4.2 Case study 2 (CS2 Slovakia)

Concept focus	The effects of microgravity
Activities implemented	Activities A-D
Inquiry skills	Planning investigations Developing hypotheses Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (choosing appropriate experiment for evaluation in microgravity, able to explain choice scientifically)
Assessment methods	Classroom dialogue Teacher observation Worksheets
Student group	**Grade:** 1st class in Gymnasium; upper second level **Age:** 15-16 years **Group composition:** mixed gender and mixed ability **Prior experience with inquiry:** Yes, previous IBSE experiences with interactive demonstrations/discussion, guided discovery

In this guided inquiry implementation, the teacher assessed skills in *planning investigations*, *developing hypotheses* and *scientific reasoning*. The teacher tried to use formative assessment as much as possible for evaluation of peer discussions, whole class discussions and creation of conclusions. In addition, the teacher prepared a three-level rubric for assessment of the skills. *Working collaboratively* was assessed through teacher observation of group discussions.

(i) How was the learning sequence adapted?

A physics teacher adapted the worksheet (Figure 1) for classroom activities with an introductory part related to introducing the topic "How does microgravity work?" After this, three activities from the original unit were implemented, and were renamed on the modified worksheet as follows:

- Activity A: Daily routine at home and in microgravity (Activity B: Lets explore... in unit)
- Activity B: My microgravity experiments (Activity C: Going further... in unit)
- Activity C: Conclusions and feedback (Activity D: Did you know... in unit)

Six groups were created, with one computer per group and the teacher used a data projector for the whole class. Each student had a printed version of worksheet; based on group discussion, remarks were written down. The teacher introduced each part of the activities and administrated classroom discussions between groups, with short discussion within each group if necessary.

The unit was implemented over a total of three lessons, two 45 minutes classes in one day were used to address activities A and B. After two days, 20 minutes of the next class was focused on conclusions and feedback (Activity C). Worksheets were collected after the classes, scanned and return to students for own portfolio.

(ii) Which skills were to be assessed?

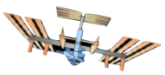
Inquiry skills developed in this case study – *developing hypotheses*, *planning investigations* and *scientific reasoning* – were assessed using a rubric (Table 1). Students discussed everyday routines, describing the influence of gravity on physical phenomena. The teacher identified particular skills to develop, based on her knowledge of the class:

- *Working collaboratively* – because the unit was implemented in 1st class of Gymnasium, students came from different lower second level schools and teamwork is not well developed.
- *Developing hypotheses* – this exercise was the students' first experience with formulating their own hypotheses related to a given problem.

- *Planning investigations* – focused on relevant steps in group's plans for their investigation (group management, steps in logical order).

Up there... how is it?

Student's document



Currently, astronauts from around the world are sent into space. Some astronauts remain in space for months on special spaceships called space stations. There have been some other stations, but currently is in service the International Space Station - ISS. It circles our orbit about 16 times per day at an altitude of 400 km.

ISS is an international collaboration involving the joint effort of 16 countries. This structure is the largest and most complex space vehicle ever built and due to its conditions of microgravity, it is a special environment to investigate the effects of a prolonged stay in space. The possibility of controlling the variable gravity creates unimaginable opportunities for research, making ISS a vital framework for developing and test new technologies, and to make decisions about the long range space exploration.

There are astronauts' teams - including many scientists - who alternately in periods of about five months, live, work, eat and sleep on the ISS. Their tasks are, for example, doing the maintenance of the station and conduct investigations. Given the environment of microgravity, astronauts incorporating ISS expeditions have to readjust all their daily routines such as eating, sleeping or going to the bathroom, to a new reality; this certainly poses many challenges.

Adapted from: http://www.nasa.gov/ retrieved on 20th July 2013

Interactive lecture discussion *How microgravity works?*

Peer Discussion

1. Pick one of your daily routines and imagine accomplishing it on board of the ISS. Discuss in groups the following thoughts:
   a. What would be different?
   b. Why?
   c. How could you perform this routine?

2. Share and debate your thoughts with the rest of the class.

Activity A

Let's explore...

... the ISS along with the commander of Expedition 33, Suni Williams
Watch this video: ttp://www.nasa.gov/mission_pages/station/main/suni_iss_tour.html

3. What have you observed in ISS that matches with your initial idea? Explain.

4. What surprised you most during the visit to the ISS?

5. Share and debate your thoughts with the rest of the class.

6. Write a question you would like to ask to the commander Suni Williams about his experience on board of the ISS.

Activity B

Going further...
As read in the text, one of the tasks of the astronauts on board the ISS is conducting investigations in microgravity.

6. Formulate a question you would like to investigate in a microgravity environment.

7. Clearly formulate hypotheses related to your question.

8. Present arguments that support your hypothesis, based on correct and relevant scientific knowledge.

9. Plan an investigation that allows you to analyze your hypotheses.

10. Describe in detail all the steps, including the variables you want to study, variables you have to control and all the equipment and materials necessary to its realization.

11. Discuss with your teacher your investigation plan and if necessary reformulate it.

12. Present your planning to the class.

13. With the help of your English teacher translate your investigation plan so it may be submitted to the ISS/NASA.

Did you know...

...that during his stay on board the ISS, Commander Chris Hadfield made the first music recording at space. Let's hear it... http://www.youtube.com/watch?v=KaOC9danxNo

Activity C

Reflect on...
What you have learned developing this activity.

What would you change if you could perform this activity again?

Difficulties you experienced.

What you found to be the most interesting.

Referring to your workgroup:
Did you listen to each other's ideas?

Were all group members involved in performing the task?

What worked? And what didn't work?

What do you have to change?

Figure 1: Worksheets for CS2

The inquiry skills were assessed through teacher observation within group work. For each activity, scanned worksheets were analysed using the three-level criteria defined in the rubrics (very low, acceptable, excellent). During the inquiry activities, the teacher observed group work and provided a small amount of support (additional questions, short explanation of physics background if necessary).

(iii) Criteria for judging assessment data

The teacher tried to use formative assessment as much as possible for evaluation of the inquiry skills developed in this inquiry activity. In particular, formative assessment was used for evaluation of peer discussion, whole class discussion and creation of conclusions.

To assess *scientific reasoning*, the teacher evaluated students' choice of experiment to evaluate in a microgravity environment. For example, how many different daily routines are described? How well can students apply previous knowledge into their explanations? Is their description of the background physics correct? To assess student skill in *developing hypotheses*, the teacher considered how concrete and correct the proposed hypothesis was. For evaluation of *planning investigations*, steps should be well defined and in a logical order. It should be possible to evaluate the proposed hypothesis using the selected steps. The teacher prepared a three-level rubric for assessment of the skills, as shown in Table 1.

Table 1: Rubric for assessment of inquiry skills

Assessment criteria	Performance level		
	1	2	3
Routines are described in detail, with influence of gravitational force	Routines without gravitational influence, wrong one.	Only title with very short description.	Well described with ideas about microgravity influence.
Originality of routines with comparison to others	Frequently appeared (more than 5 times within classroom)	Only 2-3 times within classroom	Original one
Developing hypotheses	Nothing mentioned as hypothesis or completely wrong statement	Sentence is not formulated as statement	Well formulated statement
Planning investigations	No planning	Steps are not in order, or something important is missing	Planning is mostly correct or correct

Working collaboratively (peer discussion) was assessed using the following criteria:

- Was each group member active?
- Were questions relevant to the topic?
- In case of questions, who answered questions? Were questions in series (one following from previous one) or they are independent (different points of view)?
- Was the group discussion focused or diverse?

(iv) Evidence collected

Teacher opinion

Students enjoyed the activities a lot. Space science is very attractive; also videos from that environment shows reality and all daily routines are well shown there. We added an interactive discussion about the origin of microgravity as the starting point for implementation of the unit, asking the question "How we can install a space craft in orbit? Vertical throw is not possible; a horizontal one is needed with circular speed. Therefore, the space craft is in permanent free fall…" Also we recommend prescribing preparatory homework for before students' activities begin, such as asking students to "Describe different processes that are influenced by gravity." This preparatory activity could be summarised by teacher as starting point for the implementation.

For our students, it was a problem to formulate a hypothesis as a statement. They are not used to formulating a hypothesis in cases where they do not have a lot of knowledge about the problem. Discussion between students and teacher about the importance of activity steps were used for formative assessment. This focussed on the skill of *developing hypotheses*; many times students created questions, but were unsure of which statement was correct.

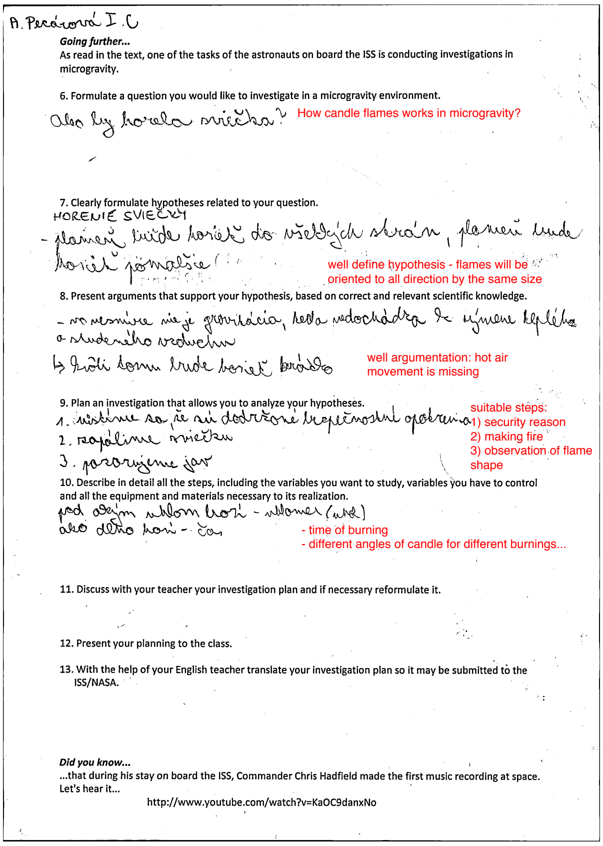
A rubric was created for internal evaluation of the level of the selected skills (Table 1). To evaluate *scientific reasoning*, the teacher observed and evaluated the peer discussion: ***"Pick one of your daily routines and imagine accomplishing it on board of the ISS."*** The teacher can also use it when analysing the scanned worksheets.

Observer notes

Inquiry was a new approach for the students. They discussed a lot with peers and also with their teacher.

Sample student artefacts

Scanned worksheets from one class were collected for the case study. Figure 2 shows a selected page with teacher comments.


A. Pecárová I.C

Going further...

As read in the text, one of the tasks of the astronauts on board the ISS is conducting investigations in microgravity.

6. Formulate a question you would like to investigate in a microgravity environment.

Ako by horela sviečka? How candle flames works in microgravity?

7. Clearly formulate hypotheses related to your question.

HORENIE SVIEČKY

- plameň bude horieť do všetkých strán, plameň bude horieť pomalšie

well define hypothesis - flames will be oriented to all direction by the same size

8. Present arguments that support your hypothesis, based on correct and relevant scientific knowledge.

- vo vesmíre nie je gravitácia, teda nedochádza k výmene teplého a studeného vzduchu

k vôli tomu bude horieť krátko

well argumentation: hot air movement is missing

9. Plan an investigation that allows you to analyze your hypotheses.

1. uistíme sa, že sú dodržané bezpečnostné opatrenia
2. zapálime sviečku
3. pozorujeme jav

suitable steps:
1) security reason
2) making fire
3) observation of flame shape

10. Describe in detail all the steps, including the variables you want to study, variables you have to control and all the equipment and materials necessary to its realization.

pod akým uhlom horí - uhlomer (uhol)
ako dlho horí - čas

- time of burning
- different angles of candle for different burnings...

11. Discuss with your teacher your investigation plan and if necessary reformulate it.

12. Present your planning to the class.

13. With the help of your English teacher translate your investigation plan so it may be submitted to the ISS/NASA.

Did you know...

...that during his stay on board the ISS, Commander Chris Hadfield made the first music recording at space. Let's hear it...

http://www.youtube.com/watch?v=KaOC9danxNo

Figure 2: Example of student work, with teacher comments

(v) Use of assessment data

As this was the first inquiry activity undertaken by these students, the teacher intends to focus on *developing hypotheses* in the next activity and compare level of statements to those in this activity. Future inquiry activities will also seek to provide training in *planning investigations*.

(vi) Advice for teachers implementing the activities

Take care about the timing of activities steps. Make a time schedule beforehand.