## 4.1 Case study 1 (CS1 Denmark)

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| **Concept focus** | Global warming |
| **Activities implemented** | Activities A-B |
| **Inquiry skills** | Forming coherent arguments<br>Working collaboratively |
| **Scientific reasoning and literacy** | Scientific reasoning (argumentation) |
| **Assessment methods** | Classroom dialogue<br>Self-assessment<br>Student devised materials (written arguments) |
| **Student group** | **Grade:** lower second level; independent boarding school for lower secondary students<br>**Age:** 15-16 years<br>**Group composition:** mixed ability and gender; 19 students<br>**Prior experience with inquiry:** No prior experience with inquiry |

The **Global warming** SAILS inquiry and assessment unit was implemented as part of a topic on energy and the environment. The teacher used the materials provided with minor adaptations, and focused assessment on skills in *forming coherent arguments*, *working collaboratively* and *scientific reasoning* capabilities. The primary assessment method utilised was self-assessment using rubrics, but the teacher also provided formative feedback on both verbal and written contributions from the students.

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

For implementation of the **Global warming** SAILS unit, the material was used in the original way with only minor adjustments. The work order was outlined on the blackboard before beginning the exercise. This was done to optimise the students' understanding of arguments made by student A and student B and to compare them. On the blackboard was put:

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| Read page 1 thoroughly | |
| Exercise1: | Where in the figures is there something that underpins the student's conclusion that the rise in Earth's mean temperature is caused by emission of carbon dioxide.<br>1.a) Give supportive arguments with reference to the figures.<br>1.b) Use the rubric to check and to optimise your answer |
| Exercise 2: | 2.a) Find places that do not underpin the conclusions of Student A and make arguments for Student B's conclusions.<br>2.b) Use the rubric to check and to optimise your answer |

The students were introduced to the exercise with a short introduction to IBSE and the purpose of the task. The exercise fitted well into a running topic on energy and environment.

Students received the task well and started working on it right away. They had a choice to work in pairs or alone but were encouraged to work in pairs in that they could debate their arguments and optimise them. Only one student chose to work alone.

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

The activity was used in order to assess students' skills in *forming coherent arguments*, *working collaboratively* and their *scientific reasoning* capabilities. Primary assessment method was self-assessment using rubrics, but the teacher also provided formative feedback on both verbal and written contributions from the students.

### (iii) Criteria for judging assessment data

During the assignment the task was assessed by the questions the students asked to the teacher. Many asked several times if they were doing it right. Afterwards there was a small oral follow-up. Students handed in their written work and the teacher commented on this.

Some students asked during the lesson to recap several things they thought they knew about global warming and they searched for content knowledge on the Internet and in their earlier work. They also asked questions of the teacher to find arguments for their case – especially against Rick Perry.

A satisfactory answer was that the students could work their way through the exercise and improve their argumentation in regard to the two activities. The students should themselves discuss if they had come up with optimal arguments.

### (iv) Evidence collected

**Teacher's opinion**

Most of the students actively took part in the task, but some students were lost during the lesson. This could be due to the time of the lesson (late afternoon, 16.00-18.00) or because the figures were a little blurred, meaning that it could be difficult to read. At that time of the day, that is all it takes to lose some of the students.

Others did really well and liked the exercise – especially because they were to write arguments from content knowledge and then optimise these arguments with insight from the provided rubrics. Some student made self-assessment according to the assessment criteria in the task. They asked for help to understand the words in the rubrics. These words were not that student friendly but with some help they managed to understand them.

**Observer notes**

Part of the assessment procedure was hard to use for the students since the words were not that student friendly. There was a demand for an explanation for what is meant by "underpinning arguments." This is ok for gifted students but hard for the rest. So an explanation of scientific concepts in the area of arguments would be appropriate.

**Sample student artefacts**

Included are four examples of students' work, in which the performance level of each section has been noted (Figure 1 to Figure 4). In one example, the students revised their answer following discussion and assessment using the rubric. The revised answer was evaluated as a performance level higher (Figure 1).

***Global warming – Fact or myth?***

Exercise 1***: Student A has read through the figures that the higher the emission of carbon dioxide the higher the mean temperature in Earths' atmosphere. On the figure, the mean temperature starts to rise around 1940 and it happens at the same time as the emission of carbon dioxide rises. The temperature rises because the atmosphere becomes thicker due to more carbon dioxide. The heat then has a hard time in getting out and in this way the temperature rises.***
Performance level: 2

Exercise 1b (optimised answer): ***Student A has through the two figures – that show how much carbon dioxide is emitted and the mean temperature of Earths' atmosphere – read that the more carbon dioxide emitted the higher the mean temperature in Earths' atmosphere. Around 1940 the figure shows that the emission of carbon dioxide is rising and this happens at the same time as the mean temperature on the other figure starts to rise. The temperature rises because the atmosphere becomes thicker due to more carbon dioxide. The heat gets thereby harder in in getting out again and in this way temperature raises.***
Performance level: 3

Exercise 2: ***Student B thinks that Student A's conclusions are wrong because from year 1910 till 1940 there is a dramatic increase in mean temperature while the emission of carbon dioxide is almost stable, but from year 1940 and till the end of the figures there is an increase of emission of carbon dioxide while middle temperature is almost stable in that period. This could as well be that the consequences of the carbon dioxide emission will come later and this makes the conclusions of Student A look wrong.***
Performance level: 3

Exercise 3: ***Rick Perry thinks that scientists have manipulated data on global warning to receive further funding to their projects. He thinks that it is due to natural causes that the climate changes and that it has done so throughout Earth's history. He thinks it is foolish to spend American money based on theory that is still arguable.***
***It is 99% certain that the Earths' atmosphere has become thicker in relation to the increase in carbon dioxide emission. It is true that through Earth's history there have been great global climate changes but we are not in the middle of an ice age or other natural things that can make Earths' climate change that much as it has done during the last century. It is because we become more and more people who use more cars and other machines that emit carbon dioxide.***
***What Rick Perry thinks about scientists manipulating data to get more money to their projects and that he thinks that scientists spend American money on a theory that not all agree on is only his own opinion – not fact.***
***Another thing is that there in millions of years have been oil, coal and other fossil fuels lying deep down in Earth and have not been part of the carbon cycle. When we humans take up these fuels and uses it in our cars and different machines and we not at the same time plant new things or get more sea then the cycle gets unbalanced and carbon dioxide comes into the atmosphere instead of going into plants which we miss to keep up the balance.***
Performance level: 3

**Figure 1: Arguments presented and optimized by group A (2 girls)**

***Global warming***

Exercise 1: ***You can see that both the emission of carbon dioxide and the rise in temperature has increased rapidly in the same years (the mean temperature follows the carbon dioxide emission). When our carbon dioxide emission is 4000 million ton our mean temperature is 14.8 degrees and from there the mean temperature rose to 15,2 degrees and our carbon dioxide emission rose to 20.000 million ton. Student A is right because the temperature follows the carbon dioxide (or the other way around)***
Performance level: 2

Exercise 2: ***We can agree with student B as the figures do not follow each other correctly. Temperature does not follow carbon dioxide correctly on the figures. But this does not mean that Student A is not right.***
Performance level: 1

Exercise 3: ***The argument that Rick Perry uses is that humans are the cause for global warming and that Earth has changed ever since it was created. It is an attitude you can have. But humans are not the cause for it, as he writes that sciences think that climate changes have been there all the time. It is fact because it is a cycle that has been there all the time before fossil fuel was found. We breathe out carbon dioxide – apple trees consumes it – carbon dioxide goes into the apples – animals eat the apples – we eat the animals – and then it starts over. You can also say that cows have made carbon dioxide emissions before we got our fossil fuels.***
Performance level: 1

**Figure 2: Arguments presented by group B (2 boys)**

Exercise 1: ***Around 1960 a rise begins in the emission of carbon dioxide in the atmosphere. This is shown in the upper figure. In the figure below the mean temperature begins to rise at the same time as carbon dioxide. The temperature of course lacks a little behind, as the earth has to be heated first. The reason for the bigger emission of carbon dioxide after 1900 is due to industrialisation. Factories and transportations come up and emit a lot of carbon dioxide.***
Performance level: 3

Exercise 2: ***When you look at figure 1 you see a general rise that does not fall or make strange curves. But on figure 2 you see a big decline in temperature after the year 1900. This is somewhat peculiar as the emission of carbon dioxide rises at that time. There are also other places later where carbon dioxide emission rises a lot.***
***One of the reasons for temperature not rising between 1950 and 1980 could be due to the Gulf Stream. Because when temperature raises on earth the ice melts on the North Pole and the South Pole. The cold ice water can run down the Gulf Stream and thereby dampening the temperature of the water and the weather.***
Performance level: 3

Exercise 1&2: ***You can draw a parallel between the two figures by seeing that they both increase at the same time. But there are also times where temperature does not rise while carbon dioxide emission still rise. Another reason for temperature not to rise but to keep neutral could be due to trees and plants. In the summer trees and plants have leaves or needles that can change carbon dioxide to oxygen. But some years the trees cannot burst into bloom or have a hard time doing so. This could have the temperature rise again.***
Performance level: 3

Exercise 3: ***The climate has changed through time but not as fast as it has done during the last 1000 years. It took millions of years before the ice was gone but within 1000 years we have already melted a part from the different poles. Since year 1900 factories have come up and temperature has risen a lot. This is due to that factories did not have any catalysts to diminish the carbon dioxide emission. In this way the atmosphere has become thicker so carbon dioxide does not leave the Earth that easy.***
***The reason for Perry not to trust scientists is because they spend a lot of money to fix the problem but nothing really happens that can help us. It is just a way of making money. A scientific fact that Perry uses is that temperature has gone up since the birth of the Earth and till now. But it is over a long period that temperature has gone up.***
***A counter argument to Perry's opinion that scientist manipulate data is that we ourselves can see and feel both temperature and carbon dioxide going up. Just look at China where people have to wear masks for not to breathe the bad and toxic air. Another counter argument is that it should not be a political issue. But it is a big political issue. If a country's people and the politicians do not know what is happening to the Earth you cannot change it. Cities like e.g. Berlin have laws that driving in the city is related to a carbon dioxide tax for the car***
***A model that shows that we people contribute to the amount of carbon dioxide is the carbon cycle. The carbon cycle works well with what it had. But when we started digging coal and oil up from the ground we emitted that much carbon dioxide that the cycle could not follow up.***
Performance level: 3

**Figure 3: Arguments presented by group C (2 boys)**

Exercise 1: ***Arguments for Student A being right:***

- ***The more carbon dioxide flying into the atmosphere the warmer it gets***

Performance level: 1

Exercise 2: ***Arguments for Student B (who thinks Student A is wrong):***

- ***Many times on the figures it possible shows – in detail – that there is no connection with normal temperature.***
- ***It falls over and over and rises independently of the carbon dioxide figure***
- ***The temperature figure rises at different times to the carbon dioxide figure***

Performance level: 2

Exercise 3: ***Arguments against Rick Perry***

- ***His opinion – His opinion is what he accuses the theories to be – pure rubbish. He has no clear answers to it – only more questions***
- ***His lack of examples – He accuses scientists of being corrupt and mad. But with no examples. He has no claim for his accusations***
- ***Change on Earth – Yes it is correct that Earth changes over time. But it has never changed this fast. His mentioned changes happened over millions of years while temperature in the last 1000 years (or since industrialization) never has gone up this fast.***
- ***Science – 98% of all scientists believe that global warming is caused by humans***
- ***American economy – He thinks that we play hazard with the American economy but we don't. We spend the money carefully on science and necessary equipment in reducing the carbon dioxide usage***

Performance level: 3

**Figure 4: Arguments presented by group D (2 boys)**

### (v) Use of assessment data

Students asked for and got oral feedback from the teacher during the task. This made them enhance their answers and go to new levels in the rubric assessment. Most students used the rubric by themselves after an explanation from the teacher.

Most students found that this was a different way to learn science. They wished that they had more content knowledge than that gained during the lesson. They were particularly interested in Activity B, with Rick Perry. They wanted knowledge to argue against him. They were enlightened by the task. Many searched the Internet for knowledge and they asked for explanations and more arguments because almost all meant that he was wrong.

Two students said just after the lesson that it was fun and they learned a lot. That they could see how they could use the techniques for argumentation in other courses as well. Two weeks later the same two students said – without encouragement – that it was a good and fun way to learn. It should be said that the two students handed in one of the best presentations.

### (vi) Advice for teachers implementing this unit

I would encourage other teachers to use it. Tell the students beforehand that this is about scientific argumentation and explain the concepts in the rubrics.

It was frustrating for the students that they lacked content knowledge in Activity B: Forming scientific arguments, but at the same time it provided motivation to search for more knowledge. Teachers could consider if students would benefit from having more content knowledge before doing the lesson, so that the students will be able to make better arguments.