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Dataset-based learning pedagogical guidelines

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1. Introduction

Dataset Based Learning (DBL) is a student-centred pedagogy in which students learn about a subject through the experience of working directly with a dataset taken from a real-life situation. In a DBL activity, students - guided by teachers - should be able to analyse the provided dataset in order to solve the problems or questions proposed, or to obtain behaviour patterns that are useful for learning in depth about some topics. The DBL activity must be contextualized in active learning methodologies such as Problem Based Learning (PBL), Inquired Based Learning (IBL) or Scenario Based Learning (SBL).

Figure 1 shows the practical flow to follow to create your own DBL activity. The steps that are common to all methodologies (formulate the intended learning outcomes –ILOs-, select learning outcomes and check constructive alignment) are described in a separate document.

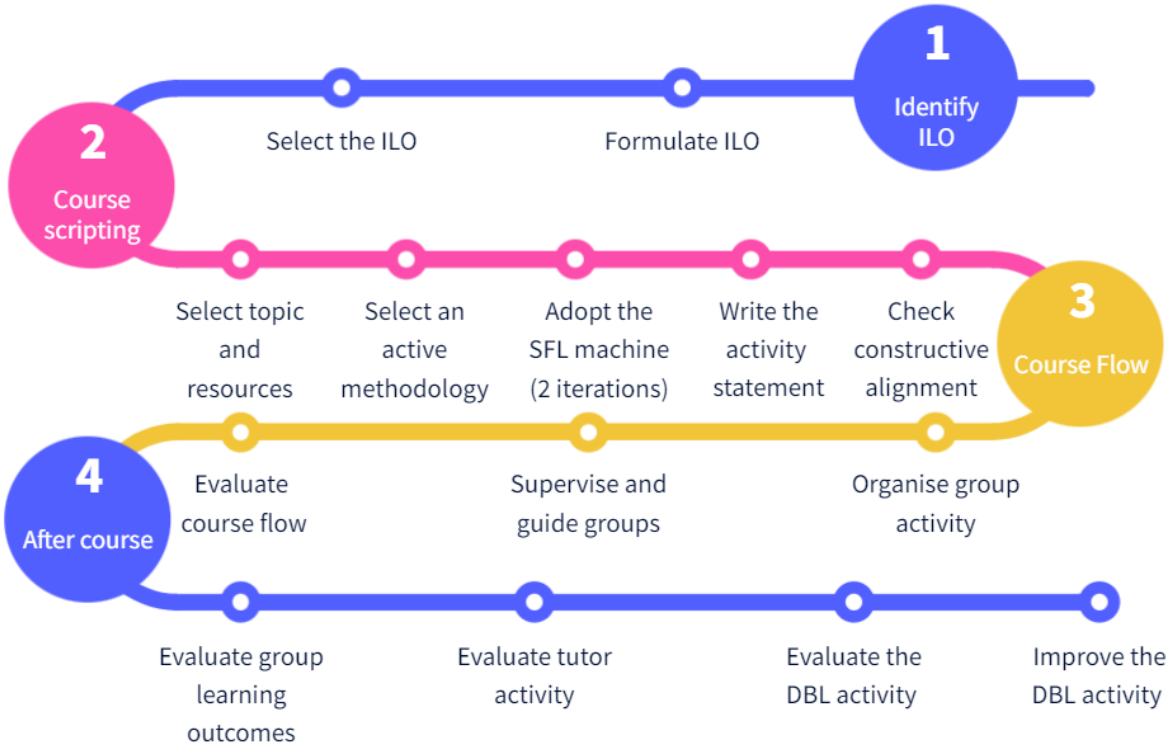

Figure 1. Flow chart of the creation of a DBL activity

The examples given in this guideline are extracted from the document IO4-DBL-example, which details the use of a DBL methodology in the subject Innovation management in ICT, from the Master Degree in Informatics at the University of Zaragoza. The general process flow of the DBL example is the following:

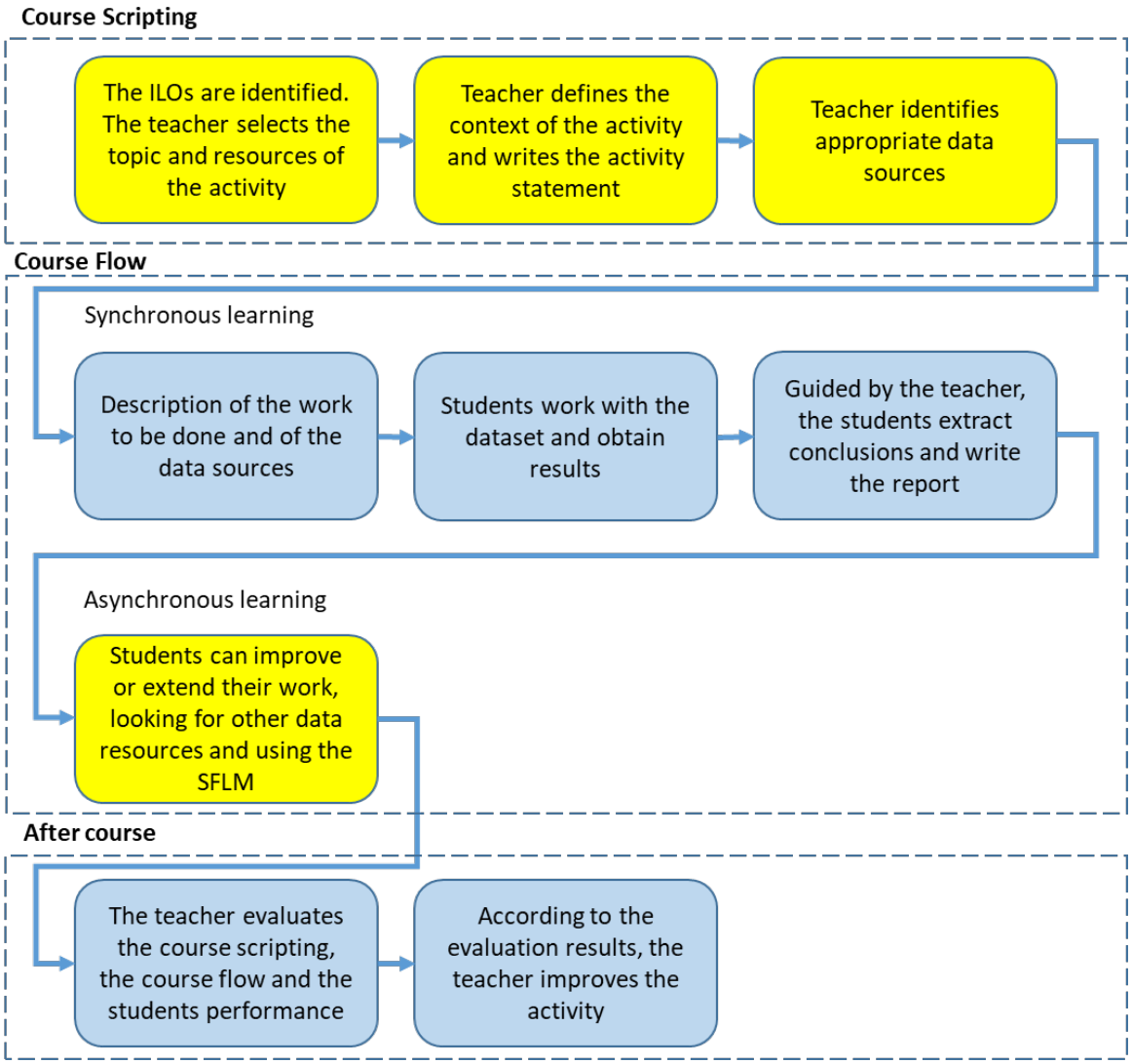

Figure 2. Flow chart of the DBL example.

2. Course Scripting

As shown in the graphical guideline, the course scripting phase occurs after the intended learning outcomes (ILOs) have been selected. During the course scripting process, the teacher prepares the material for the DBL activity, taking into account the ILOs. For this, first, the teacher must select the topic of the lesson, reference information and dataset for the learning process. Then, the teacher must select an active learning methodology such as PBL, IBL or SBL that contextualizes the DBL. Once this is done, the teacher can proceed to adopt the SFLM and design the activity statement that shapes the exercise to be solved by the students. It is worth mentioning that the original dataset may need to be adapted to the exercise to "force" specific results.

2.1. How to create a DBL activity?

2.1.1. How to design a DBL activity using active learning methodologies?

The DBL activity must be contextualized using active methodologies such as PBL, IBL or SBL. The selected methodology determines the activity statement, the information that is given to the students and what is expected from them.

2.1.2. In which active learning methodologies could DBL be introduced?

The structure of the activity is defined by the methodology, while the dataset and the information that the students should extract from it is adapted to the methodology.

2.1.3. How to integrate the DBL into the IBL?

In IBL, the students are asked questions on a researchable issue that do not have a predetermined answer. The answer to that question could be obtained by analysing datasets and extracting conclusions. In this case, the dataset must be given to the students as part of the question statement and/or as the central resource of the lesson.

2.1.4. How to integrate the DBL into the SBL?

In SBL, students work in interactive scenarios that take them through a storyline. In this case, the dataset must be given as decisive part of the scenario and must help students to make decisions or solve a given problem, so they can move forward to the next scenario.

2.1.5. How to integrate the DBL into the PBL?

In PBL, the students have to solve a complex problem whose solution is not predictable and may be different for each group. In this case, the students have to research the dataset by themselves. However, to narrow down the solutions, the teacher should define which sources of information they can use. In addition, the teacher should also explain how to select a good dataset and present possible resources. During the activity, all the groups should work on the same data, therefore, the part of selecting the dataset should be done in common.

2.1.6. Is the topic of the lesson restricted somehow?

The teacher can freely select the topic of the lesson, independently of the selected active learning methodology. However, the lesson must be focused on the dataset that the students need to work with. Students should be able to identify problems in the dataset or analyse it to solve the proposed problem.

2.1.7. Must the dataset be taken from a real-world source?

Ideally, the dataset should be taken from a real-world source. Real-world problems enhance students' motivation and help them to gain confidence. However, the dataset can be adapted to the objectives of the lesson. In some cases, this implies a previous work with them: establish data collection relations, check the data quality, format the data to be given to the students. Several versions of an original dataset can also be created, in order to simulate different scenarios.

2.1.8. How to select my reference dataset?

The dataset depends on the topic of the lesson, and, as mentioned, ideally it should be real-world data. Several open sources are available to obtain the datasets, such as the ones provided by the National Statistical Offices

2.1.9. Must the dataset be given to the students with the activity statement?

Not necessarily. The dataset could be given to the students with the activity statement. However, an approach in which the students need to research or perform experiments to obtain the dataset by themselves is also possible.

2.1.10. Can any subject be taught using the DBL methodology?

In the DBL methodology the dataset is the key element of the problem to be managed and, thus, not all topics can be explained with this approach. In fact, identifying appropriate datasets is one of the main challenges of developing this

learning approach. An appropriate dataset is one that helps to achieve the activity learning outcomes without unnecessarily complicating the lesson.

2.1.11. Do the students have to obtain results during the lesson (synchronously), before or after it (asynchronously)?

The DBL methodology can be applied synchronously and asynchronously. It is advisable that, before the lesson, the students refresh the knowledge that they are going to need during the activity. The teacher should always (synchronously and asynchronously) be available to guide the students during the learning process.

2.1.12. How to prepare the activity statement?

The activity statement must be prepared by the teacher prior to the lesson. The statement must include a summary of the concepts in which the students will be working on. The extension of the explanation depends on whether these concepts have been previously taught in class. The statement must also detail the work to be carried out by the students, providing all the required information to complete it. It may include a description of the software and the tools to be used. This statement must include the dataset for the DBL activity.

2.1.13. Do I need to adapt the dataset to my course context?

Ideally, the dataset that is going to be utilized in the DBL activity should be obtained from a real-world source. However, the data may be adapted to the activity. That is, the dataset may be tailored to emphasize some of the lesson objectives. In some cases, this implies a previous work with the dataset: establish data collection relations, check the data quality, format the data to be given to the students. Several versions of an original dataset can also be created to simulate different scenarios.

2.1.14. How do I adapt my dataset?

It depends on the learning outcomes of the course and it may be different for each lesson. In some cases, the students may need to work with the complete dataset to analyse it and extract conclusions. In other cases, the dataset may have missing data that the students need to obtain throughout the calculations or experiments performed during the lesson.

DBL methodologies are the base of how artificial intelligence techniques work, mainly machine learning / deep learning. From a broader sense, the process to transform the dataset for teaching a lesson is very similar to the process that is necessary to prepare the dataset for training an artificial intelligence. In Altexsoft

2021, authors present a process that could be used in both scenarios: teaching lessons and training artificial intelligences.

2.1.15. Which file format should the dataset provided to the students be in?

It is advisable that the dataset provided to the students is an XLS file. In this way, during the lessons, the calculations could be performed directly in Microsoft Excel, OpenOffice Calc or Apple Numbers, or the data could be exported to other computing software, such as MATLAB.

2.1.16. Example

Example of the structure of an activity statement:

1. Brief introduction of the topic.
2. Description of the context that shapes the activity.
3. Presentation of the reports which contain the dataset that they are going to work with.
4. Explanation of some concepts or numerical methods not seen in the previous lectures that are needed for the activity.
5. Description of the software and tools that the students are going to work.
6. Description of the work that the students have to do during the activity.

2.1.17. Tool

The following checklist has been designed to help the teachers during the creation of the activity statement:

	Yes	No	Notes
Does the problem revolve around the same topic?			
Is the topic appealing to the students?			

Is the approach of the problem close to a real-life situation?			
Do the students need to work with a dataset when solving the problem?			
Do the students have to do any previous work before the lesson?			
Do the students have the previous knowledge required to solve the problem?			
Does the activity statement or report given to the student contain all the necessary information to solve the exercise?			
Is the dataset given to the students with the activity statement?			

Table 1: Checklist for the creation of the activity statement

2.2. How to adopt the SFLM?

The SFLM primary use is to help the teacher to prepare the activity during the course scripting phase. The use of the SFLM in DBL is a specific case because, as mentioned, DBL can be integrated in other active methodologies, such as PBL, IBL or SBL. Then, in this case, the SFLM is used in two iterations:

- The aim of the first iteration is to contextualize the DBL activity in an active methodology such as PBL, SBL or IBL. The Pedagogical Guidelines (PG) of PBL, IBL and SBL explain how to use the SFLM in this first iteration. In any case, the intended ILOs of the lesson must be defined prior to the use of the SFLM. It is worth mentioning that the documents input in the SFLM in this first iteration are documents with relevant information about the topic of the activity. However, it is not required that the documents include datasets nor figures in the first iteration.

- The aim of the second iteration is to select and prepare the dataset for the activity. In this second iteration, the ILOs can be refined. The SFLM has a specific functionality for DBL that discovers connections between tables and pictures in a document. Thus, it helps to identify tables and images in documents where the

information may be scattered, potentially filtering out datasets or tables that do not match the lesson topic. If the inputs of the SFLM in the first iteration did not include tables or figures, the second iteration must use a different input that must include tables and figures.

With these two iterations, the SFLM discovers enough information to the teacher for the course scripting, including the preparation of the dataset that the students are going to work with. In addition, the students could also use the DBL functionality of the SFLM to extract relevant information about the dataset from external documents which could be given to the students or which the students had to find by themselves in external resources.

2.2.1. How to select the input of the SFLM?

The input of the SFLM are digital textual documents that contain information about the topic of the lesson. The complexity of the information contained in the document will determine the complexity of the lesson. As mentioned above, in the first iteration of the SFLM, the input documents do not need to contain tables or figures. The PG of each methodology details which input documents are recommended for each case. In the second iteration, the SFLM will help select and prepare the dataset for the activity, thus, the input documents must include tables and/or figures. The SFLM will find connections between them and filter out tables and figures which do not match the lesson topic.

2.2.2. Does the input file need to be of any specific type, format or have any specific length/size?

The SFLM accepts input files in several formats such as .pdf, .docx, .pptx and. txt. However, it is important to note that the input documents must be in English for the SFLM to work. The type of document and its length are not limited. Once the input file is loaded, the user can select the document type (dissertation, government document, academic paper, etc.). Next, the user can insert and indicate a page range of interest, by inserting the number of pages that are endpoints of the desired range. If the user wants to process the whole document, no page specification is needed. This selection can be repeated for each file.

2.2.3. What if my input information is in a webpage?

If the source is a webpage in English, e.g., from Wikipedia, Quora, Medium, Reddit, wikiHow, Stack Overflow, HowStuffWorks, TED Talks transcripts, Informal University Facebook groups, etc., you will need to save it as a PDF file[1].

2.2.4. What is the output of the SFLM in the first iteration?

The output of the SFLM for PBL, SBL and IBL is explained in their respective PGs.

2.2.5. What is the output of the SFLM in the second iteration?

The output of the SFLM for DBL is a set of sentences' clusters accompanied by "clusters_info" that describes the list of obtained clusters. Each cluster is selectable from a dropdown menu. Once a cluster is chosen, displayed data are respectively: filename, filetype, page, paragraph related to the reference identified in the document (column sentence) and related to a specific image or table (column match). The cluster "others" contains all contents not homogenous with the other clusters. Finally, the user can download all the clusters in XLS format.

2.2.6. Example

When the teacher prepares the material for a DBL lesson, he/she also has to prepare the dataset or the reports containing the dataset. At this point, he/she can use the SFLM to find relationships between data, to filter information, or to check if they have enough data resources to be used in the lesson.

In addition, during the lesson, the students can also use the SFLM to solve the proposed activity. They can research new data sources or reports, and use the SFLM to find relationships between data, or to filter information, when the time is limited.

[1]Save as PDF is available as "File | Export as PDF" or "File | Print ..." in modern web browsers. This process may produce a loss of content. There are some browser plugins that try to produce PDF files with a close resemblance with the original web page.

2.2.7. Tool

The following flowchart has been designed to help the teachers during the use of the SFLM:

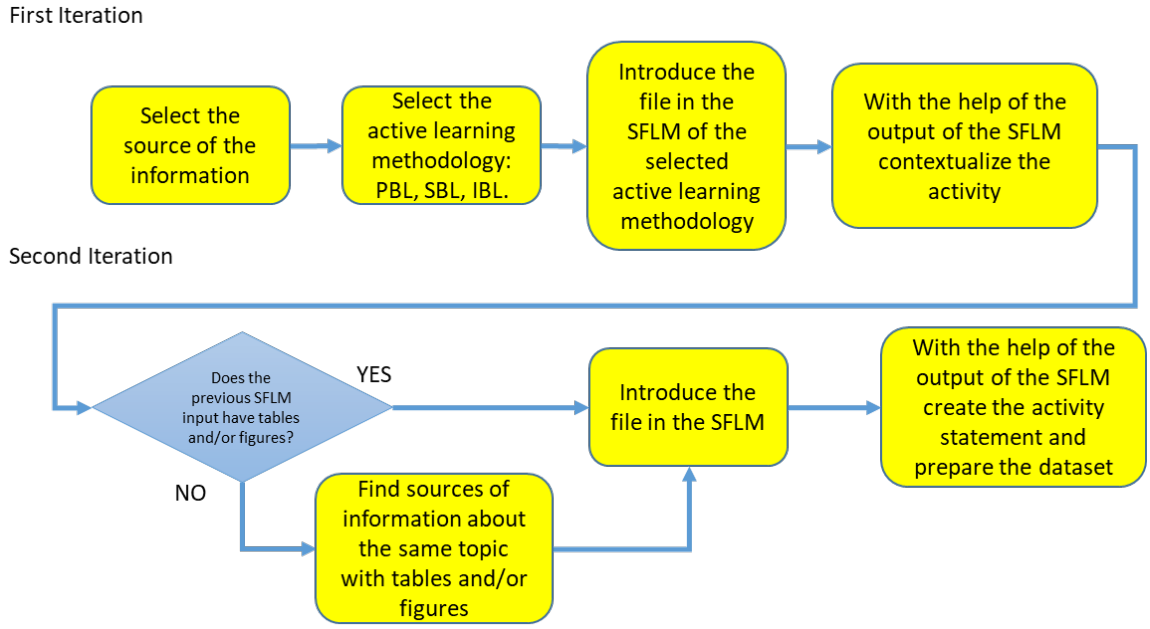

Figure 3. How to adopt the SFLM for DBL in two iterations.

The following table has been designed to help the teachers to adapt the dataset regarding the course context:

	Tutors' aims	Comments (to be filled by user)
Step 1	Collect information from a real-world source.	
Step 2	Find relevant information, and relations between datasets and images, using the SFLM	
Step 4	Design the activity and write the activity statement with the help of the SFLM outputs	
Step 5	Analyse the dataset and see if it fits the learning outcomes	
Step 6	Adapt the dataset to the learning outcomes of the lesson	

Table 2: Steps for adapting the dataset regarding the course context.

2.3. How to adapt my DBL activity regarding my course context?

2.3.1. Must the other activities of the course be related to the DBL activity?

In a DBL activity the students learn about a subject through the experience of working directly with a dataset taken from real situations. To improve the flow of the activity, the concepts that are used during the activity should be taught in advance. Thus, the DBL activity should be preceded by at least one theory class. However, the methodology used during the theory classes is not restricted to a master class. Active learning methodologies, such as flipped classroom, are recommended to help the students to get used to student-centred and collaborative learning.

2.3.2. At which point of the course should I introduce the DBL activity?

In DBL activities, students need to apply previously acquired knowledge and critical thinking. For this reason, it is advisable to introduce the DBL activity once the students are used to the course dynamics in order not to overwhelm them. However, the DBL activity could also take place at the beginning of the course, but its difficulty should be adapted to the students' level.

2.4. How, when and what to evaluate?

2.4.1. What is the target of the course scripting evaluation?

The target of the evaluation is to identify the strengths and areas for improvement of the course scripting, which allows the teacher to reflect on the designed learning process and improve it to correct its deficiencies.

2.4.2. What do I evaluate during the course scripting process?

The course scripting process evaluation must analyse if the course scripting designed by the teacher is sufficient to achieve the learning outcomes of the course.

2.4.3. When and how do I evaluate the course scripting?

The course scripting must be evaluated prior to the lesson, during the lesson and after the lesson.

Before the lesson, the available data is limited, thus, the teacher must review the course scripting by themself. It can be helpful to use tools such as the checklist provided in section 5.4.

During the lesson, the teacher can observe how the course scripting conditions the course of the lesson and evaluate if it is appropriate for the achievement of the learning outcomes.

After the lesson, the teacher can analyse how the course scripting has conditioned the reports handed over by the students and evaluate if it is appropriate for the achievement of the learning outcomes.

2.4.4. What do I do after the course scripting evaluation?

As mentioned, the target of the evaluation is to identify the strengths and areas for improvement of the course scripting. Once they are identified, the teacher should work on them to improve the learning process.

2.4.5. Tool

The following checklist has been designed to help the teachers during the course scripting evaluation prior to the lesson.

	Yes	No	Notes
Does the course script contain all the information required to follow the lesson?			
Does the course script consider the previous knowledge that the students may have?			
Is the course script easy to follow without misinterpretation?			
Are all the tools and equipment required for the lesson described in the course script?			

Table 3: Checklist for the course scripting evaluation.

3. Course Flow

3.1. What are student's activities during the lesson?

3.1.1. How many activities do I need to include in my lesson?

The number of activities in the lesson depends on the design of the lesson itself and may vary. However, a DBL lesson should have at least one DBL activity.

3.1.2. Do the activities have a certain duration?

The duration of the activities may vary and depends on the duration of the lesson, the number of activities in the lesson and the complexity of the activity.

3.1.3. Do the DBL activities have a common structure?

The basic structure of the activity is defined by the active learning methodology in which it is contextualized. In general, it could be the following: the students are given the activity statement, and the dataset that they are going to work with (if required). The teacher must ensure that the students understand the activity statement and the target of the activity. Then, the students work in groups (preferably small groups of 2 or 3 people) to solve the activity. During the process, the teacher must act as a guide, letting the students be the principal actors during their learning process. Once the working groups have reached a possible solution, the teacher will validate it. Optionally, the working groups may expound their solution to the rest of the class. This is especially relevant in activities in which the solution is open and may completely vary from one group to another.

3.1.4. Example

In the proposed example, the core of the lesson is performed synchronously in approximately 2 hours. It follows the following script:

i. Description of the work to be done. The teacher explains the hypothesis: "investment in R&D improves life standards". She/he proposes students the following scenario: the student is the Minister responsible for research in a national government and she/he is trying to convince the Minister responsible for managing the national budget, and the other Ministers from the Cabinet, about the national interest in using the money for investment in research and innovation. Thus, she/he has to develop a report that exposes the thesis and its validation by making a data analysis looking for relations between both concepts at EU level.
ii. Description of the data sources. The teacher presents Eurostat and the reports used for this exercise. Several documents coming from Eurostat are

used for the data analysis, so it is necessary to explain what Eurostat is in order to justify the relevance of its reports.

iii. The students work guided by the teacher. Students have to develop a short report that validates (or not) the hypothesis. This report has to include data analysis from the documents provided. It can include data, tables and figures from them, but with the corresponding citation. They can use the SFLM to extract elements for the analysis because they do not have too much time for reading all the reports.

iv. Presentation of the results: Students expose their results to the class and the teacher promotes discussion.

v. After the lesson (asynchronous and synchronous learning) the students have the opportunity to improve their qualifications by making the same analysis in other geographic areas: comparing different regional areas (regional level, not countries) inside the EU, or comparing the EU data with other countries data. They will need to look for other data sources and to manage them with the SFLM. With this analysis, students will develop a report that they will send to the teacher.

The process is shown in the following diagram:

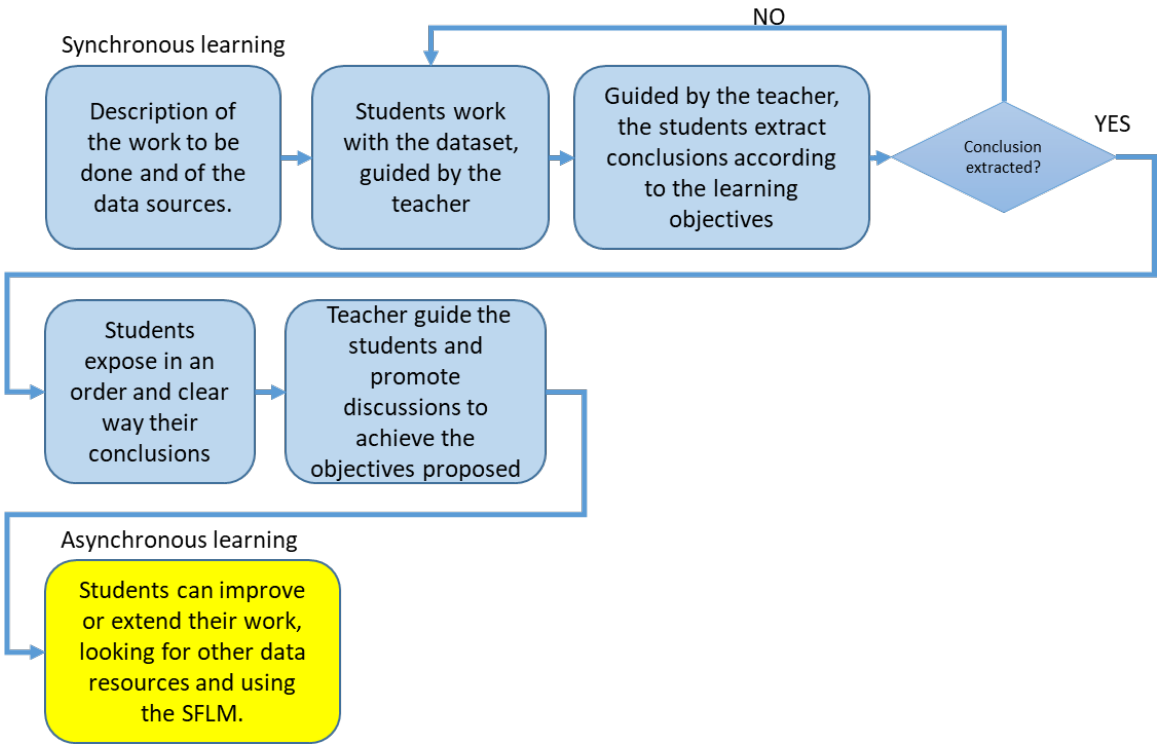

Figure 4. Flowchart of the course flow of the DBL activity example.

3.1.5. Tool

The following table has been designed to help teachers to follow the DBL activity:

	Tutors' aims	Comment (to be filled by user)
Step 1	The activity starts when the students are given the statement. This may include the dataset that is going to be used.	
Step 2	The teacher and the students read the activity statement, and the teacher ensures that they have understood the activity correctly.	
Step 3	The students work in groups with the dataset to solve the proposed activity. The teacher acts as a guide, helping the students during the process when needed.	
Step 4	Once the working groups have reached a solution, they can present it to the teacher who will validate it.	
Step 5	Optionally, the working groups can expound their solution to the rest of the class.	

Table 4: Steps to follow during the DBL activity

3.2. How to guide students in their learning activities?

Due to the fact that the DBL is contextualised in an active learning methodology (IBL, SBL, PBL), it is the active methodology that defines how the teacher must guide the students through the learning process. Therefore, we advise the reader to revise the Pedagogical Guideline of the methodology under consideration. However, in general terms, the teacher should promote collaborative learning and encourage the students to achieve their own solutions.

3.2.1. How to promote collaborative learning?

Teachers must give students the chance to share their ideas, listen to the ones of their classmates, and enhance dialogue (Brooks & Brooks, 1999).

3.2.2. How to help students to develop their own solutions?

Instead of giving solutions, the teacher must let the students find their own. This can be done by asking questions with open answers and letting them learn from their own mistakes (Brooks & Brooks, 1999).

3.2.3. Examples (video, interview, pictures, schemes)

If the students do not arrive at the right conclusions during the activity, the teacher can motivate them to repeat experimental and/or numerical work. Once the right conclusions are reached, the working groups share all the information in an oral presentation that can be completed with other information obtained from scientific papers, books, web pages, notes and so on. The teacher guides the students and promotes discussions to ensure that the learning objectives are achieved.

3.3. How, when and what to evaluate?

3.3.1. What to evaluate during the course flow?

During the course flow not only the performance of the students should be evaluated, but also the development of the course itself.

3.3.2. How to evaluate the course flow?

During the course flow, the teacher must monitor ongoing learning through observation. The observation should focus on the students to evaluate their performance and behaviour during the activity, as well as on the acquisition of transversal competences. In addition, students can also evaluate their own performance and that of their peers.

3.3.3. When to evaluate the course flow?

The course flow can be evaluated during and after the lesson. However, it is important to collect as much information as possible during the lesson.

3.3.4. Tool

A list of classroom evaluation (or assessment) techniques can be found here: https://vcsa.ucsd.edu/_files/assessment/resources/50_cats.pdf (Angelo & Cross, 1993).

4. After course

4.1. How, when and what to evaluate?

4.1.1. What to evaluate after the course?

After the course, the teacher should evaluate the whole learning process, that is: the course scripting, course flow, the students' performance, the teacher's performance and the outcomes.

4.1.2. How to evaluate after the students' performance?

The students' performance needs to be evaluated not only for grading, but also to analyse the effectiveness of the learning process. Rubrics can be used to evaluate the acquired knowledge, the acquired transversal competences and the level of engagement and behaviour of the students (Brookhart, 2013; Ragupathi & Lee, 2020).

4.1.3. What is the purpose of evaluating once the DBL activity is over?

The purpose is to make judgments about the program, to improve its effectiveness, and/or to inform programming decisions (Patton, 1987).

4.1.4. How to grade the students in a DBL activity?

The grading methodology depends on the teacher criteria.

4.1.5. Tool

Several Universities and educational organizations have created a bank of rubrics which are available in their webpages, such as:

- https://castle.eiu.edu/sa-assessment/rubricbank.php
- https://www.kent.edu/ctl/rubrics
- https://www.aacu.org/value-rubrics

Some advice for evaluating can also be found here:

- https://meera.snre.umich.edu/evaluation-what-it-and-why-do-it

Glossary

SFLM: Super-Fast Learning Machine.

PBL: Problem Based Learning.

IBL: Inquiry Based Learning.

SBL: Scenary Based Learning.

DBL: Dataset Base Learning is a student-centred pedagogy in which students learn about a subject through the experience of working directly with a dataset taken from a real-life situation.

ILO: Intended Learning Outcomes. It refers to the knowledge or abilities that students acquire during a learning activity or a lesson.

DBL activity: It refers to an activity that is designed according to active learning methodologies in which the students work with a dataset. In this activity, the students need to apply previously acquired knowledge and also acquire new knowledge. In addition, the activity requires the students to make reflective decisions, understand and justify the results.

Dataset: It is a collection of data that is going to be used as working material in the course context. It may be a complete dataset or it may have missing data that the students need to complete by themselves. Ideally, it should be taken from a real-life situation.

Activity statement: It is referred to the document that the teacher hands out to the students at the beginning of an activity. The activity statement contains the description of the issue that is going to be addressed during the activity, additional information such as datasets can be attached to this document. The first step of conducting an activity is understanding the activity, that should be the aim of the activity statement.

Database: A structured set of data, which can be stored in an internal computer system, or it can belong to an external source which can be accessed remotely. Datasets can also be included as tables in documents.

Course context: It refers to the academic and social context of the course. In addition, each lecture also has its own context: the type of methodology that is being used, the attitude of the students towards the lesson, the previous knowledge and experience of the students, etc.

Learning Activity: Student's activities can be seen as teaching resources that can be used not only to evaluate knowledge but also to acquire it. It is a procedure that takes place during the teaching process, focuses on the students and its

target is to motivate the involvement of the students. It has been defined by some authors (Lockwood, 1992) as exercises or practical cases whose intent is not that the students memorize concepts and apply them in a mechanical way but to convert them into something dynamic and functional.

Guidance: In the context of a learning activity, guidance may be understood as the process of helping the students through their own efforts to develop a solution for the proposed activity. Thus, guidance is not giving directions, but rather helping them to make their own decision and achieve their own solution

Evaluation of the learning process: Evaluating the learning process is a systematic and planned process that consists in collecting information which allows to analyse and extract conclusions about the learning process with the purpose of improving its effectiveness. The evaluation of the learning process includes the evaluation of the course scripting, and the teacher and students' performance.

Evaluation of the students performance: Students' evaluation is a crucial part of the learning process. Two evaluation types can be performed during the course flow: formative and summative. Formative evaluation is used to identify strong points and areas of improvement in a learning process in order to improve it. While summative evaluation is used after the course completion to assign the grades.

Grading: Grading is judging the knowledge displayed by the students during an exam or an activity. It is commonly performed as part of the evaluation of the course, after the course (New Faculty Academy, s.f.).

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