

### 4.3 Case study 3 (CS3 Portugal)

<b>Concept focus</b>	Introduction to the concept of speed
<b>Activities implemented</b>	Activity B
<b>Inquiry skills</b>	Planning investigations
<b>Scientific reasoning and literacy</b>	Scientific reasoning (identification of variables)
<b>Assessment methods</b>	Classroom dialogue Student devised materials (investigation report)
<b>Student group</b>	<b>Grade:</b> 11 <sup>th</sup> grade (upper second level) <b>Age:</b> 15-18 years <b>Group composition:</b> mixed ability and gender (10 boys, 6 girls) <b>Prior experience with inquiry:</b> Limited experience in <i>planning investigations</i> , but experience in inquiry questions (challenging students to think for themselves)

This case study details implementation in two lessons, in which the focus for development of skills was on *planning investigations* and associated *scientific reasoning*. The teacher developed criteria for a three-level rubric that aimed to collect evidence concerning identifying the problem, identifying variables, developing a procedure, carrying out investigations and analysing data. The teacher provided formative feedback after evaluation of student artefacts.

#### (i) How was the learning sequence adapted?

The **Speed** SAILS unit was implemented in two consecutive lessons (225 minutes in total). Activity B was implemented and the learning sequence followed the steps described in the unit with no significant modifications. At the beginning of the lesson, the students read an introductory text, which showed the semantic plurality of the concept “speed”. For their first task, students, in groups of three or four members, had to plan their investigation. They had to identify the problem, define the objective, identify variables and develop a procedure. Then, students had to carry out their investigations and analyse the data obtained. Since only Activity B: the path to school was completely fulfilled by all groups, the evidence collected focuses solely on this activity.

#### (ii) Which skills were to be assessed?

The skill *planning investigations* was assessed using an assessment tool that aimed to collect evidence concerning identifying the problem, identifying variables, developing a procedure, carrying out investigations and analysing data. It was based on students written answers in the worksheet. The rubrics categorise the students’ answers into three performance levels, in which level 1 corresponds to the lower level and 3 to the highest level (Table 1).

#### (iii) Criteria for judging assessment data

The task was made available to students in advance so that they could prepare their work. The assessment instrument was discussed with students in the classroom. After this class discussion it was clear that most of the students had an understanding of the task, and how it related to the assessment criteria that were discussed.

At the end of the task, each group of students handed over a written document that was analysed using the assessment tool and the criteria that had been discussed. After the analysis and interpretation of students written productions, the teacher, taking into consideration the different levels of performance, gave feedback to the students.

**Table 1: Teacher rubric for assessment of inquiry skills for planning investigations**

Performance levels			
Objective	3	2	1
Identify the problem	Identifies the proposed problem with precision	Partially/hardly identifies the problem	Does not identify the proposed problem
Set objectives	Defines coherent objectives according to the identified problem	Defines just some objectives which are coherent with the identified problem	Does not define coherent objectives according to the identified problem
Define operational variables	Operationally defines the variables under study	Defines with difficulty the variables under study	Does not operationally define the variables under study
Devise procedure	Properly prepares a procedure/strategy that allows for manipulation and control of the variables under study	Prepares a procedure/strategy that hardly allows for manipulation and control of the variables under study	Prepares a procedure/strategy that does not allow for manipulation and control of the variables under study
Control variables	Outlines a procedure managing a correct control of the variables under study	Outlines a procedure that hinders the correct control of the variables under study	The outlined procedure does not allow the correct control of the variables
Measure data	Correctly registers all data and measurements made	Inconsistently registers all data and measurements made	Inaccurately registers data and measurements
Select appropriate resource	Selects appropriate resources for the problem under study	Selects just a few appropriate resources for the study of the problem	Cannot make an appropriate selection of resources

#### (iv) Evidence collected

##### Teacher opinion

The first reaction of students to the proposed activity was to mention its high degree of difficulty. They reported not knowing where they should start. The teacher attributes this behaviour to the fact that the students are not used to performing this kind of activity. After this first impression, the teacher showed and explained to them the assessment criteria. Students expressed the opinion that this helped them to understand how they could organise their work.

Nevertheless the teacher found that the majority of students had difficulty in identifying the proposed problem, and needed a lot of guidance from the teacher on this matter. This is evident in students written reports (examples A, B and C), with example C representing the maximum performance shown by students (partially identifies/hardly identifies the problem). This difficulty partially compromised the success of the activity. However, the teacher observed a great commitment and motivation on students, especially from the most absent students, in successfully performing the proposed task.

Students took more time to accomplish the task than what was originally planned. It was also found that written communication is a skill in which most students have difficulties. This aspect is clear in

the presented examples. On the other hand, the teacher field notes showed that the students written communication distorts the message in many cases, where they record the opposite result to what they say in oral communication.

Finally, samples B and C support the teacher's opinion about the need to introduce another performance level in the descriptors. Despite being at the same overall level of performance, example C reflects the performance of a student group that showed a higher level of performance in some parameters. The evidence is a transcript of students' written answers in the worksheet (*italic black*) and teacher field notes (*italic red*).

### **Sample student artefacts**

Figure 1 is an example of a student's group performance at level 1. Students in this group cannot identify the problem, set objectives, define operationally variables, establish a procedure enabling them to operationalise variables or develop a procedure enabling them to control variables, and the only objectives in which they achieved performance level 2 was to register inconsistently measurement data and to select some features appropriately.

In the second example, Figure 2, students demonstrate a level of performance 1 with regard to the problem identification and proposed scheme that allows them to control the variables. The remaining objectives were classified as level 2, giving an overall performance level 2.

In the third example, Figure 3, there are students who have a performance level 3 in the operational definition of the variables under study, in data recording and measurements performed. However, for the remaining operations and actions considered in the assessment of *planning investigations*, the students group stood at performance level 2.

### 1. Objective

Measure *(you will not measure, but instead you will determine from the measurement of other variables)* the average speed of the vehicles used to travel to school, in this particular case, just ~~the car speed~~ and measure the average speed on foot.

With this table we intend to create a chart with the data of each stage of the route *(this is not an objective but instead it is an instrument that allows you to register the data you will collect)* and the used means of transportation (by car and by foot), and compare the distances and the used means of transportation according to the data registered on the chart.

### 1. Necessary materials Chronometer and GPS

### 2. Experimental procedure

1. Measure the time we take to travel the distance between home and school on foot and by car.
2. Measure the distance travelled in both routes.
3. Repeat the procedure 3 times in order to obtain more accurate measures.

*(You do not explain how you have realised those measurements. What did you do to collect the data you present in table 1?)*

### 3. Table

	By car	On foot
Distance	500m	181.16 m <i>(the units should not be placed here)</i>
Time	7.36 minutes	3.38 minutes
	7.40 minutes	3.43 minutes
	7.42 minutes	3.50 minutes

**Table 1:** Results *(these are not results, but instead they are distance data)* time and speed *(I do not see speed here)* of the vehicle and on foot.

	By Car	On foot
Distance	500 m <i>(units!!!!)</i>	181.16 m <i>(units!!!!)</i>
Time	7.39 minutes (7.39 ± 0.03 minutes)	3.44 minutes (3.44 ± 0.06 minutes) <i>(the measurement error should not be placed here)</i>

### 4. Schema of the route to school by car and on foot.

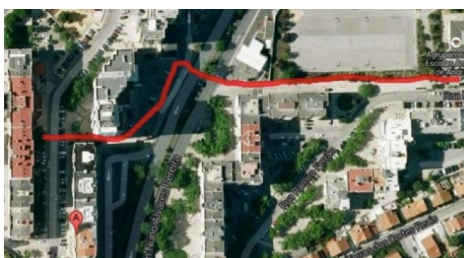


Image 1 – Route to school on foot.

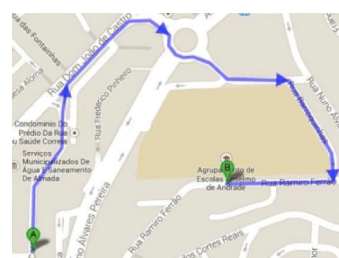


Image 2 – Route to school by car.

*(What did you do to measure the distance and time of this route?)*

**Figure 1: Example A – performance level 1**

## Activity A

### Research question:

What is the average speed of the route between the school entrance and the block 5 entrance? *(Is this really your research question?)*

### Strategy to avoid mistakes

Calculate an average of the length of each step;

Set an exact point of departure and an exact point of arrival on the route;

Calculate the average time we take to travel the route.

### Objectives

Determine the average speed of a fixed route inside and outside the school; *(why outside the school if your question is only set inside the school?)*

Compare the distance versus the used means of transportation with the registered data;

### Variables

Time; *(which time?)* Distance *(which distance?)*

### Material:

Measuring tape; Chronometer

### Procedure (for the route inside the school):

Take 10 steps and measure the length of each one; *(of each one or the total?)*

Calculate the average length of each step;

Take the route counting the steps and then multiply by the average length of each step;

Take the route several times timing how long it takes; *(why several times?)*

### During the procedure the following errors may occur:

There may not be the exact length of the route because the curves can be travelled in a more open or closed way;

The steps may not all have the same size; *(how would you minimize this aspect?)*

### Prediction:

We can predict that if we walk the route more quickly, it will take less time to travel the route hence it will be travelled with a superior average speed; *(what does walk more quickly means?)*

### Suggestion:

In order to obtain a relatively constant speed it will be preferable to set a number of steps per second (for example: 1 step per second).



1 – Route inside the school.

Figure 2: Example B – performance level 2

### Research question:

How to get to school more quickly? *(Is this the question? In this part did you test different ways to travel the route?)*

### Objectives

Measure the distance home-school;

Measure the time it takes to travel the route;

Conclude about the average speed of that route. *(With these objectives how will you answer the research question you have set?)*

### Studied variables

Distance of a step ( $p$  – constant) *(This is not a studied variable)*; Number of steps ( $n$ ) *(idem)*; Distance of the path/route ( $d$ ); Time span ( $\Delta t$ ); Average speed ( $r_m$ )

### Material:

Chronometer ( $\sigma = 0,01$  s); Measuring tape ( $\sigma = 0,0005$  m)

### Procedure (for the route inside the school):

1. Measure the distance of a step of the individual  $x$ ;
2. That individual  $x$  travels from a roundabout situated East of the school to the school's gate, which section corresponds to  $5/6d_2$  with constant pace; *(why  $5/6 d_2$ ?)*
3. Multiply by  $6/5$  the distance of that section, which product corresponds to section  $d_2$ ; *(how have you done this approximation?)*
4. Walk with constant pace from the East extremity to the West extremity of the school by the North side, which will approximately result in section  $d_1$ ; *(idem)*
5. Measure the time span of each section of the route; *(what did you do to measure the time?)*
6. Calculate the average speed of each section of the route and the total average speed of the route considering distance and time span.

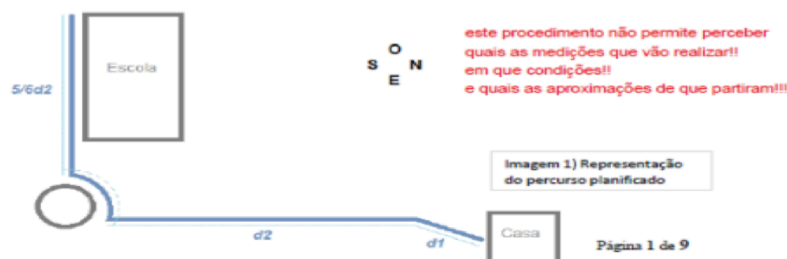


Image 1 – Representation of the planned path. *(This procedure does not allow one to understand the measurements you will do!! Under what conditions!! And which approximations have you set out!!!)*

### Data register instrument

Section	$p \pm 0,0005/m$	$n$	$d \pm 0,0005xn/m$	$\Delta t \pm 0,01/s$	$r_m/ms^{-1}$
d 1	0,710	147	104,370	81,23	1,29
d 2		--	219,816	175,43	1,25
5/6d2		268	183,130	146,19	1,25
Total		--	507,666	401,85	1,26

Table 1) Data register from part A of Activity A

*(It is understood that you have only done measurements for sections d1 and 5/6d2. How have you estimated the time for the other sections? You have estimated route d2 based on what?)*

Relations  $d = n \times p$   $r_m = d/\Delta t$

### Errors that may occur:

The steps' distance may not be kept constant;

In the real route there are slight curves;

In the real route the slope of the descents and ascents may be steeper;

There may be obstacles in the real route (traffic lights, zebra crossings, poodles, among others).

Figure 3: Example C – performance level 2