INQUIRY AND ASSESSMENT UNIT

UP THERE... HOW IS IT?

How to live on the International Space Station?

Vanessa de Andrade, Mónica Baptista, Cláudia Faria, Cláudia Gonçalves, Cecília Galvão

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HOW TO LIVE ON THE INTERNATIONAL SPACE STATION?

Overview

KEY CONTENT/CONCEPTS

- Gravity
- The study of gravity in the International Space Station
- Effect of microgravity on everyday activities
- Impact of scientific and technological development in society

LEVEL

- Lower second level
- Upper second level

INQUIRY SKILLS ASSESSED

- Planning investigations
- Developing hypotheses
- Forming coherent arguments
- Working collaboratively

ASSESSMENT OF SCIENTIFIC REASONING AND SCIENTIFIC LITERACY

- Scientific reasoning (choosing appropriate experiment for evaluation; argumentation)

ASSESSMENT METHODS

- Classroom dialogue
- Teacher observation
- Worksheets
- Student devised materials (investigation report)

Classroom materials for this Inquiry and Assessment Unit are available at WWW.SAILS-PROJECT.EU

1. INQUIRY AND ASSESSMENT UNIT OUTLINE – UP THERE... HOW IS IT?

The **Up There... how is it?** SAILS inquiry and assessment unit aids students to learn about the concept of gravity and offers an opportunity to learn about the International Space Station (ISS); understanding its impact on the scientific, technological development and society. In this unit, students are encouraged to develop interest and curiosity about space exploration. While recommended for upper level physics students, the activities could be explored with different disciplinary areas, namely chemistry, biology and geology, or adapted for implementation at lower second level.

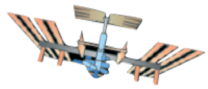
The four activities serve to consolidate prior knowledge, before introducing the concept of microgravity and how it might impact on everyday activities. Students plan an experiment that can be conducted in a microgravity environment and end the lesson with a reflection on what has been learned and achieved. These activities can be carried out in a sequence of lessons, which would require about three lesson periods (ideally one 45 min and one 90 min lesson). Through this activity series, students are provided the opportunity to develop inquiry skills such as *planning Investigations, developing hypotheses* and *working collaboratively*, as well as progressing their *scientific literacy* and *scientific reasoning* capabilities. Possible assessment opportunities include student observation, group discussion or presentation and evaluation of student artefacts.

This unit was trialled by teachers in Portugal, Slovakia and Sweden, with students aged 13-16 years (8 classes in total, mixed ability and gender). The teaching approach in all case studies was that of an open/guided inquiry. Inquiry skills assessed were *planning investigations* (Portugal), *scientific reasoning* (observation skills, Slovakia) and *forming coherent arguments* (Sweden).

2. IMPLEMENTING THE INQUIRY AND ASSESSMENT UNIT

2.1 Activities for inquiry teaching & learning and their rationale

The unit **Up there... how is it?** was set up under the 1st SAILS Portuguese workshop for teachers: "Why is there so much talk about INQUIRY across Europe? A proposal to work with the science curriculum in the classroom" (May 2013). It was proposed by Vanessa de Andrade and adapted to the SAILS inquiry and assessment unit structure. The unit develops in four parts (activities A-D); Activity A is a preliminary activity to aid the students' learning about the concept of gravity, while Activity B introduces the activities of the ISS. Activity C allows the students to understand the impact of the ISS in scientific, technological and societal development, and apply their prior learning in a new situation. In the final activity, each student reflects on what he has learned in carrying out the activities, seeking to develop interest and curiosity about space exploration.



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 the International Space Station, ISS, is in service. It circles our orbit about 16 times per day at an altitude of 400 km.

The 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 the ISS a vital framework for developing and testing new technologies, and for making decisions about 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 conducting 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.

Figure 1: Student document. Adapted from: http://www.nasa.gov/ retrieved on 20th July 2013

Activity A: Up there... how is it?

Concept focus	Gravity
Inquiry skill focus	Working collaboratively
Scientific reasoning and literacy	Scientific literacy (understand how microgravity impacts everyday activities)
Assessment methods	Classroom dialogue Worksheets

Rationale

In this activity, students are invited to read about the International Space Station (ISS). After this, they are urged to imagine what it would be like to carry out some of their routine activities in a microgravity environment and to discuss their individual ideas with the class. This activity is intended to assess students' prior knowledge on the concept of gravity.

Suggested lesson sequence

1. Students are invited to read about the ISS (student document, Figure 1).
2. The teacher poses questions to encourage the students to consider how microgravity conditions would affect their daily routine.
3. Students first discuss their ideas in small groups, then participate in a class discussion of their ideas. They are assigned the following tasks:
    a. Pick one of your daily routines and imagine accomplishing it on board of the ISS. Discuss in groups the following thoughts: What would be different? Why? How could you perform this routine?
    b. Share and debate your thoughts with the rest of the class.

Activity B: Lets explore...

Concept focus	Gravity Everyday life on the ISS
Inquiry skill focus	Working collaboratively
Scientific reasoning and literacy	Scientific literacy (understand how microgravity impacts everyday activities)
Assessment methods	Classroom dialogue Worksheets

Rationale

In this activity, students watch a video about everyday life on the ISS. This seeks to aid the students to articulate prior knowledge with new information. Finally, the teacher presents a summary of new concepts and ideas, to ensure that new knowledge is not misinterpreted.

Suggested Lesson Sequence

Let's explore... the ISS along with the commander of Expedition 33, Suni Williams.

1. The students watch a video about everyday life on the ISS. http://www.nasa.gov/mission_pages/station/main/suni_iss_tour.html [accessed October 2015]
2. The teacher offers prompt questions, asking the students to consider how their previous ideas (activity A) match with observations in the video
   a. What have you observed in the ISS that matches with your initial idea? Explain.
   b. What surprised you most during the visit to the ISS?
3. Students share and debate their thoughts with the rest of the class
4. The teacher summarises the key concepts and ideas at the end of the discussion
5. Students are asked to write a question they would like to ask Commander Suni Williams about his experience on board of the ISS.

Activity C: Going further...

Concept focus	Gravity Working in a microgravity environment
Inquiry skill focus	Developing hypotheses Planning investigations Working collaboratively
Scientific reasoning and literacy	Scientific literacy (understand how microgravity impacts everyday activities)
Assessment methods	Classroom dialogue Worksheets Student devised materials

Rationale

In this activity students apply the learned concepts to a new situation. They are asked to formulate a question they would like to investigate in a microgravity environment. They must raise a hypothesis and plan an investigation in order to answer their research question. The main goal is not to actually develop the activities on the research plan built by the students (since that would not be possible) but to raise a rich discussion on the conclusions one might reach.

Suggested Lesson Sequence

Going further... conducting an experiment in microgravity.

1. The teacher reminds the students that, as read in the text, one of the tasks of the astronauts on board the ISS is conducting investigations in microgravity.
2. Students are asked to "formulate a question you would like to investigate in a microgravity environment," in which they should:
   a. Clearly formulate hypotheses related to your question.
   b. Present arguments that support your hypothesis, based on correct and relevant scientific knowledge.
   c. Plan an investigation that allows you to analyse your hypotheses.
   d. 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 realisation.
3. Discuss with your teacher your investigation plan and if necessary reformulate it.
4. Present your planning to the class.
5. With the help of your English teacher translate your investigation plan so it may be submitted to the ISS/NASA.

Activity D: Did you know...

Concept focus	Gravity Working in a microgravity environment
Inquiry skill focus	Developing hypotheses Planning investigations Working collaboratively
Scientific reasoning and literacy	Scientific literacy (understand how microgravity impacts everyday activities)
Assessment methods	Classroom dialogue Worksheets

Rationale

In the final activity, students reflect on what they have learned through carrying out the activity.

Suggested Lesson Sequence

Did you know...that during his stay on board the ISS, Commander Chris Hadfield made the first music recording in space? Let's hear it... http://www.youtube.com/watch?v=KaOC9danxNo [accessed October 2015]

1. The teacher asks the students some questions, to help them to reflect on what they have learned
   a. What have you learned while developing this activity?
   b. What would you change if you could perform this activity again?
   c. Difficulties you experienced.
   d. What you found to be the most interesting.
2. Students are asked to reflect on their *working collaboratively* skills through a series of questions
   a. Did you listen to each other's ideas?
   b. Were all group members involved in performing the task?
   c. What worked? And what did not work?
   d. What do you have to change?

2.2 Assessment of activities for inquiry teaching & learning

Within the suggested learning and assessment sequence specific inquiry skills are emphasised for development and assessment. Note, however, that throughout the activities students will have opportunities to practice a range of inquiry skills not identified in the description. It is the teachers' choice to select what inquiry skills they want to address depending on the level of their students. Similarly the teachers can choose whether or not to complete all of the activities described or to select a specific one based on the context of their students and time demands of their curriculum.

This unit provides an excellent opportunity for formative assessment that can be focused on the group written work, the research plan, the communication to the class, collaborative attitudes and students' individual reflections. Table 1 provides an assessment instrument, which details some assessment criteria for several inquiry skills. A teacher guide was devised in cooperation with Portuguese teachers to enable them to follow the same structure for the assessment, where two inquiry skills were selected for assessment (*planning investigations* and *working collaboratively*).

Table 1: Assessment of reasoning skills. Adapted from: Galvão, C., Reis, P., Freire, A. M., & Oliveira, T. (2006). Avaliação de competências em ciências. Porto: Edições ASA.

Criteria/Performance levels	Rating
Formulate questions	
Formulates clear and creative questions, related to the topic under study	4
Formulates uncreative questions, but clear and related to the topic under study	3
Formulates questions, but with little purpose or relevance to the topic under study	2
Doesn't formulate questions	1
Formulate hypotheses	
Formulates relevant hypotheses, well-grounded in scientific knowledge	4
Formulates relevant hypotheses, but with some flaws in scientific knowledge	3
Formulates weak hypotheses, with little grounding in scientific knowledge	2
Doesn't formulate hypotheses	1
Planning an Investigation	
Research plan designed is clear, concise and complete	4
Effective research plan but lacks description of some materials or procedures	3
Effective research plan but needs reformulation. It doesn't consider variables or important limitations	2
Ineffective research plan. Needs major help or it doesn't present any research plan	1
Present and explain ideas	
Presents and explains ideas with scientific accuracy and carries out a well-grounded debate	4
Participates in the presentation, explains and discusses ideas, but with some scientific in accuracies	3
Participates in the presentation, but with great difficulty on explaining ideas and with little discussion. Discourse presents scientific inaccuracies	2
Doesn't participate in oral presentation	1
Overcoming difficulties	
Shows capacity to overcome difficulties individually	4
Shows capacity to overcome difficulties but sometimes needs help	3
Seeking to overcome difficulties individually, but needs help	2
Does not try or does not show capacity to overcome difficulties. In great need of help	1

Teacher guide for the construction and application of an instrument for formative assessment

1. Before class
   a. Build an assessment instrument considering that the main focus will be on *planning investigations* and *working collaboratively* (communication skills);
   b. Adapt the task to students and to the context.

2. In class
   a. At the beginning of the process clarify the assessment criteria (in particular those relating to *planning investigations* and *working collaboratively*).
   b. At the end of the process, apply a semantic differential to students for identification of their perceptions related to the assessment process.

3. After class
   a. Assess student artefacts, having regard to the developed instrument and produce written feedback;
   b. Reflect on the assessment process.

Note: Evidence collected can include student artefacts, classroom video recording (optional) or other evidence.

2.3 Further developments/extensions

During Activity C, students will apply the learned concepts into a new situation. They will be asked to think about and therefore formulate a question they would like to investigate in a microgravity environment. They must raise a hypothesis, and plan an investigation in order to answer their research question. The main goal isn't to actually develop the activities on the research plan built by the students (since that would not be possible) but to raise a rich discussion on the conclusions one might reach. The best research plans can be submitted to NASA (this institution receives and selects activities submitted by schools, performing the best ones on board of the ISS).

3. SYNTHESIS OF CASE STUDIES

This unit was trialled in three countries, producing three case studies of its implementation – **CS1 Portugal**, **CS2 Slovakia** and **CS3 Sweden**. In all three case studies, the teachers and students had previous experience with inquiry but not all of them have prior knowledge about microgravity (**CS3 Sweden**).

The ages of the students involved in the case studies were 15-16 years old in **CS1 Portugal** and **CS2 Slovakia**, and 13/15 years old in **CS3 Sweden**. The students in each class were mixed ability and mixed gender. In **CS1 Portugal**, the unit was implemented in two 11th grade classes (32 students in total), where each class worked in groups of 3-4 members, over two 45-minute classes plus a double lesson period of 90 minutes. **CS2 Slovakia** was implemented with upper second level students (1st class of Gymnasium), consisting of 30 students working in six groups, over three 45-minute lesson periods. **CS3 Sweden** comprises five classes: four grade 7 classes and one grade 8 class. The schools were primary preschool to grade 9 schools and one grade 6-9 school. The students worked in groups of 3-4 students.

In the case studies, the teachers identified different skills for assessment. The teacher in **CS1 Portugal** focused on *planning investigations* and in **CS3 Sweden** on *forming coherent arguments*, which were assessed through evaluation of students' written reports. In **CS2 Slovakia**, the teacher assessed several inquiry skills – *planning investigations*, *developing hypotheses* and *scientific reasoning* capabilities – using formative assessment and a three-level rubric. In addition, students' skill in *working collaboratively* was assessed through teacher observation.

3.1 Teaching approach

Inquiry approach used
In all cases unit was implemented as an *open/guided inquiry*, as anticipated in the unit description. It was guided in the sense that the teacher posed the initial question but there were open inquiry opportunities in that students had freedom in addressing the question.

Implementation
This unit has four activities, each of which addresses the concept of gravity and life on the ISS to form the basis of the inquiry. The activities focus on ensuring students understand the concept of gravity (activities A & B), allowing them to devise an experiment to be carried out on the ISS (in a microgravity environment, Activity C) and reflecting on new knowledge and skills (Activity D). The three case studies utilised text (Activity A) and video (Activity B) to focus the students on the topic of gravity and space. The students in all the case studies worked in groups throughout the lessons (see Table 2).

CS1 Portugal and **CS2 Slovakia** implemented the unit in full, as detailed in the suggested lesson sequence for activities A-D. In Slovakia, a physics teacher adopted the worksheet for the classroom activities with an introductory part related to: How does microgravity work? What is the origin of microgravity? In **CS3 Sweden** activity C was not implemented and the students did not plan experiments. Instead their investigations focused on carrying out daily routines in a microgravity environment. In all case studies, students worked collaboratively and discussed their ideas in groups and with the class.

3.2 Assessment strategies

While the case studies highlighted the development of several inquiry skills, the assessment was only described for a few of these skills (Table 3). For some skills, the assessment was carried out after class and was based on a written artefact produced in class. In other situations, formative assessment guided the student learning during the class.

Table 3: Inquiry skills identified by teachers in the case studies

CS1 Portugal	• Planning investigations
CS2 Slovakia	• Developing hypotheses • Planning investigations • Working collaboratively (peer discussion) • Scientific reasoning (choosing appropriate experiment)
CS3 Sweden	• Forming coherent arguments • Scientific reasoning (argumentation)

Table 2: Summary of case studies

Case Study	Activities implemented	Duration	Group composition
CS1 Portugal	Activities A-D	Three lessons (2x45 min & 1x90 min)	• Two classes; groups of 3-4 students
CS2 Slovakia	Activities B-D	Three lessons (45 min each)	• 6 groups of 5 students (30 students)
CS3 Sweden	Activities A-B Activity D	One lesson (60-80 min)	• Five classes; groups of 3-4 students

The element of inquiry that was assessed in **CS1 Portugal** was *planning investigations*. In order to assess this skill, the teacher designed an assessment tool formed by three levels of performance (Table 4). Students' written evidence was examined and assigned a mark of 1, 2 or 3 using the rubric as a guide. The assessment instrument was built before the task implementation in the classroom. After the task completion, students' work was collected and assessed according to the instrument. This instrument allowed the teacher to assess the students' performance regarding in *planning investigations*, particularly in defining a research problem and its objectives; identification of variables to measure and control; construction of a proper procedure with the data to be collected, clear and reproducible and predicting possible limitations to the proposed procedure. The use of this instrument, organised by criteria and performance levels, allowed decreasing the subjectivity of qualitative assessment, such as to assess skills and to enable the teacher to collect information from students' work and facilitating the oral feedback that was carried out after the completion of the task.

Table 4: Rubric for the assessment of the inquiry skill planning investigations in CS1 Portugal

Assessment criteria	Performance level		
	1	2	3
Do students define the goals of the experience clearly and in accordance with their initial research question?	Goals of the experience are not clear or aligned with the initial research question.	Goals of the experience are aligned with the initial research question, but are not clear enough.	Goals of the experience are clear and aligned with the initial research question.
Do students identify variables that should be measured and controlled?	Independent or dependent variables are not identified at all, when applicable.	One or more of the independent or dependent variables are not identified or are irrelevant for the research.	Identifies control, independent, and dependent variables that are relevant for the research, when applicable.
Is the proposed process adequate for collecting relevant data, written in a clear language and easy to reproduce?	Proposed process is not adequate; students do not know which data to collect or they do not know how to proceed in order to collect data. They develop a process for collecting irrelevant data.	Proposed process is adequate, but it still requires reformulation, as students know which data to collect but they do not know how to proceed in order to collect the data.	Proposed process is adequate; students know which data to collect and they know how to proceed in order to collect the data.
	It is difficult to understand the experimental plan. It will be difficult to reproduce it.	The experimental plan is clearly written. Nevertheless, it lacks some detail and so it will be difficult to reproduce it.	The experimental plan is clearly written and it presents enough details for being reproduced later on.
Do students foresee possible limitations of their experimental plan?	Students only consider some possible limitations of their plan or students point out incorrect limitations	Students consider possible limitations of their experimental plan.	Students consider possible limitations of their experimental plan and they reveal understanding of those limitations.

In **CS2 Slovakia**, *scientific reasoning, developing hypotheses* and *planning investigations* were assessed. Students discussed everyday routines, from a physical phenomenon perspective, describing the influence of gravity on these activities. During the inquiry activity the teacher observed group work and provided some support to the students (asking additional questions, outlining short explanations of physics background). The teacher developed a 3-level rubric (Table 5, 1: very low, 2: acceptable, 3: excellent), which was used for evaluation of the student artefacts. The teacher tried to use formative assessment as much as possible, especially during peer discussion, whole class discussion and creating of conclusions.

Table 5: Rubric for the assessment of inquiry skills in CS2 Slovakia

Assessment criteria	Performance level		
	1	2	3
Routines are described in detail, with influence of gravitational force	Routines without gravitational influence, or incorrect routines.	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
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

In **CS3 Sweden**, the unit was implemented in order to assess students' skills in *forming coherent arguments* and *scientific reasoning* (argumentation). To assess students' skills, the teachers listened to the group discussions and collected students' written ideas. The teachers made attempts to assess how students argued for changing their initial ideas, after watching the video. The main success criterion was whether the students could form coherent arguments. Students were given group feedback during the activity. The unit was implemented as a stand-alone activity, and as a result the teachers did not provide summative assessment or use the data for their own planning or evaluations.