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Integration Week-end (WEI):

In the International Space Station Or in Dordogne?

A problem-based learning (PBL) intended for students of the NDT module of the AP5MO UE of 1st year of ENSPIMA

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The students

Participants are first year ENSPIMA engineering school students (Evering site) who have taken courses (lectures/Exercises/Practicals) on NDT that address NDT techniques independently.

The intended learning outcomes

- establish a control process adapted to a given problem (ILO1 at the end of the return session)
  - analyse the problem and extract important data for the choice of techniques (LO1a)
  - choose one or several adapted techniques and justify the choices (LO1b)
  - state the limitations of the different techniques chosen (LO1c)
  - describe the expected results (LO1d)

Major challenges of this PBL

- Convince people that not all techniques are suitable for all situations and that they do not lead to the same information on defects;
- Encourage an analysis phase to extract important information for the choice of techniques;
- Encourage that the choice is not only based on qualitative elements (preliminary calculations);
- Encourage the combination of several techniques to have the most information possible on the defect.

Global recommendations
R1: Avoid having students focus on only one technique. R2: Be careful that they do not get lost in the story (departure for the station) and the objectives of the study.

You may avoid diversions and manage time using the following questions.	**You can redirect students with the following questions.**
• Can we return to a more methodical approach? • Who can summarise what we've learnt so far? • Can we go back to our discussion plan? • Since we're making little progress, can we write down a study question? • Could we look for other hypotheses now?	• What's the main problem? • are there any inconsistencies? What are they? • What's expected from your group? • Are you sure this is what is expected from you? • What relevant information did you find in the situation?

Each phase of this PBL sequence will last 1h20min

The Mission

A problem of cracks was detected in the International Space Station in July 2021: https://www.independent.co.uk/space/iss-cracks-space-station-international-b1911557.html[1]

Thamos Pesteque, a frequent visitor to Evering as part of his zero G flights, believes that Evering students, excellent in NDT thanks in part to their outstanding professors, could be of great assistance in determining the severity of the cracks and searching for other possible defects in the surrounding metal and composite parts. Your mission, if you accept it, is to present a precise test procedure to Thamos Pesteque that could be implemented with the NDT* equipment available at Evering.
In exchange for this first mission, if the proposed procedure seems useful to him, he will send you the suspicious parts to screen them at Evering (this will be the subject of PBL2). In exchange for this valuable service you provide (and also because it suits him), he will suggest that you bring back the parts yourself and spend a weekend at the ISS (much better than a WEI in Dordogne!!).
NB : Thamos Pesteque, an NDT expert (yes we can't have everything), will be available for a short time during the first session of the PBL1 to answer your questions.

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* NDT : NonDestructive Testing

[1] Link verified on the 07/11/2021

What main questions the students should emerge during the first phase

What are the important elements of the text? What information is missing about the parts to be tested?
=> When given a text, where do you start? What is given? What is asked? What is missing? What information is important? How do you pick it up (highlighting)?
What NDT techniques are available?
Which ones are not suitable?
=> Can all techniques be used?
What are the limitations and expected results of each method?
=> Does the technique address the whole problem?
What is the performance of each technique?
=> What can we know about the possible defect with each technique?
What is the deliverable and what level of detail is expected?
=> Are we stopping at the qualitative?
What are the objectives?
=> What information should the NDT techniques provide?
What procedure should be put in place to achieve the objectives?
=> What do you do to select / compare the results? Is there an order in the use of the techniques?
Do you know what to do during the individual work?

What elements of response are expected from students

- Dye penetrant testing only for open defects.
- Magnetic particle testing only for ferromagnetic materials and defects very close to the surface (2mm)
- Eddy current only for electrically conductive materials. Defects must be within the skin thickness (to be calculated for the material). Conductivity of the composite? The precise characterization of the defect is only possible if the standard block is used beforehand.
- US contact in reflection. It is necessary to make the calculation to be able to separate the echoes. It is necessary to know the frequency of the sensors. It is necessary to make the presettings of the device t0, V. Depending on the location and orientation of the defects it is sometimes necessary to use a wedge and transverse waves and therefore make the appropriate settings. We do not know the nature of the defect but well located.
- US in immersion in reflection. It is necessary to make the calculation to be able to separate the echoes. It is necessary to know the frequency of the sensors. It is necessary to know how to adjust the gates to make the measurements. We do not know the nature of the defect but it is well located.
- US in immersion in transmission. No precalculation. It is necessary to know how to prepare the measurement (gate, gain). We do not know the nature of the defects and we do not know their location in the thickness. On the other hand we can not miss a defect.
- Infrared thermography: not suitable for metals with the camera available. Settings to try according to the types of defects and locations in the thickness. We can know the nature of the defects once detected.

Resources to give to students

- *Documents on MOODLE Pages : NDT Courses, Exercises and correction, Test of the practicals*
- *Article2: https://www.independent.co.uk/space/iss-cracks-space-station-international-b1911557.html*
- *Other ressources : On the second reflection phase of the "GO" session, specific items on the parts to be inspected will be available to the students (short mock call with Thamos Pesteque).*

[2] Link verified on the 7th November 2021

Group n°…..

Organisation of this sequence

First phase: exploring the problem		
Students' steps	Tutor's aims and possible questions	Tutor's comments
Organise group (5min)		
Discover and rephrase the problem (20min)	**Make sure the problem is understood** In this first step, the tutor must ensure that the relevant terms are understood and identified by the students as part of a potential learning goal. The tutor encourages the students to clarify items if necessary. • *How do you define the key terms?* • *What elements need to be clarified?* The tutor can help the students to express their representations and their hypotheses to obtain an explanation of the problem in their own words. The tutor needs to prevent the group from further analysis before overall agreement to the problem reformulation is reached. • *Can you rephrase your statement?* • *What are the main components of the situation?* • *What do you think of the opinion expressed by your colleague?* • *Why do you think that?*	
Design pathways (30min)	**Help to extract questions from the problem** The tutor helps students to structure their thinking around the key concepts to explain the problem, and actively pushes them to make links and ask questions. The tutor can ask questions if necessary. • *How do you explain this situation?* • *How could we represent the situation using a diagram or a network of concepts?* • *Does one problem lead to other problems?* • *What would be the possible causes, hypotheses, solutions, or diagnoses?* • *What questions should we try to answer?* • *Can we think of any other underlying mechanisms?* • *Does this impact other mechanisms?* • *What is the list of items to be discussed, their priorities?* • *Have we forgotten anything?*	
Define the knowledge needed (10min)	**Help to draw out knowledge** The tutor helps the students to Identify the relevant knowledge they already have to solve the problem and what they need to acquire. • *What do you already know?*	

	• *What factors allow us to retain or reject this hypothesis?* • *What do you feel needs to be mastered?*What elements lead us to keep or reject this hypothesis? • What do you feel essential to master?	
Define a working plan (15min)	**Ask for the working plan** The tutor also asks for the different tasks done by each student. The tutor needs to check that the planned data collection is done in accordance with the students' initial questions. At this point, the tutor may compare the intended learning outcomes defined by the teacher with those of the students. • *What resources do you plan to consult?* • *How do you plan to divide your work time between the different objectives?*	
	Provide the materials and resources, if applicable, and final recommendations The tutor then provides the materials and resources the teacher prepared ahead of the problem. The teacher may also let the students find the relevant resources or provide a supervised "guided search" strategy. The tutor may suggest that the students produce a mind map, incorporating all the notions they are about to learn, which will serve as a synthesis of their theoretical learning.	

Final phase: feedback and assessment		
Steps	**Tutor's aims**	**Tutor's comments**
Determine the role of each partner (5min)		
Share everyone's production and prepare the deliverable (50min)	**Make sure the group pools and shares ideas and information** The tutor ensures that students do not complete the problem without identifying their inaccurate, incomplete, or false conceptions, leading to a definition of future intended learning outcomes. The tutor encourages students to identify other situations where the new knowledge acquired may be useful. • *What are the important points to take away from our discussion?* • *Can we find links between the different hypotheses put forward?* • *Did you achieve the objectives?* • *Are the concepts clear?* • *What are the diagnoses, solutions, or actions to be retained?* • *In what other contexts might these new insights be applicable?*	
Assess (25min)	**Review the group's performance**	

	The tutor helps students to analyse their group dynamics, interactions, and the work atmosphere in order to identify areas for improvement in the way the group functions. • *How did the group interact?* • *Did the group work together effectively?* • *Was everyone able to express themselves?* • *Was the time allocated for each step sufficient?* **Review individual performance** The tutor helps students to reflect on the process, to become aware of their attitudes, values, problem-solving strategies, and what they have learned (skills, knowledge…).	

Assessment

Questions to ask to ensure that the intended learning outcomes are achieved

- What are the important elements in choosing a method or combination of methods?
- What information about defects can each method provide or not provide?
- Which methods require preliminary calculations before writing the procedure and carrying out the experiments? What are these calculations?

Student will assess individually the group work: on a scale from 1 to 5:

Assessment	Totally no	no	yes	Totally yes
About the group's outputs				
Did the group follow each step of the PBL sequence?				
Did the group achieve the intended learning outcomes?				
Did the group produce what was asked?				
About the group's organisation				
Did the group atmosphere and interactions facilitate efficiency?				
Was everyone able to express themselves?				
Could the group's work be improved?				
Did everyone stick to their role during the different phases?				
Self-assessment				
How qualitative and efficient were my interactions with the group?				
How qualitative and efficient was my production?				
About the complex problem				
Was the topic interesting?				
About the relationship with the tutor				
Did the tutor guide the group effectively by asking the right questions to refocus when needed?				