Problem-based learning
Pedagogical guidelines

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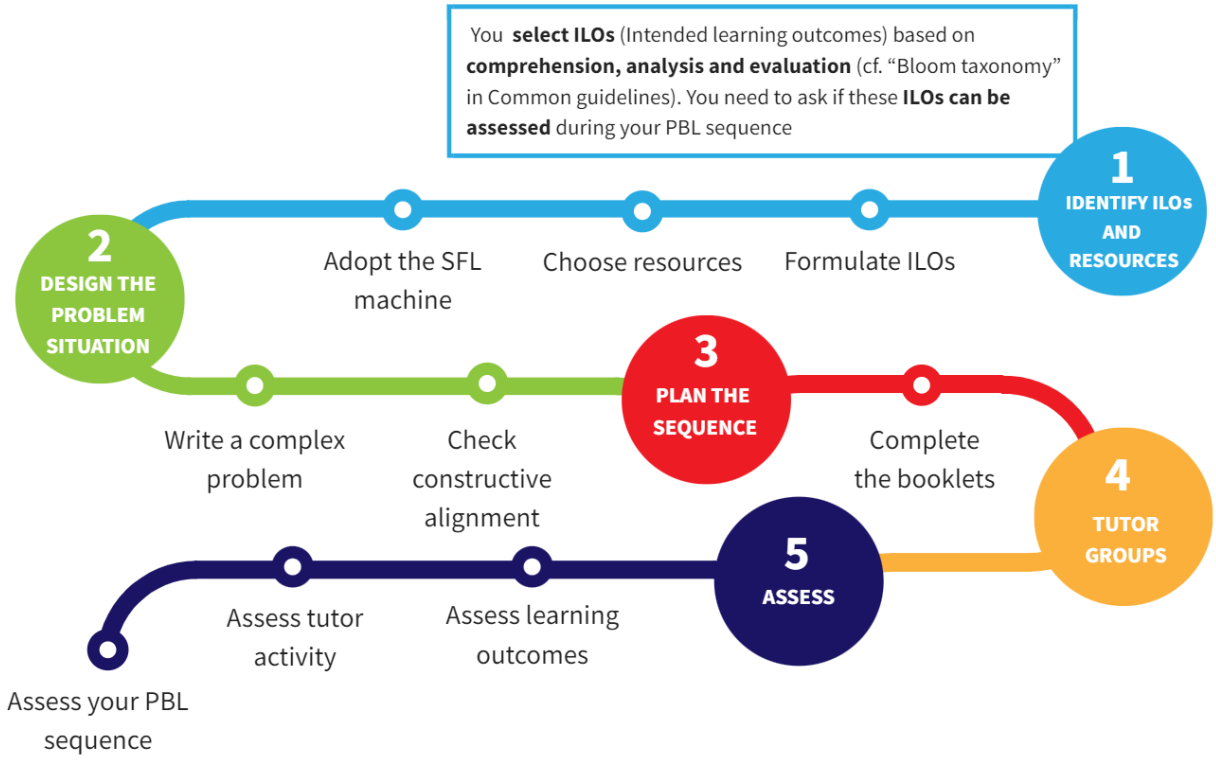
Introduction

REMINDER: A PBL sequence has three phases

1. **In group, synchronously, tutored;**
2. **Individually, asynchronously, not tutored;**
3. **In group, synchronously, tutored;**

When designing a PBL sequence, below are all the steps you need to think about.



1. Course scripting

1.1. How to create a complex problem

REMINDER:
Your PBL sequence is based on a complex problem. Designing your problem is the most important aspect of your course scripting.

1.1.1. Questions

What kind of problem is used in PBL?

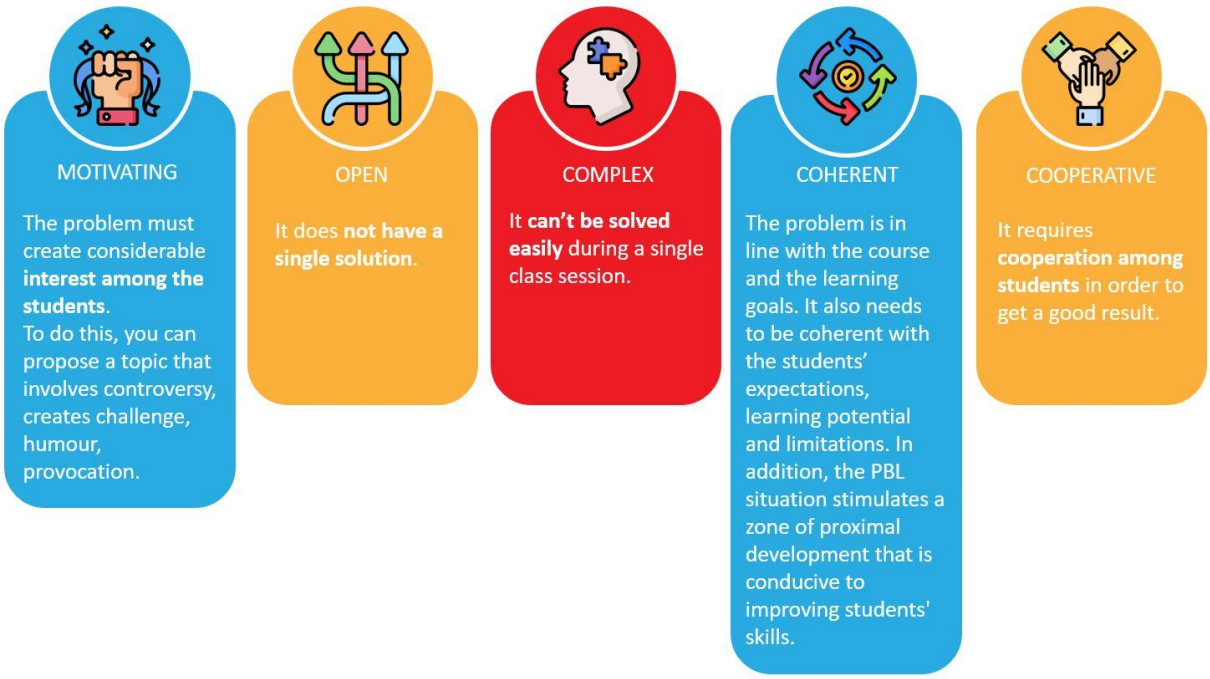
When tackling a challenge, the typical starting point is to determine which root problem needs to be addressed. But before you roll up your sleeves, it's important to first understand what *kind* of problem we're dealing with. Solvable problems can be divided into four distinct categories: *Simple*, *Complicated*, *Complex*, and *Chaotic*. It seems that you can neatly put every problem you face into one of these categories, and each category requires a very different strategy.

Simple problems are solved by just following obvious rules. There's only one solution and it's intuitive. *Complicated* problems are ones where the rules are known and predictable, but they are onerous and cannot be instinctively understood without some training. *Complex* problems are ones that involve multiple factors and we can't predict whether a change in one aspect might affect another. And finally, *Chaotic* problems are those where, even when witnessing a change, we can't be certain of the cause and effect.

PBL works on a complex problem as it requires a different skill set. Students can't just learn all the rules. They need to be able to probe, understand, and then respond.

What is a good PBL problem?

A good PBL problem should be:



A good PBL problem is original, potentially with a high level of interaction between the learning team.

What type of PBL problems can I use?

Jonassen and Hung (2008) identified three main kinds of problem (mostly distinguished by the type of solution sought) from a list of ten types of PBL problem:

- Decision-making
- Diagnosis-solution
- Policy problems/situated cases

How to check PBL problems (cf. point 1.1.2. A useful 'tool')

EXAMPLE:

ILOs:

- 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 (ILO1a)
    - choose one or several adapted techniques and justify the choices (ILO1b)
    - state the limitations of the different techniques chosen (ILo1c)
    - describe the expected results (ILo1d)

Complex problem:
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.html1
Thamos Pesteque, a frequent visitor to Evering as part of his zero G flights, believes that Evering students, excellent in Non-Destructive Testing (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 APP2). 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 International Spatial Station (much better than a WE 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 APP1 to answer your questions.

NOTE:

- Motivating: There are several familiar elements for students in this problem
- Open: It doesn't have a single solution
- Complex: Students need to solve several sub-problems to achieve the mission
- Coherent: The problem is in line with the course
- Cooperative : Students need to work in group

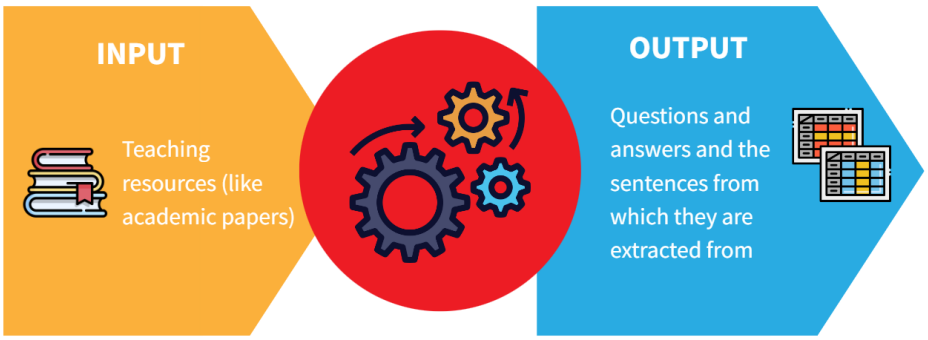
1.1.2. A useful 'tool': Checking your complex problem

This checklist was created to help you design and check a PBL problem. Three main properties are considered here: problem interest and motivation for students (PIM), learning process (LP) and feasibility conditions (FC).

Checking complex problem quality		Assessment
How to check:	***G*** *Good* ***F*** *Fair* ***TBI*** *to be improved*	
Problem interest and motivation (PIM)		
New problem	Will the students need to analyse and explore the situation before starting the problem-solving process?	
Problem relevant to curriculum	Will the students consider that the PBL problem is linked to their curriculum and to their training programme ILOs?	
Context-induced motivation	Will the context be a source of motivation and interest?	
Contextualisation details	Is the context correctly described? Do enough details emerge?	
Real-world links	Is the problem related to real professional issues?	
Learning process (LP)		
Relevant to ILOs	Has the problem been defined to achieve the ILOs?	
Relevant to pre-existing knowledge	Will students need to use their existing knowledge as input in their method?	
Teamwork	Does the problem need group work to be solved?	
Several solutions	Is the complex problem open-ended?	
Feasibility conditions (FC)		
Difficulty	Is the problem difficult enough for learning? Is the problem too difficult to solve?	
Scheduling	Is the sessions scheduling suitable to deal with the PBL problem?	

1.2. How the SFLM can help me create a PBL sequence

REMINDER:
The SFLM is a tool that can help you design your PBL sequence. It will extract information from documents uploaded as input to make some of your design steps easier and faster.



1.2.1. Questions

What is the purpose of the PBL SFLM?

The SFLM is designed to help users create their PBL sequence and relate the material contents to the ILOs or the complex problem.

How to use the SFLM

- Users select documentary resources relevant to the topics under study and upload them to the SFLM. It is recommended to upload between 3 and 10 documents to get conclusive results. The SFLM can only process resources written in English.
- Users choose whether they want the results to be based on specific keywords
- The SFLM output can be downloaded as an Excel document.

For full instructions on how to use SFLM, please refer to the *SuperFast Learning Machine Technical Guidelines*.

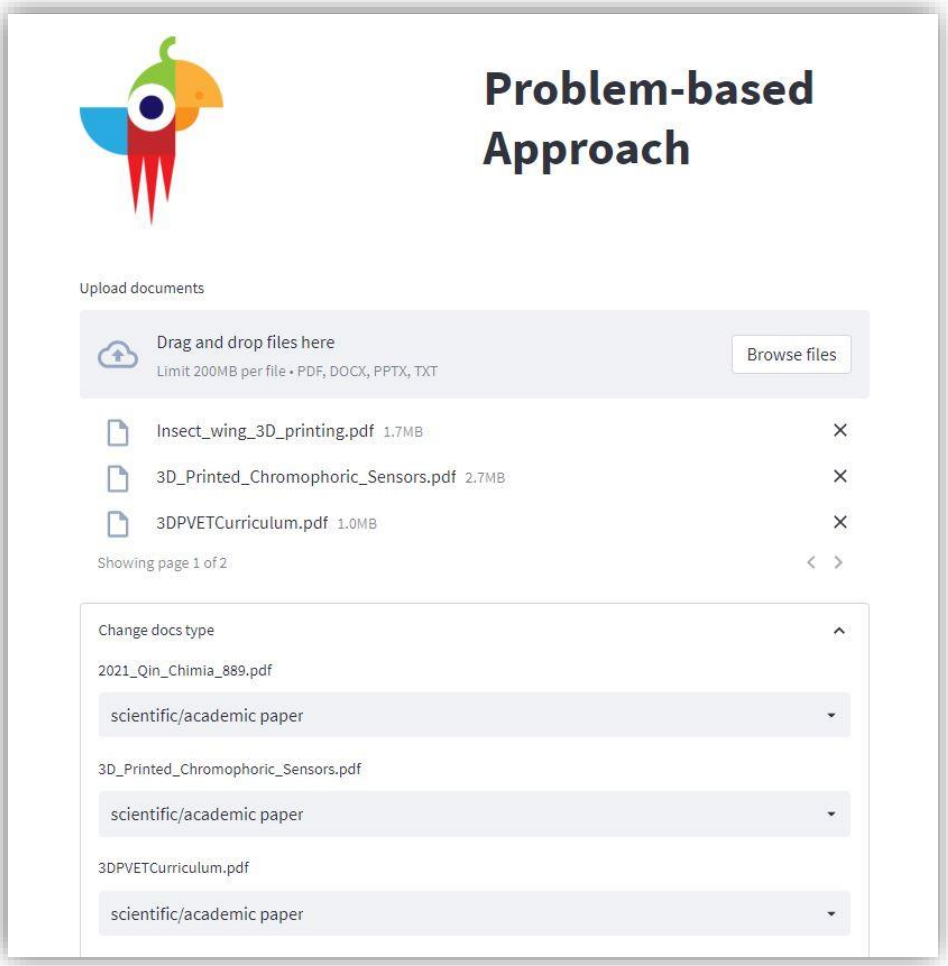
How the SFLM can help me design my sequence

You can relate the extracted questions to your intended learning outcomes. It might help you make your Intended Learning Outcomes more specific, or split them into sub-objectives. It can help you identify relevant part of the documentation, for instance, to give to your students as handouts.

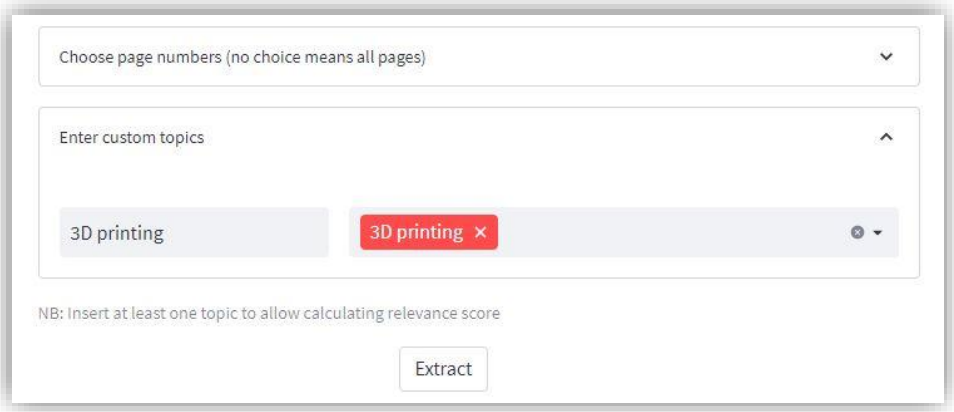
The extracted questions can help to create a knowledge test, or to design the content of a follow-up class (e.g., topics/terms to be clarified after the PBL sequence).
Last but not least, the machine gives reading time estimates for each document, which could help complete the student booklet regarding student workload for the autonomy phase.

1.2.2. Practical example

- Theme: 3D printing
- Resources uploaded:
  - https://www.researchgate.net/publication/356091585_3D_Printed_Chromophoric_Sensors
  - https://www.researchgate.net/publication/356041652_3D_Printing_in_VET_IO3_Curriculum_on_3D_Printing
  - https://www.researchgate.net/publication/355913918_When_Photoswitches_Meet_3D-Printing
  - https://www.researchgate.net/publication/356760272_Application_of_3D_printing_in_casting
  - https://www.researchgate.net/publication/355212472_Insect_wing_3D_printing
  - https://www.researchgate.net/publication/313904803_The_rise_of_3-D_printingThe_advantages_of_additive_manufacturing_over_traditional_manufacturing

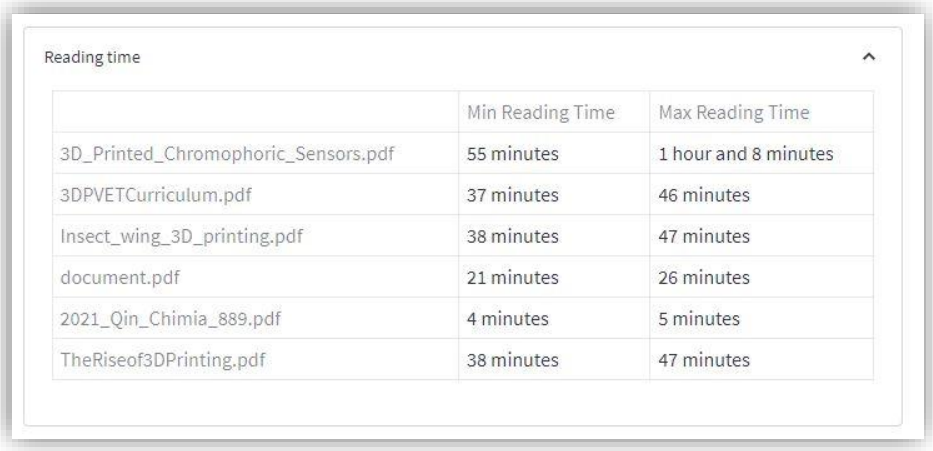


We chose to process the whole documents and not specific pages, and we typed “3D printing” as a topic of interest so that a relevance score could be calculated based on this topic.



- SFLM extractions:

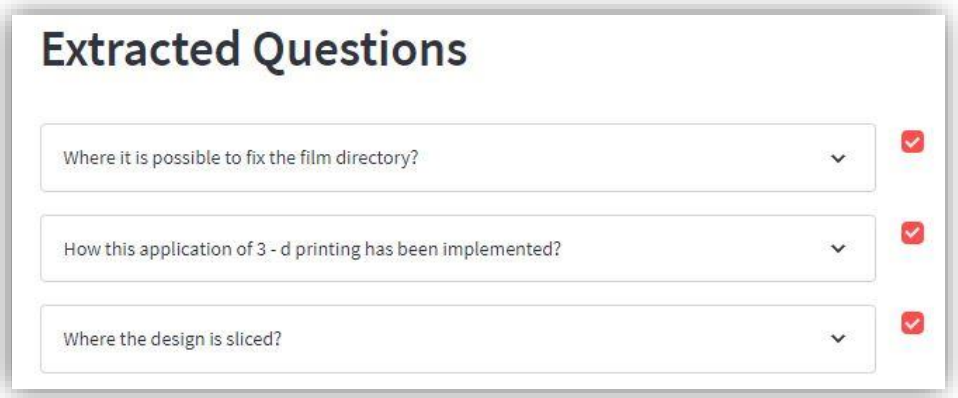
We got the reading times estimates for the entire documents (also possible for a range of pages as well). We can see that some of these documents would be too long to give to read for the autonomy phase. We will have to select the relevant part to give as handouts.

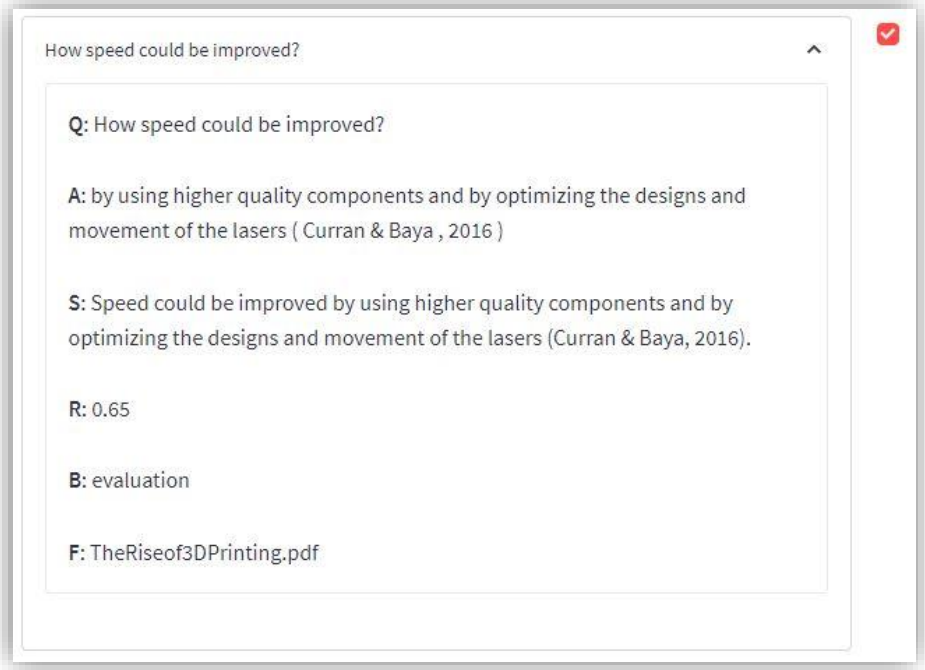


Reading time

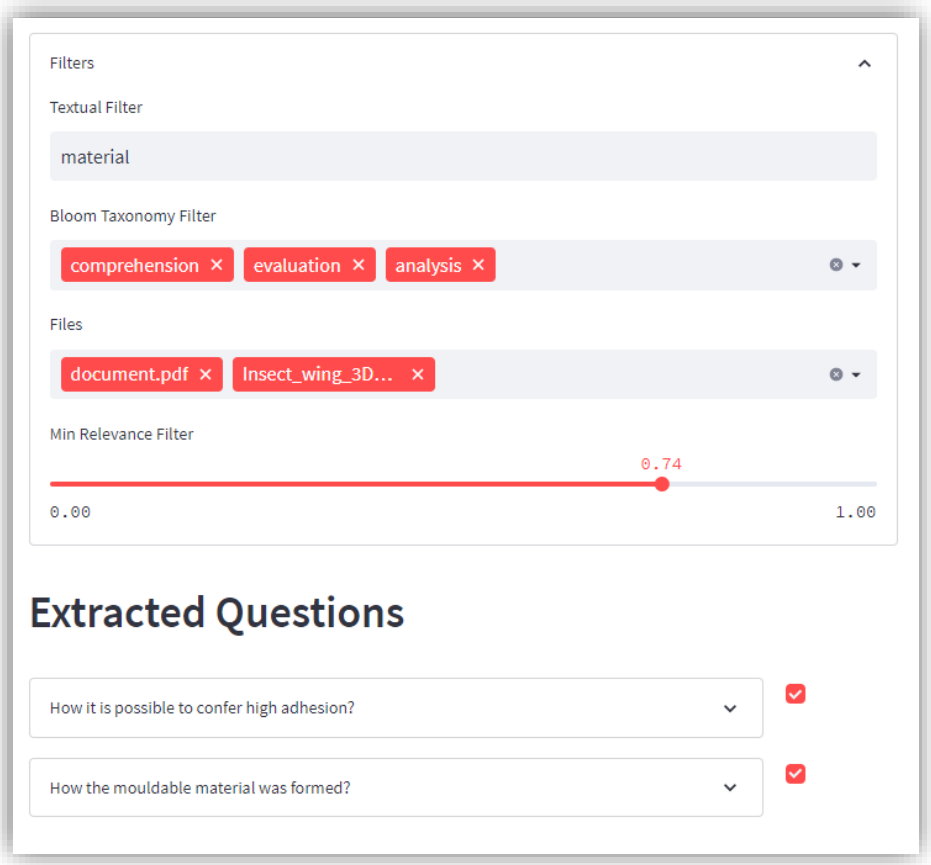
	Min Reading Time	Max Reading Time
3D_Printed_Chromophoric_Sensors.pdf	55 minutes	1 hour and 8 minutes
3DPVETCurriculum.pdf	37 minutes	46 minutes
Insect_wing_3D_printing.pdf	38 minutes	47 minutes
document.pdf	21 minutes	26 minutes
2021_Qin_Chimia_889.pdf	4 minutes	5 minutes
TheRiseof3DPrinting.pdf	38 minutes	47 minutes

We got a list of questions that we could expand to get other useful elements: the answer (A), the sentences (S) from with they were extracted from, the relevance score vs our topic “3D printing” (R), the attribution of the extraction to one or more levels of the Bloom taxonomy (B), the file from which the information were extracted from (F).





We also played with the filters.



1.2.3. A useful 'tool'

	Questions you want to ask yourself when reading SFLM output
ILOs	*Which questions should students answer to achieve the ILOs?* *Are all of these questions in the SFLM output?* *Will I need more resources?* *Which questions (and answers) do I let the students search for themselves? Which documents, or part of them, should I give to students?*
Complex problem	*Which questions are related to the problem situation?*
Workload	*Are the time estimates I give my students to read the materials appropriate?*

Course flow

1.3. What do group activities involve in the Problem Based Learning sequence?

REMINDER:
After designing the problem, you want to complete a student booklet to give them. Students will work from this booklet. They won't need any teacher's instructions if everything is explained in the booklet.

1.3.1. Questions

What are 'the group activities'?

By "the group" we refer to student teams that work together during the first and the final PBL phases. Group activities are the tasks they have to do during the PBL sequence, especially during the group work phases.

What are the roles in a PBL group?

During the group work phases, there are several roles that can be played according to the number of students in each group. Basically, the number of roles depends on the number of group members. The most common roles are the following: driver, timekeeper, scribe, facilitator, secretary, speaker, reviewer.

How are the activities presented to the students?

The roles and activities are presented in a booklet and can be explained by the tutor if necessary. To ensure that students actually do what is expected of them, clear directives should be given to the groups, setting out the sequences of work to be performed and clearly explaining what they need to do.

Why prepare a student booklet?

The students may be surprised by the organisation of a PBL sequence as it involves active learning and requires skills that are not always used in traditional teaching sessions. Consequently, the teamwork needs to be specified and organised both in time and space. This is essential for successful outcomes.

What should a student booklet contain?

The booklet should guide students in their activities.

When do students work in groups during a PBL sequence?

The booklet should clearly explain **what is expected** from the students, such as group work. The PBL sequence is usually split into different phases:

- a first phase when the students work in groups (first teamwork session),
- an individual work sequence
- a final phase when the students work in groups (second teamwork session)

How many students are there in a group?

A group can have from 5 to 8 students, but usually has 6 students. In specific cases like a practical class, you can have 3 or 4 students so they can manipulate and experiment. However, 3 or 4 students in a PBL group might be challenging.

How to form a group

You can form groups randomly, especially if you don't know your students (at the beginning of a course, for example). You might pay attention to gender: in previous sessions, we noticed that one female student in a group otherwise made up of boys, or one male student with only girls is more reserved and less likely to express their ideas.

If you know your students, it can be interesting to separate friends, for instance; two or three friends in a group of five or six students might take the lead to the detriment of the others.

Do we change groups around sometimes?

If possible, keep the same groups for several PBL sequences. They will learn to work together and each will take an increasing amount of responsibility. For example, if one student doesn't get involved as intended, other group members will ask the tutor for help after two or three PBL sequences.

FEEDBACK AND GOOD PRACTICE:

- There are 7 main roles, and sometimes fewer students in a group. In such cases, they can choose more than one role. If there are more than 7 students, 2 students can choose the same role.
- Students are used to being told what they have to do, and are used to having a teacher who answers their questions. They may initially be a bit lost by this new way of learning, but don't worry! The second time they will be more used to it.
- The first PBL teamwork phase is devoted to explaining the PBL sequence goals and to determining what they have to deliver in the final phase. The first teamwork session is crucial: students must not begin their individual work until the goals have been clearly set out and validated by the tutor.

1.3.2. A useful 'tool': Student booklet for the PBL sequence

We created a template for you to complete and then print so your students will know how to work. The student booklet is based on the **FA2L booklet**, the **Bordeaux academy booklet**, and **Geneva University booklet**. Please refer to the annexes to find our student booklet to fill in and print when designing your lesson.

1.4. How to guide the students

REMINDER: Your main role is to facilitate students' learning by guiding the groups, and not giving them the answers. If you need other people, such as students, to guide your groups, you need to design a complete tutor booklet.

1.4.1. Questions

Why does PBL need a tutor more than a teacher?

Students are expected to think for themselves. They have to be able to solve problems which they may not have encountered previously. Traditional teachers, similar to the "sage on the stage", are expected to possess knowledge and to transmit it. While this is great for passive learners, it doesn't help students to process information using their own intelligence. Alternative student-centred learning methods, such as PBL, tend to stimulate deep-level processing and critical thinking in students. These methods require teachers to be tutors instead, similar to the "guides on the side", whose goal is to facilitate students' interaction with the material. The tutor acts as a coach who monitors students' actions in the problem-solving process through the use of previous knowledge, teamwork, and relevant information searches. Students thus take ownership of the goals and outcomes.

Who can be a tutor?

Teachers can become tutors during a PBL sequence. However, it might be challenging for only one tutor to guide more than 3 or 4 groups. To solve this issue, more advanced students who already have the knowledge to be taught can be tutors. Student tutors could earn ECTS for taking on this task by producing a portfolio, for example.

Anyone can be a tutor as long as they have been trained for the task and studied the PBL sequence prepared by the teacher in depth. The teacher might ensure that they can follow the conversations between students.

When does a PBL need a tutor?

Tutors guide students only during the group phases: i.e., during the first phase and the final phase.

What qualities does a tutor need?

Tutors ensure that a learning atmosphere is fostered. They guide the different analytical sequences and the group's progression towards identification of the learning objectives.

Tutor must be able to display the following skills:

- to guide students through the process
- to listen to students in order to provide effective guidance if needed
- to ask questions at the right moment (depending on the steps in the process)
- to assess the work done by the students

Tutors also need to:

- understand the intended learning outcomes defined by the teacher
- withhold opinions, solutions, and ideas to ensure that answers only emerge from the students' views
- stimulate the group to look for the "why" and the "how" of events, and analyse them in detail, identifying the most relevant explanations
- encourage different ideas that may be divergent as long as it doesn't lead groups down a rabbit hole
- support strategies to promote the gradual acquisition of autonomy
- monitor students' progress to give formative feedback at the end of the sequence

FEEDBACK FROM TUTORS AND GOOD PRATICE:

What can be expected in the first phase: exploring the problem

- Make sure the action plan is understood by each group member. Everyone needs to know what to do and what research is needed
- Guide the group to identify all intended learning outcomes
- Tutors must be proactive: listen to the students' questions and help them to develop their strategy. Tutors must avoid leaving the students on their own. Active guidance has proved to be a key success factor in PBL. On the other hand, do not over-guide. Open questions are more interesting for better guidance.
- Tutors must discuss the PBL with the teacher beforehand in order to understand the expectations.
- If documents are given to the students during the PBL sequence, it needs to be done at the right time. Given too early in the first phase, the documents might distract students from their analysis of the PBL problem and from developing their group method. Good practice suggests giving access to resources at the end of the first teamwork phase.

FEEDBACK FROM TUTORS AND GOOD PRACTICE:

What can be expected in the second phase: student information seeking

- Each student must complete all the tasks in the action plan defined by the group.
- Avoid contact with the students during this phase as the students have to understand that they are on their own. In our experience, many students come and ask questions to see if they are on the right track. The answer is either "you ought to have asked before (in the first phase)" or "we'll see this soon with the whole group in the next phase". This way, students will learn to make better use of the three phases. They will also gain confidence in their individual work with time.
- Some students (often those who are beginning PBL) are afraid of not meeting expectations. Tutors can reassure them that the final phase will put them on the right track if they are not already on it. The teacher can also help with this task. A calm mindset and greater confidence will help the students to be more efficient.

What can be expected in the final phase: feedback and assessment

- The feedback phase helps the students to identify the learning outcomes they have achieved.
- During peer assessment, tutors must ensure mutual respect between students. The feedback phase helps student to be more efficient in future PBL by understanding what has been well done or what can be improved.
- Each student chooses a role, but it might be difficult for them to embody it. Moreover, they sometimes forget to stick to the role in the whole group phase. Give the group the option to change roles at the beginning of the final phase!

What else?

- A guide is written by people who want to share their experience and there is no harm in the tutor deciding to do things otherwise (this can be discussed with the teacher). This is also valid for the next chapter. Best practices are only best if the tutors agree with them and adopt them with conviction.
- Tutors must ensure the timing of the different steps is respected.
- Practice makes perfect: practice tutoring under the supervision of other tutors to improve your skills.

1.4.2. A useful "tool": How to be the "guide on the side"?

The student booklet was created based on the FA2L booklet, the Bordeaux academy booklet and Geneva University booklet. Please refer to the annexes to find the tutor booklet to be filled in and printed to design your lesson.

1.5. How to adapt my PBL sequence to my course context

REMINDER:
It is crucial that the generic PBL sequence is adapted to the specific situation we want to teach, depending on:

- the teacher/tutor's knowledge of PBL,
- the students' characteristics (number, level, etc.),
- the kind of learning outcomes expected,
- the institutional constraints (location, time, online, …)

1.5.1. Questions

What should I do if there are too many students in my class? [The number of students in my class seems inappropriate.]

The minimum number of students to make a group is 4. One tutor may follow 2 to 6 groups. Consequently, the number of tutors may be increased accordingly. You can ask advanced students in your field to be tutors. This means that you ought to think about their reward. They could obtain ECTS for tutoring some sequences with you, for example.

I'm used to the PBL approach, but this year, teaching must be done online. How can I adapt my PBL sessions to online teaching? [Face-to-face vs online teaching].

Avoid using a PBL approach online if you are a beginner to both online teaching and the PBL approach. If you master at least one of these two forms of teaching, you can try both at the same time.
Whatever the situation, for online teaching, you will need software allowing for the use of breakout rooms. Invite students to use their video camera to be able to benefit from non-verbal communication.
In online teaching, attention should be paid to time management during the different steps. In fact, it's more difficult to leave a group in a virtual room than in a classroom situation.
You ought to have more tutors in online PBL vs Face-to-face PBL, especially as some important stages in group learning like defining the learning outcomes need to be checked by a tutor. Without being in a class, you might miss this phase and the group might continue in the wrong direction (without understanding the real learning outcomes).

Time schedules in universities are not always guided by learning. How can I manage a PBL sequence if I teach two hours every Monday? [Time constraints]

It's often the individual-work phase which will need to be adapted. Reducing individual work time may mean providing students with documents, allowing them to reduce the amount of time spent on the web and searching for documentation. Increasing this time may not be a problem. Depending on the students' profile, when individual-work session time lasts several days, it may be useful to provide some organisation guidelines and/or to train students in documentation research before the final PBL phase.
The main factor to keep in mind is that you need to take the time students spend working at home in the individual phase into consideration. If it's too long, the final phase should not be

organised just a week after the first phase, but rather two weeks later. For the Monday that is not used as the first or final phase, you can give a lecture or adopt a different teaching mode, working on concepts that could be used for the problem.

How can I teach the know-how and theoretical knowledge? [Theoretical vs know-how intended learning outcomes].

While theoretical information is often easy to obtain over the internet, know-how related intended learning outcomes may mean that learners require access to a laboratory, computers, software, or specific installations. Consequently, it's very important to plan specific times devoted to this part of the learning input.

Can I do a debriefing session during the final phase when groups share their findings with the whole class or when students summarize which learning input was important? [Debriefing session]

Some tutors find it useful to end a PBL sequence with a debriefing session where learners can discuss their conclusions, even between groups. This step may also be useful to check whether the intended learning outcomes have been achieved and that no misconceptions have arisen from the work. It may be interesting to keep records of the debriefing and all discussions at the end of the PBL sequence.

EXAMPLE

Example 1
Subject: Applied physics. ILOs included both theoretical knowledge and know-how: Describing a concrete problem, proposing solutions, defending the choices made
2 tutors for 28 students; 7 groups of 4

Specific factors:
- Given the number of ILOs, two PBL sequences were organised
- Finding a solution to the problem involved using information learned during more traditional courses. It wasn't necessary to get new information.

The basic ILOs were:
- Use previously learnt information to solve a new problem
- Communicate a solution, draft a report, and create a video sequence

Variant: A debriefing session was introduced at the end of the PBL sequence to train students to defend their decisions.
These kinds of adaptation are useful to learn how to draft a report and make a video

You can find other examples of PBL adaptations in the appendix

1.5.2. A useful "Tool" to adapt PBL sequences according to specific contexts

Issue	Solution	Remarks
Number of students	☞ Adjust the number of tutors. 1 tutor for 2-6 groups	A novice tutor would only deal with two groups. For the very first time, one group would be even better All tutors should know the ILOs perfectly and coordination meetings should be held before the sequence starts
Online teaching	☞ Use breakout rooms when students work in small groups ☞ For tutors who are used to and feel comfortable with online teaching, an in-class teaching PBL sequence may be transferred online ☞ Online teaching may be avoided by tutors who are novices in both the PBL approach and online teaching	☞ Keep in mind that it is more difficult to effectively allocate time between groups in virtual rooms than between groups in a physical room
Time constraints	☞ When individual work time is too short, students should be given documentation that fits in with the timeframe ☞ When individual work time is too long (i.e., there are several days between the first phase and the final phase), students should be told how much time is needed for it, and, if possible, it should be scheduled on the timetables	
Theoretical *vs* know-how intended learning outcomes (ILOs)	☞ No major difference between these two kinds of ILOs regarding the implementation of a PBL sequence ☞ Tutors need to ensure that students have access to the required documentation for the two kinds of ILOs, and to the required material for know-how ILOs	Students won't memorize the concepts; they will do research and use it to acquire "know how"
Debriefing time	☞ Given that the PBL approach is effective because it is based on active learning principles, when used, it is important that the "whole class" debriefing time keeps to the active learning ethos. ☞ Tutors should avoid giving solutions. They should ask students question to help them find the intended solutions by themselves. ☞ In the meantime, tutors should stick to their role as tutors and should not return to a teacher position.	Debriefing time is not included in the 'traditional' PBL sequence. Several tutors find it useful to organise whole class debriefing time.
All [above-mentioned	During a PBL sequence adaptation, tutors should keep in mind that the ILOs are the target of the sequence. At each step of the PBL sequence building	These two conceptual tools should be considered as the main threads for taking

and other] adaptations	or adaptation, tutors should ask whether the decision they take is the best way to achieve the ILOs	decisions and making choices between putative options, both in the conception and the adaptation of PBL sequences.
	Active learning: ☞ Always guide the students to find their own answers by questioning them rather than giving them solutions ☞ Tutors should encourage solutions and answers proposed by students ☞ Tutors should encourage self-organisation by the groups	

2. After the course

2.1. How, when and what to assess?

REMINDER:
As there is self and peer assessment in PBL, you ought to put assessment activities in both the students' and the tutors' booklet.

2.1.1. Questions

What is assessed?

Group output and group organisation is assessed by both the group and the tutor/teacher. Each student assesses their own knowledge progression and their own involvement in the group. The complex problem can be assessed by the students. The relationship with the tutor can be assessed by the group. Finally, you need to think about the ILO assessment.

How and when to assess?

PBL implies self-assessment and peer assessment during the final phase. Apart from checking the students' ILOs, you can use a Likert scale, for example.
You can also provide an assessment of ILOs right after the sequence, but you don't have to. It can be part of the final semester exam. Please refer to the common guidelines to learn more about assessments.
It's important to keep in mind that it's better to assess the students' processes during the PBL sequence rather than a deliverable if you asked for one. You can base your assessment on the summary written by the secretary.

EXAMPLE

You can find an example of an assessment after a PBL in the appendix

2.1.2. A useful 'Tool'

Checking assessment quality		Assessment
How to check:	***G** Good* ***F** Fair* ***TBI** to be improved*	
Format	Does the assessment format allow you to measure all levels of learning outcomes (knowledge, comprehension, analysis, …)?	
Timing	Is the timing of the evaluation coherent with the tasks the students have to complete?	
Grading system	Is the grading system clearly defined? Can students identify it?	
Constructive alignment	Is the assessment consistent with the learning outcomes?	
PBL assessment*	Is there an assessment of the complex problem, of student satisfaction?	
Group assessment	Is there a self and a peer assessment of the group organisation and soft skills?	

*You can find a PBL assessment in the Student booklet and the Tutor booklet.

Glossary

SFLM: Super-Fast Learning Machine. This is an IT tool that extracts relevant information through data mining to develop digital content (one for each methodology)

ILO: Intended learning outcomes. Refers to students' abilities after a sequence compared to their prior abilities (cf. Common guidelines).

PBL: Problem-based learning. Activity-based learning where students have to solve a complex problem.

Complex problem: A complex problem contains several sub-problems and can be solved in different ways. Unlike a simple problem, a complex problem does not contain all the information needed to solve it. A complex problem is often transdisciplinary.

Sequence: In this document a sequence is a non-defined session of PBL. It can last several hours, several days, several weeks, or several months.

Phase: In this document, a phase is part of a PBL sequence. There are 3 phases. The first phase, when students work in a group to explore the problem and devise an action plan; the second phase, when students work asynchronously and individually; the final phase, when students work in a group to collect and gather the information found in order to solve the problem and then make an assessment.

Step: In this document the steps are students' or teachers' activities. There are several steps in a PBL sequence phase. There may be steps before and after the PBL sequence.

Appendix

EXAMPLES of PBL adaptations

Example 2
Subject: Bibliographical analysis
1 tutor for 12 students

Particularity/adaptation: Information learned during more traditional courses needed to be used. Students had to divide up a set of academic papers depending on the interests and competences of the different group members.
This variant, which consists of distributing information depending on personal interests, is supposed to increase the students' motivation.

Example 3
Subject: Genetics. ILOs encompassed both theoretical knowledge and know-how
1 tutor for 18 students

Particularity/adaptation: The groups worked on complementarity, so they had different problems. After the final phase, there was a collective debriefing session with presentations. In this PBL sequence, the debriefing allows students to learn how to share information with colleagues. At the same time, the other students learn by listening, so learning is passive not active.

Example 4
Subject: Biostatistics. ILOs encompassed both theoretical knowledge and IT know-how
1 tutor for 15-20 students

Particularity/adaptation:

- Due to time schedule constraints, the first phase lasted 2 hours and the final phase lasted 1 hour. Individual work was intended to last 3 hours, but the first phase and the final phase were 1 week apart.
- No paperboard was available, so students worked on collaborative documents on the web.

EXAMPLE of an assessment

In the Mechanical department, more specifically in a Design course, the teacher first defined the outcomes in the 6 steps proposed:

- To set up a revolute system based on angular contact-bearing technology
- To justify the mounting choices (set position/hold in position)
- To check the service lifespan of the selected bearings

The assessment was defined to get three marks at the introductory stage, after research had been conducted and after product performance.

- During the introduction, a document was given with empty spaces, designed to guide the different functionalities and the different elements
- A short problem description was given and the PBL began
- Peers assessed understanding of the mechanical system before the research stage (each student had to explain to another one how the mechanism works, its specifications, and the input/output laws). Validation followed as a starting point to begin the research stage on the specific outcomes
- Product performance was developed by the students after a relatively short discussion
- A drawing was used to assess the group, and the lifespan computation was evaluated individually

Assessment was then completed by an individual report which described the methodology and the results obtained. It also included a short description of skills. In addition, an analysis of the drawing and the lifespan assessment was used to check the group and students' understanding based on their methodology description. Feedback was given to the group informed by the real problem resolution made by the industrial in question.

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