

Students were unaccustomed to IBSE, however they are encouraged in all classes to think for themselves with plenty of questions in relation their work and problem solving scenarios. I was surprised by the volume of questions generated and was equally impressed by the quality and relevance of the questioning and planning (see sample student artefacts).

All students worked individually, as I wanted to see if all students could generate questions. Unfortunately students with specific learning difficulties were lost in the activity and did not generate any questions. Similarly some high achieving students struggled with the activity as they, in their own words, were accustomed to being given information and not thinking for themselves.

At the end of the first forty-minute session, students sitting beside each other were encouraged to engage in a five-minute think-pair-share and the class engaged in a five-minute class discussion. Think-pair-share is a teaching methodology where all students are requested to discuss ideas with the student they are sitting beside and share with the class at the end of the think and pair, in this way students are all held accountable as they know they will have to share with the class. Students were excited to impart information and were engaged in open and active discussion and actually questioned other students planning activities with a lot of "what if…" and "but if you…" type questions (similar to the higher order questions I would ask in class). I was intrigued by the discussion that ensued about how the finish could be decided, if it was the toe, the middle of the foot, the heel of the foot etc. that marked the finish and the timing. One student suggested that in the Olympics that the end is marked by toes going across the line and the class decided they would take the same stance.

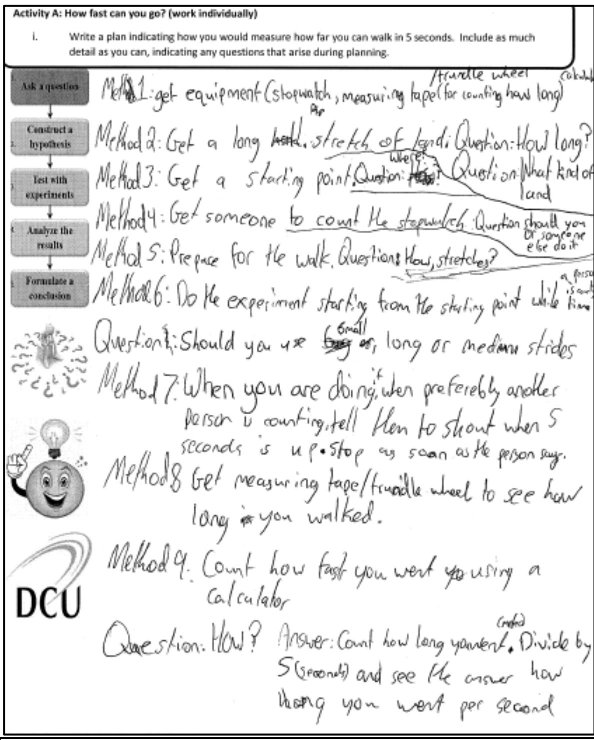
The assessment of student descriptions was difficult as sometimes the planning just incorporated a list of questions, which were related to planning but were missing a sequenced approach. Other students wrote a list of equipment needed but did not state how it would be used. Others wrote a list of steps but did not elaborate on variables, etc.

Sample student artefacts

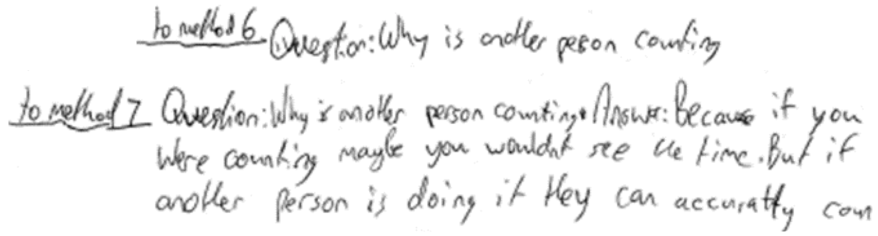
Activity A (i)

The artefacts shown below illustrate the wide range of quality in the written evidence of students' abilities to generate questions and plan and experiment. In my opinion these students show a depth of questioning and treatment of a high level.

Student A worked on his own and was very methodical in his approach and work. The student shows a clear thought process, an organised and sequential approach to the experimental design (Figure 1). The experiment was planned clearly; each step was questioned showing problem solving and logic skills. The student devises a formula to calculate speed towards end of experimental plan. The student deals with sources of error and the planning suggests clear understanding of unbiased experimentation. This student scored in the upper percentile ranges in initial entrance exam to the school and has been underperforming in class tests. This student therefore presents in the gifted and talented range but has withdrawn from class discussions/test performances so as not to appear different. This task allowed him to work covertly and seemed to provide a safe environment for him to do so.



(i) Write a plan indicating how you would measure how far you can walk in 5 seconds. Include as much detail as you can, indicating any questions that arise during planning.
Method 1: get equipment (stopwatch, measuring tape, trundle wheel (for counting how long), calculator)
Method 2: Get a long stretch of land. Question: how long, Question: what kind of land
Method 3: Get a starting point. Question: where?
Method 4: Get someone to count the stopwatch. Question: Should you or someone else do it?
Method 5: Prepare for the walk. Question: How, stretches?
Method 6: Do the experiment starting from the starting point while a person is counting time. Question: Should you use small, long or medium strides?
Method 7: When you are doing it, when preferably another person is counts, tell them to shout when 5 seconds is up. Stop as soon as person says
Method 8: Get measuring tape/trundle wheel to see how long you walked
Method 9: Count how fast you went using a calculator. Question: How? Answer: Count how long you went (metres). Divide by 5 (seconds) and see the answer how long you went per second

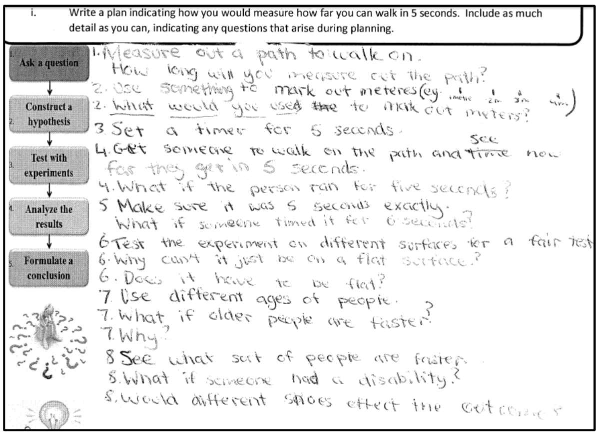


to method 6: Question: Why is another person counting?
to method 7 Question: Why is another person counting? Answer: Because if you were counting maybe you wouldn't see the time. But if another person is doing it they can accurately count

Figure 1: Student artefact – student A

The feedback given to this student would be in written format as described in assessment criteria as well as orally to the student himself and by referring to student answers in class discussions. This student would also receive a letter home to his parents commenting and complimenting him on his aptitude in this subject area. I would have high expectations of this student in future tasks but also in class, I would also give careful consideration to compacting and/or accelerating his learning in conjunction with himself and his parents.

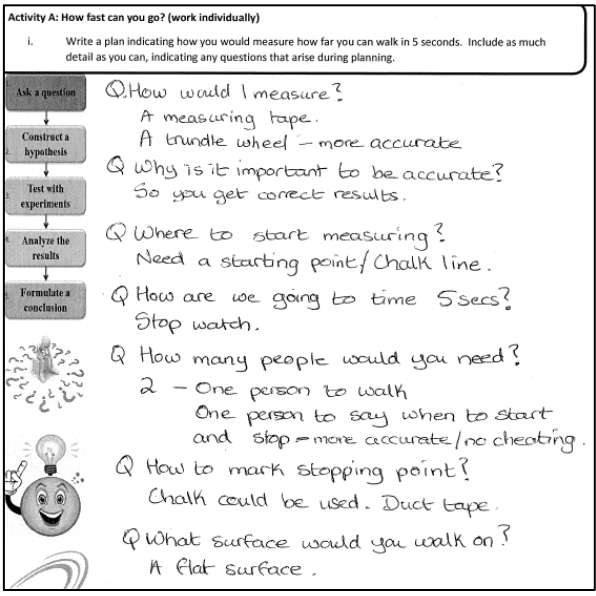
Some students mention variables, "different land", "persons mass", "different weather", "does it have to be on flat ground", "does the temperature effect this hot/cold", "would temperature affect speed", "where you walk grass, concrete, mud, stones", "straight or curvy." Many students mentioned the need to calculate averages for more accurate results. Student B would receive marks in the 7-10 range. This student shows insight into experimental design but has to think more carefully about the sequence and order of experimental steps (Figure 2). In future this student would be encouraged to write down the steps that would be taken and then add the questions.



1. Measure out a path to walk on. How long will you measure out the path?
2. Use something to mark out metres (1, 2, 3, etc.). 2. What would you use to mark out metres?
3. Set a timer for 5 seconds
4. Get someone to walk on the path and see how far they get in 5 seconds. 4. What if the person ran for 5 seconds?
5. Make sure it was 5 seconds exactly. What if someone timed it for 6 seconds?
6. Test the experiment on different surfaces for a fair test. 6. Why can't it just be on a flat surface? Does it have to be flat?
7. Use different ages of people. 7. What if older people are faster? 7. Why?
8. See what sort of people are faster. 8. What if someone had a disability? 8. Would different shoes affect the outcomes?

Figure 2: Student artefact – student B

This student puts together a series of questions but fails to plan experiment. However the student does raise some good questions, such as "what surface would you walk on" and "how to mark stopping point." Student C scored in the 6-7 range (Figure 3). In an individual conversation with the student, the student was praised for his/her questioning skill, but was encouraged to actually write a step-by-step experimental plan. This student will need a little more guidance in planning experiments.



Q. How would I measure?
A measuring tape,
A trundle wheel

Q. Why is it so important to be accurate?
So you get correct results

Q. Where to start measuring?
Need a starting point/ chalk line

Q. How are we going to time 5 secs?
Stopwatch

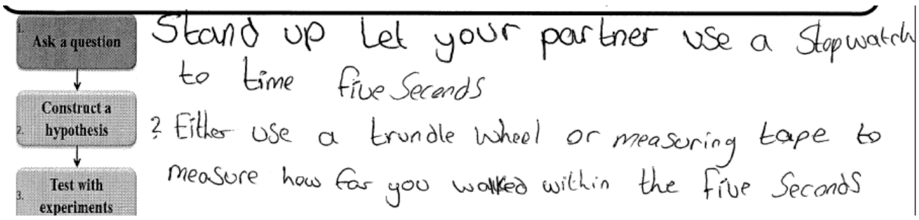
Q. How many people would you need?
2 – one person to walk, one person to say when to start and stop – more accurate/ no cheating

Q. How to mark stopping point?
Chalk could be used. Duct tape

Q. What surface would you walk on?
A flat surface

Figure 3: Student artefact – student C

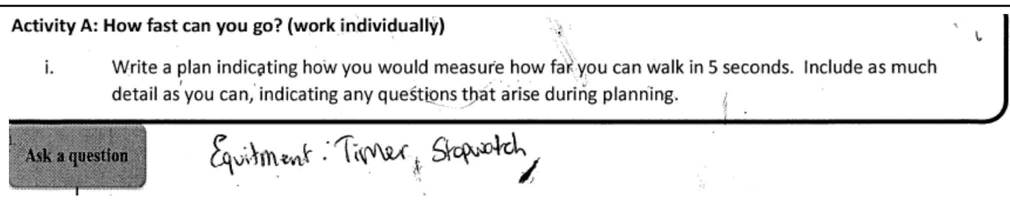
Student D attempts to put an experimental plan together but does not give evidence of coming to the point where an experiment could be carried out (Figure 4). This student falls in the specific learning difficulty range and struggled with this task, despite encouragement and questioning. The SLD is dyspraxia, so in the future, given the nature of this learning difficulty I would provide the student with a very basic step by step experimental and ask him/her if he/she could see if they could make the experiment better or if they had any questions to ask.



Stand up. Let your partner use a stopwatch to time 5 seconds
2. Either use a trundle wheel or measuring tape to measure how far you walked within the five seconds

Figure 4: Student artefact – student D

Student E provides a list of equipment and moves no further in the task (Figure 5). This student does not fall into any SLD category, however does score in the lower percentile ranges in entrance tests. This student was observed struggling and the teacher questioned and probed in order to elicit some response, however the student did not engage in the activity. This student will be watched very closely in the future and would probably benefit from working with a kind and caring laboratory partner.



Equipment: timer, stopwatch

Figure 5: Student artefact – student E

Quality and relevance of student questioning

Further evidence of students work is provided, along with teacher feedback. The students in Figure 6 have identified variables and questioned if they will make a difference to his/her experiment.

Some students suggested implicitly that they would carry out duplicate experiments, and one student even noted that they would repeat their experiment and obtain an average value (Figure 7).

During this activity, teacher took care not to use the word “speed”, and made no reference to this in the introduction to the task or on the worksheet. Nevertheless, some students still used this term and even questioned how speed might vary with mass (Figure 8).

Is the surface the assistant is walking on up a hill, down a hill, grass, gravel or tarmac, would it make a difference?

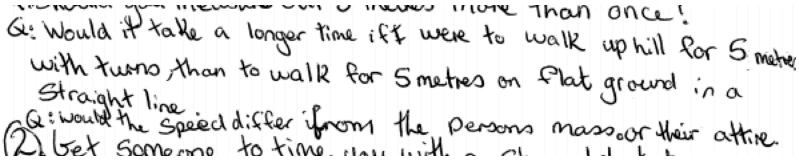
Make a clear path. ***Q. or why not a curved path?*** ***Q. Where could walk? E.g. tarmac or AstroTurf***	***1. what if you have a bigger step than others?*** ***2. What if its not accurate?*** ***3. is there any thing we can you to be more acc.*** This student mentions the variation in steps and questions the accuracy of the experiment.
Would it make a difference to use different footwear? ***Does the faster or the slower of the partners walk*** This student mentions the variation in steps and questions the accuracy of the experiment.	***Q What would happen if it was icy or mucking or sandy-snowy*** ***Q what shoes would you where (wellies, football boots, snow boots, runner)***

1. Place down a marker to indicate where to start (try on different land, their speed will vary depending on the land ***Q. Would it depend on mass (size) of the person, to see how far they would go?***

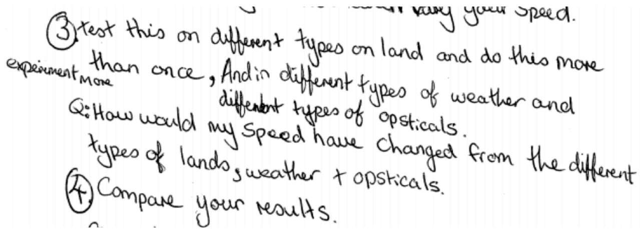
Figure 6: Student artefacts, showing consideration of variables

Step 4: Repeat 5 times and get the average length This student suggests that the experiment should be repeated to get average results.

Figure 7: Student artefact noting the need for duplicate experiments


Q: Would it take a longer time if I were to walk up hill for 5 metres with turns, than to walk for 5 metres on flat ground in a straight line
Q: would the speed differ from the persons mass or their attire.
(2) Get someone to time

Q: Would it take a longer time if I were to walk up hill for 5 metres straight line
Q: Would the speed differ from the persons mass or their attire
This student refers to speed despite no reference to speed. Student also refers to variables in terms of flat ground, uphill and mass or clothing


vary your speed.
(3) test this on different types on land and do this more than once, And in different types of weather and different types of opsticals.
experiment more
Q: How would my speed have changed from the different types of lands, weather + opsticals.
(4) Compare your results.

3 Test this on different types on land and do this more than once, and in different types of weather and different types of obstacles
Q: how would my speed have changed from the different types of lands, weather and obstacles.
4. Compare your results
This student refers to variables (types of land), repetition of experiment and weather conditions. The students also hints at the need for comparison of results, indicating they would engage in more than one experiment to test their thoughts.

Figure 8: Student artefacts identifying the concept of speed

(v) Use of assessment data

The assessment while giving a numerical value for achievement was used primarily to identify student needs, but also to give a base line value for future activities. Students received both verbal and written feedback, the verbal feedback was in the form of questioning asking them to reflect on what they would do differently the next time. Students therefore know that they have a second chance to practice these skills, which could be a motivating factor.

The assessment also provided the teacher with information that students were in the main actively engaged and enjoyed the inquiry-based class. It also provided significant hints as to how the activities can be fine-tuned for future use. It identified to the teacher some students who need a challenge, and others who need more personalised attention to make progress.