

Investigating how Learning Design tools can support Spaced Learning

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For all who unconditionally stood by my side during this journey

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Abstract

Nowadays, neuroscience is advancing very fast the understanding of how our brain works. There are lines of investigation dedicated to the process of learning. Methods such as Spaced Learning that optimize the learning process have been discovered but most of the time these methods are not applied in real classes. However, these methods could be improving learning in students. Spaced Learning is a learning method which aims to encode knowledge in long term memory on a short time scale. Studies have shown it to be more efficient than conventional classroom methods.

The main objective of this work is to find a way to apply a method that optimizes the velocity of learning with the help of learning software. In order to do that, I evaluate two learning design tools (FROG and edCrumble), select the one that best suits Spaced Learning, evaluate its performance, identify its limitations, and detail improvements.

Resum

Avui en dia, la neurociència avança ràpidament en l'estudi sobre com funciona el nostre cervell. Hi ha línies d'investigació dedicades especialment al procés d'aprenentatge. Gràcies a elles, s'han descobert mètodes com l'Aprenentatge Espaiat que optimitzen el procés d'aprenentatge però la gran majoria d'aquests mètodes no s'acaben aplicant a les aules. Tot i així, aquests mètodes podrien estar millorant l'ensenyament als estudiants. L'Aprenentatge Espaiat és un mètode d'aprenentatge que pretén codificar coneixement a la memòria a llarg termini en un curt interval de temps. Estudis han demostrat que aquest mètode és més eficient que els mètodes convencionals d'ensenyament.

L'objectiu principal d'aquest treball és trobar una manera d'aplicar un mètode que optimitza la velocitat d'aprenentatge amb l'ajuda d'un programa d'aprenentatge. Per tal de fer-ho, s'avaluaran dues eines de disseny d'aprenentatge (FROG i edCrumble), es seleccionarà la que es consideri més convenient per aplicar l'Aprenentatge Espaiat, s'avaluarà el seu rendiment, s'identificaran les seves limitacions i es proposaran possibles millores.

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1. INTRODUCTION

This project contains two states of the art as both are equally important to remark in order to correctly introduce the state of the problem and the content of this work. It is the combination of a learning method called Spaced Learning and how it could be applied through learning design tools.

1.1 State of the problem

Many studies in neuroscience have been centred around learning and finding methods to create a long-term memory learning in students in a short amount of time. An example of these type of studies was done by Prince and Felder (2006) at *Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases* [11]. They compared different learning methodologies based on their performance. There have been found innovative methods that reduce the time that a person needs to learn. Then, why most of the classes are still done by using conventional learning methods?

Ways that tie together these methods with learning tools that teachers can use in everyday classes have the potential to greatly help learners. There is already a project called *IlluminatED*¹ whose main goal is “*to reduce the existing gap between teaching practice and cognitive neuroscience*” (according to its definition in the official project website). Therefore, we should test and develop learning tools that can be easily applied in class in order to make more attractive the idea of applying these methods.

1.2 State of the art: Spaced Learning

Spaced Learning is a learning method which aims to encode knowledge in long-term memory on a short time scale. It has been proven to reach important time differences between it and the time applied to learning using conventional class methods. A specific study *Making long-term memories in minutes: a spaced learning pattern from memory research in education* by Kelley and Whatson (2013) [8] compared results in an exam between groups of students with different learning methods. The results were remarkable, the marks of the groups using one hour spaced learning class and groups doing four months teaching were very similar. Also, the best marks were reached by a group in where Spaced Learning was used to replace the end of course review for one of two examinations. In Table 1.1 we can see the specific differences in the scores between the group doing only conventional teaching and the group with an extra Spaced Learning session, which reach the highest scores.

¹ The consortium includes different universities from around the world: Pompeu Fabra (Spain), University of Western Macedonia (Greece), Advancis (Portugal), Boon (Portugal), the University of Helsinki (Finland) and Metropolia UAS (Finland). For more information check the website [16].

Instructional hours	Avg. score per group	Standard deviation
22h conventional teaching + 1h Spaced Learning	62.84%	15.47
23 h conventional teaching	55.24%	14.39

Table 1.1: Spaced Learning Experiment results
Student's scores using a spaced learning session or fully conventional teaching².

Knowing the results of that experiment, we need to understand why Spaced Learning should work, and how to apply it in a real class.

1.2.1 How it works? The method

Spaced learning combines periods of stimuli of no more than 20 minutes (which the student receives information with minor variations) with break periods where no information is provided. Break periods are a minimum of 10 minutes long and involve distractor activities to occupy the learner's mind.

1.2.2 Why it should work

The Spaced Learning structure with intervals of stimuli and distractor activities is not trivial. It has a neuroscientific basis as the structure potentially interacts with learning processes in the following manner.

Stages of memory and long-term potentiation

We can distinguish 3 stages of memory³. Firstly, the sensory register that is an automatic process that retains the impressions of sensorial information after the stimuli happens. It holds the information for at most a few seconds. Secondly, short-term memory which holds the information that you can actively think about. It lasts about 10 or 15 seconds. To retain the information from sensory register to short-term memory attention is the stage between them. Thirdly, there is long-term memory which retains the information for long periods from minutes to a lifetime. This is the state of memory that we want to reach in learning. To create long-term memories Long Term Potentiation (LTP) is required [19]. LTP is a process by which connections between neurons become stronger with frequent activation. Therefore, it is shown that repetition is an important factor to potentiate the long-term memory, that is why the Spaced Learning basis is repetition of information with minor variations.

² Data extracted from the results of Kelley, and Watson (2013) [8].

³ More information about stages of memory can be found in references [14] and [15].

Attention curve

There are variations in students' attention during a lesson. These variations have been illustrated in a diagram called Attention Curve. As Wilson and Korn (2007) reviewed in their study [12], Lloyd (1968) proposes the hypothetical curve of student's level of attention over time [9]. As we can see in the Figure 1.1, we can identify 4 different periods in the typical diagram of attention in a one-hour class. In the period I the attention increase. In this period the student generally has a fast understanding of the information and high motivation as well. In the period II the attention decreases so the efficiency in the learning process decreases too. In the third period the attention increases a little bit. This is usually a period where the teacher makes a review of the concepts exposed in class.

As we see in this diagram, according to attention the first 15-20 minutes are the most likely to students to learn. Therefore, a useful learning method could be a one that takes profit of this high attention period. That is why Spaced Learning uses this length for the stimuli periods.

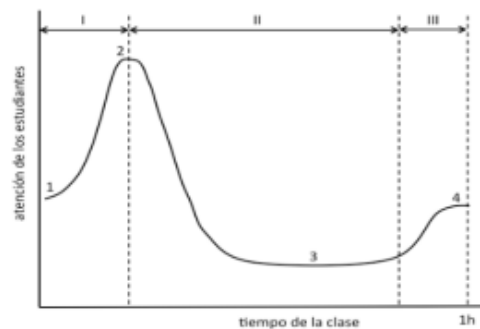


Figure 1.1: Attention Curve proposed by Lloyd (1968)

Spacing

Spacing effect is the phenomenon by the learning process results greater using spaced sessions instead of doing it at one single session. Some experiments have proved this fact, one example is explained in a study by Helene, Arnold and Tracey (2007) [7]. In this paper is explained that spacing positive effect in learning could be explained as “*cells are generated over time*” and also “*learning enhances their survival*”.

The spacing effect must seem contradictory with Spaced Learning, as we are proposing to reduce the time to learn, but it is not. We are just doing these separate “sessions” in a short amount of time, that is the reason why we do the distractor activities between the stimuli intervals.

1.3 State of the art: Learning Design tools

Learning Design (LD) tools are created to plan and structure learning sessions. There are multiple software tools designed to support learning by different perspectives. An example is shown in a study that illustrates different approaches to design a lesson done by Persico, Anastopoulou, Conole, Craft, Dimitriadis, Hernández-Leo, Kalu, Mor, Pérez, Walmsley (2013) [10].

The objective of LD tools is to help the teacher to easily plan the classes by sorting out the different parts of it and their duration. Furthermore, these planned sessions can be shared between teachers so they can exchange their methods and planning. In this work I have tested two tools of this type: Ed Crumble and FROG. I chose these two tools because both have features of a LD tool but with different perspectives regarding its functionalities. I also chose them because both are free to use and are still under development which means that they will be probably updated. Also, their developers were open to talk and discuss about their software which gave me the opportunity to go deeper in their analysis and in the understanding of its design.

1.3.1 EdCrumble

It is a web-based LD tool presented in the 13th European Conference Technology-Enhanced Learning (2018) by Albó and Hernández Leo [2]. It was created by the Interactive and Distributed Technologies for Education (TIDE), a research group from Universitat Pompeu Fabra (UPF). It is still a prototype, but it is functional and able to use for free. As it can be seen in the Figure 1.2, the environment is quite minimalistic with the timeline in the bottom of the screen helping the user to be aware of the structure and times of the session.

Its main functions are:

- Creation of Learning Designs.
- Design analytics computation.
- Sharing diagrams within community of educators.

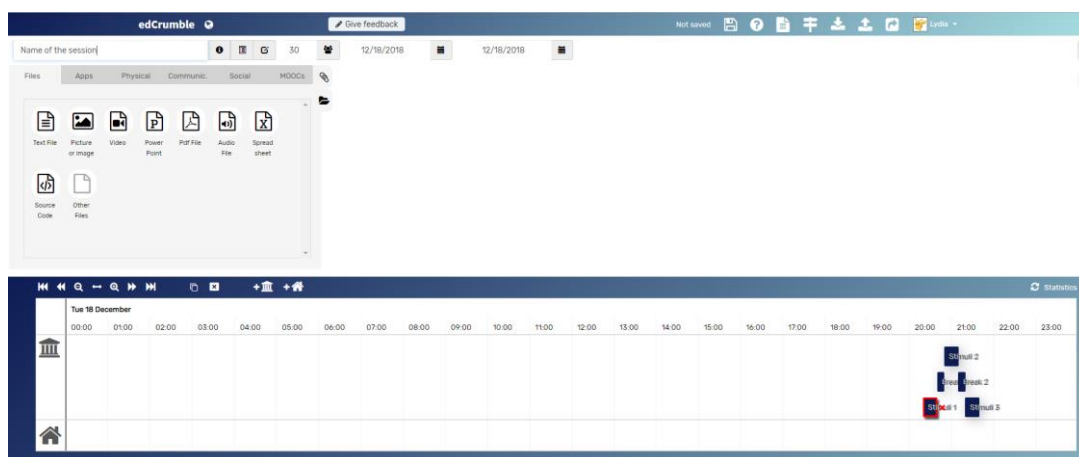


Figure 1.2: EdCrumble environment

1.3.2 FROG

It is a web application that allow teachers to design scripts by creating Orchestration Graphs (OG). It was presented at EC-TEL 2017 at Tallin by Håklev, Faucon, Hadzilacos and Dillenbourg [6]. It is still a prototype, but it can be downloaded in GitHub website so users can test it in their own local machines. It was created by collaborators from École Polytechnique Fédérale de Lausanne and from the Open University of Cyprus. This tool is not only a LD tool, it also allows teachers to design an entire session using an OG which is created by connecting activities and operators. As we can see in the Figure 1.3, the environment consists in different levels to place the activities. Each level performs different functionalities that will be discussed in the second chapter: Evaluation of Learning Tools.

Its main functions are:

- Creation of OG.
- Sharing OG by uploading them to a server or by downloading local files.
- Checking OG performance by a testing environment.
- Design learning analytics computation.
- Running OG and providing activities to students.

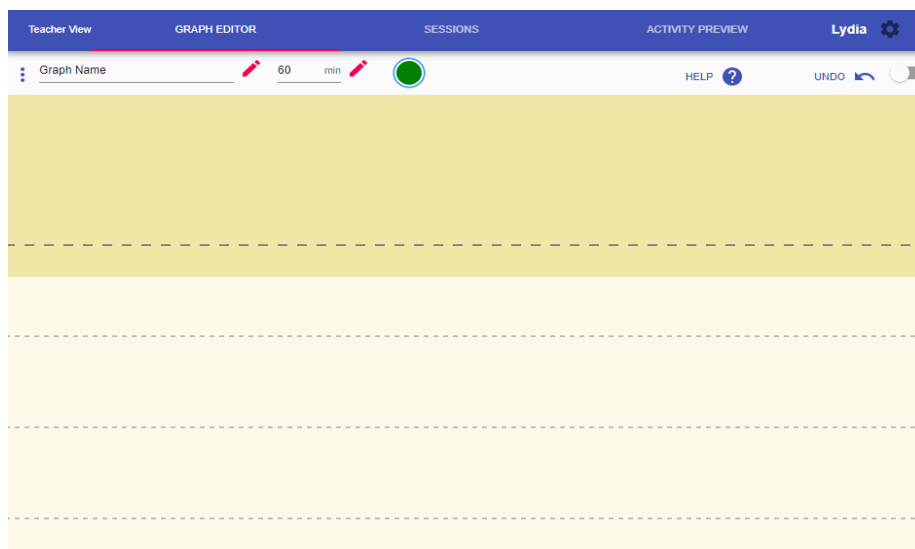


Figure 1.3: FROG environment⁴

1.4 Objectives

The main objective of this work is to find a way of applying Spaced Learning with the help of a LD tool and the support of other learning technologies. In order to do that, I evaluate two learning design tools, select the one that best suits Spaced Learning, evaluate its performance, identify its limitations, and detail possible improvements.

By following these steps, I attempt to find a way to apply an innovative and effective learning method with a software tool and find what is missing in it and how it could be improved.

⁴ Environment corresponding to FROG presented by Håklev, Faucon, Hadzilacos and Dillenbourg [6].

2. EVALUATION OF LEARNING TOOLS

In order to compare the two learning tools to apply a Spaced Learning session, I used both creating Spaced Learning diagrams and analysing their good points and disadvantages. The aim is to try to reproduce a teacher's needs in a Spaced Learning session and which of them can satisfy them better.

2.1 EdCrumble

To evaluate the performance of this learning tool to create a Spaced Learning session I designed a Spaced Learning diagram. It needs to be considered that this software is only to plan a session but not to execute it in a real time session. It should be just a guide for teachers that also allows them to share their templates.

2.1.1 Designing a Spaced Learning Diagram

In order to test the edCrumble environment, I created a Spaced Learning diagram that represents a 60 minutes session. The designed template can be seen in the Figure 2.1.

To create the template, the first step is filling basic information about the created environment such as its title, the number of students and the end and starting date. These dates can be used to plan an entire course, as you can design all sessions from the start to the end of a course in a same template. Even so, in this case I want to test the software for a single session, so the starting date is the same as the ending one.

After filling the basic parameters of the template, it is time to start creating the plan. In the window we can see two different lines. The upper line represents the work expected to be done in class and the bottom line the homework. In this case, I created all the activities at the upper line as the session is thought to be presential. The session can be planned by a block structure. I created a block for each of the Spaced Learning intervals, so we have 3 stimuli blocks and 2 break blocks. For each block we set its duration and the activities that contains. For example, for stimuli 1 can we set 7 minutes of theory lecture and 6 minutes of answering theory related questions to recall the content using Google Forms. For each activity, we can set different parameters as its duration, a short description and attached resources. For stimuli 1 attached files could be the link to the Google Forms questionnaire and the Power Point presentation that supports the lecture.

After creating all the blocks with their corresponding activities, the software gives us the option to publish and share it with the learning community. Once published, the information that will be seen of the template can be seen in the following picture.

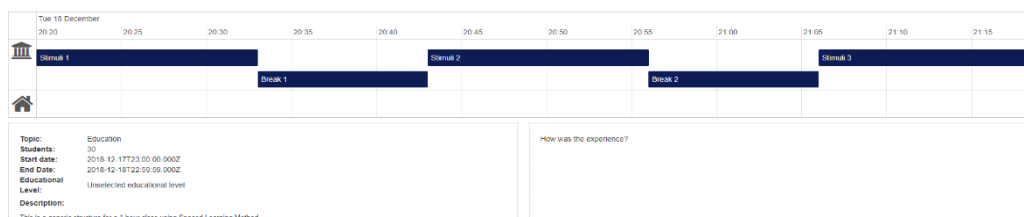


Figure 2.1: Spaced Learning template using edCrumble

It results in a published template that is too compact, so it is not possible to see either the activities that belong to each of the blocks or its description. Therefore, the resulting diagram is not enough for teachers to check all the constitutive parts of the session. An option could be to create a block for each of the activities, but then the structure will be not that clear and each block will contain only one activity, which is little redundant. It will be more intuitive if in the published version the user could double click the block in order to see the activities that constitute it.

2.1.2 Personal Evaluation

By creating the edCrumble template for the session I could notice some good points but also some inconveniences of the software. The evaluation conclusions are summarized in the Table 2.1.

Good points

There are several good points about this software. The software is easy to reach as it runs in web. The user only needs to register, and he can start his templates for free. Also, the parameters of the activities are easy to select, as the configuration can be settled by filling the gaps of the different activity settings through a drop-down menu or by typing. In addition, sharing a template is easy, the user only needs to click “publish” button and can share it within the community. Finally, in the same website of the software user can find short tutorials that show a global view of the application to the user. It is an important point as good tutorials can help to fast understand how the software works.

Inconveniences

There were some characteristics of the software that may not suit to be a software for planning a Spaced Learning session. There are some interactions that are not completely intuitive. For example, to attach a file we need to click on “attach a file” button and a menu opens on the left side of the screen. The menu is organized in different tabs and user needs to click on them in order to see the list of resources that contain. Even so, in order to select a resource within the menu you need to drag and drop it, instead of clicking on it, which could be not intuitive for the user.

The main cons of the software are the sharing options and the fact that is only a planning tool. Also, the functionality of the software is limited to just plan a session, therefore is a small support during the class, as the teacher cannot execute it in real time to “perform” the session.

Although, this software is still under development so is possible that the interaction or functionalities could change in a near future. For example, Laia Albó, an edCrumble developer, explains me that is expected that sharing options will be modified in a future to allow users to visualize all the information in the diagram when sharing it.

Good Points	Inconveniences
Web-based software.	Some interactions not entirely intuitive.
Short and useful video tutorials available.	Limited functionality: just to plan a class but not actually run it.
Easy to share content within community.	
Guided configuration of blocks.	

Table 2.1: Analysed edCrumble Pros & Cons.

2.2 FROG

To test the performance of this software, I created an interactive Spaced Learning session. As opposed to edCrumble, FROG cannot just plan but also execute a learning session in real time. Once the session is planned, it can be played in a real class so students will interact directly with the tool. Also, teachers can share their templates either downloading them or through the server so other users can use them or part of them for their own purposes.

2.2.1 Designing a Spaced Learning Diagram

In order to test FROG environment, I created a Spaced Learning diagram representing a 60 minutes session. The designed template can be seen in the Figure 2.2.

The FROG environment is quite different from edCrumble one. It uses a tab menu to navigate through the editor of the session, the activity preview and sessions tab. The activity preview tab allows user to automatically see a view of the selected activity. This is useful to test how students will see some of the resources, as the embedded videos, and check if the preview corresponds to the expected appearance of the activity. Sessions tab allows to create a session related to the created graph. Once the session is created, the user can obtain a link for students to login and teacher can control the progress of the session in real time. Also, it contains some analytics that can be downloaded and allows the user to do a preview of the graph as a student. Finally, in the Graph editor tab the user can create and edit the graphs for the session.

To start creating a new graph user needs to fill some general information about the session such as the name of it and its duration. The timeline will be displayed according to the selected duration.

In order to create blocks (that represent the activities) the user needs to do double click over the corresponding level. We can see 3 different levels inside the timeline. The levels correspond to (from top to bottom) whole class activities, team activities and individual activities. In this case, the correct form is to create the quiz questions in the individual line and the other blocks in the whole class line. In this case, the blocks represent an activity, so the final structure is quite different from the one obtained using edCrumble. Once a block is created, we need to indicate the type of activity that it represents, for

instance a chat, a quiz or a video player. Then, we need to give a name to the block so we can intuitively know its content from the graph and fill the different parameters according to the type of block. In order to select its duration, we need to select the block in the graph and stretch it until it lasts the desired duration.

After creating all the blocks, the user can share the graph with the learning community by uploading it to the server or downloading it.



Figure 2.2: Spaced Learning template using FROG

2.2.2 Personal Evaluation

While creating the Spaced Learning diagram using FROG, I notice some good points and inconveniences to plan a Spaced Learning session. The evaluation conclusions are summarized in the Table 2.2.

Good Points

Some features of this software make it likely to be used to plan a Spaced Learning session. Firstly, it contains more options in block creation and interaction, so it allows the user to create more complex graphs. Secondly, it is not just a planning tool but also an interactive one that can be used in a class. Therefore, is not just a tool for teachers but also for students. It also includes testing options in order to ensure how the session will execute and how participants will see it. It is also flexible for sharing options as the user can download it, share it and upload it to the server. The downloading option is also useful in order to keep a local security copy of the templates.

Inconveniences

Some of the FROG characteristics limit its capability to hold a Spaced Learning session. FROG can be used by locally installing⁵ it or through a web server. I used both versions to edit graphs, but the local installation is not entirely intuitive for Windows operating system, so I needed to install a virtual box in order to install it in Ubuntu. Therefore, installing the local version of the software for Windows users can be a problem. Even so, they could work with the web server version. Also, the interaction with the program is not entirely intuitive to use for editing graphs. It is based in clicks code. For example, to create a new block the user needs to double click the timeline. Then to edit it he needs to click a bar that is in the right side of the screen. Also, to move it from one level to another, the user needs to select the block and press shift to move it with the keyboard arrows. This could be a potential issue for non-expert users as they should learn these shortcuts before using the software. However, in YouTube can be found some FROG video

⁵ The local version software can be downloaded in Github [13].

tutorials⁶ that can be helpful to understand how to interact with the environment. Finally, there is no information about what each level of the timeline represents. It is not explained either in the “Help” option, so the user needs to learn it from another document as the explicative paper of the software.

Good Points	Inconveniences
More complex graphs can be done.	Local version not easy to install for Windows users.
Can run sessions in real time.	Needed to learn shortcuts before using it.
Tool for teachers and students.	No in-software information about levels.

Table 2.2: Analysed FROG Pros & Cons

2.3 Final Choice

After creating both templates and comparing the good points and the inconvenience of both software, I decided to use FROG. I made this decision mainly because FROG can also execute the sessions, so I think it will be more useful for teachers in order to create and execute a Spaced learning session. Also, sharing options are more suitable because in edCrumble teachers can only share a preview of the template so the rest of users will not be able to see the full structure of a Spaced learning session so it would be more difficult to share it. Also, FROG includes interesting options to create and test the graph, so the teacher can automatically see how the session will look like for students. EdCrumble does not give this testing and executing options so teachers will need to use other software to do this function so they will probably spend more time planning it.

⁶ FROG video tutorials can be found in Stian Håklev’s YouTube channel [20].

3. THE EXPERIMENT

The experiment to evaluate the application of Spaced Learning using FROG and its effects in a particular activity will consist in two phases. The first phase will be focused in the Spaced Learning session (plan it and execute it). The second phase will be focused in long term recall, it will be done weeks after the first phase in order to check how much can students recall about the lesson as it is important that information does not remain only in short-term memory (as it could be confused as false learning⁷) but also in long-term memory.

3.1 First phase of the experiment

The first phase of the experiment consists in applying Spaced Learning in a real class using FROG software. This phase needs to consider, not only the material for the class but also the information that needs to be collected in order to evaluate the performance of the experiment.

The main goal of the experiment is to test FROG as a LD for a Spaced Learning session. Also, it will be interesting to try to find some improvements in Spaced Learning sessions, so the class will be divided in two groups with a difference in order to detect if it affects the performance of the students. The approach is the following: *“Getting away from screen during break times will help to stop monotony of the class so it should improve the performance of students learning”*.

In this first phase, different materials will be needed. They are detailed in the following paragraphs.

Content of the class

Its needed to choose how the stimuli will be teach to students. This concept includes all the material which includes content related to the class such as a reading, a video, a Power Point presentation, questions to recall, etc.

Activities for break times

It is important to choose correctly the distractor activities in break intervals. As the main approach is that the difference between groups will be in the break intervals, we need to prepare more than one activity. The activities should be enough different between them in order to satisfy the approach but also enough similar in order to not introduce undesired differences between the groups. E.g. the cognitive charge for drawing or counting is not similar so it will introduce an undesired difference between the groups.

⁷ False learning is the phenomenon that happens when a student thinks that he or she has learning something, but the content is only in his or her short-term memory, so it is not a true learning process.

Evaluation method

In order to compare the performance of the two groups we need an evaluation method. We need to compare how much the students have learn in the class in order to check if the approach affected their performance or not.

Program the session in FROG

Once all the material used in class is prepared, it needs to be included in a FROG session. It should show the students all the material in the right order and provide them the correct instructions to follow the lesson.

Pre-questionnaire

In order to check the results of the session, we need to know the level of knowledge about the content of the students right before the lesson. Previous knowledge is a basis to construct learning, as it has been shown in some studies such as *The Relevance of Prior Knowledge in Learning and Instructional Design* by Hailikari, Katajavuori, and Lindblom-Ylänne (2008) [5]. Therefore, we need to consider the previous knowledge in order to evaluate correctly the performance of both groups.

Post-questionnaire

In order to check the impressions of students during the session a post-questionnaire is needed. It is important to know how they feel during the session and check the difference of their impressions depending on their experimental group. Also, it can be helpful to collect some possible improvements of the experiment based on student's experience.

3.1.1 Planning a class

The experiment was planned for 20th of February. The class is a lesson within an optional subject common to several Master Programs at Universitat Pompeu Fabra (UPF). The students were asked to bring a computer and headphones for the class as they would need them during the session.

The prepared material is detailed in the following paragraphs.

Content of the class: video and review questions about NGDLE

The content for the class was based on a report on research by Brown and Millichap (2015) about the Next Generation Digital Learning Environment (NGDLE) [4]. The content of the class will be provided to the students through a video and review it through questions about it.

Making a video is a good way to be sure that the exact amount of time to receive information is respected. If the information was provided by a text, for example, it will be harder to measure the amount of time that each student needs to read it. I tried different software to make a video which were easy for teachers to use and visually attractive for

students. I finally chose Moovly⁸ as there is a free trial version and it is very intuitive to create videos. The videos created for the session were uploaded in “Hide” permission in order that only those with the link can watch it [17] and [18]. The content was divided into two videos in order to divide the cognitive charge in the first and second stimuli where the new content will be provided (the third stimuli will be a review from stimuli 1 and 2).

A part of the video, I also created a set of questions about NGDLE so the students could review the content of the videos and complete their own notes. The aim of these questions was to help students identify important concepts of the video by answering them.

Activities for break times: Pictionary

The approach of the experiment is that the difference between the Group 1 and Group 2 is the break time activity. I decided Pictionary as a break activity. The reason is that I can use drawing for the two groups (so the cognitive charge in both groups will be pretty much the same) but one group will use online software to draw and the other one will use paper and pencil, so the approach is achieved.

Both groups will receive the instructions of the game through FROG and then both will start drawing something following the instructions. Group 1 will use the online software YouIDraw⁹ clicking in the link that will be provided to them using FROG. Group 2 will draw using paper but following same instructions. The same time will be provided to both groups to draw and guess their companions’ drawings.

Evaluating method: Kahoot!

After all the information and review questions are done by the student, they will evaluate their learning performance through a contest. The software used to do this contest is Kahoot¹⁰. It is a free online software that allows to create quizzes as contest. The questions will be provided to students by the projector and they will answer using their computers, tablets or phones. In Figure 3.1 we can see an example of its environment. I chose this software as there are some studies that apply this specific software to increase the engagement students, an example of these studies has been done by Alamanda, Anggadwita, Ramdhani, Krieska, Susilawati (2019) [1] .

The quiz consists in 11 questions about NGDLE. The punctuation is based on two factors: if the answer is correct and the time to reply it. If the student responds correctly, the faster he or she answer the higher punctuation will obtain. This software is very useful as it allows teachers to download the results of each of the participants to check their performance after the game is finished.

⁸ The online editor can be found in its website <https://www.moovly.com>.

⁹ The YouIDraw software used for pictionary is free to use online and its available at <https://www.youidraw.com/apps/painter>.

¹⁰ Its webpage is available at <https://kahoot.com>.

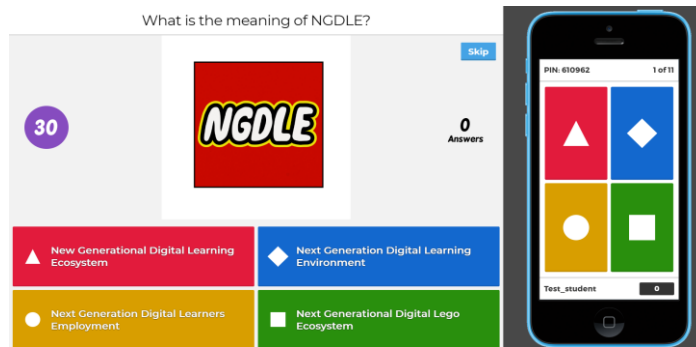


Figure 3.1: Example of a Kahoot! contest environment

Program the session in FROG: structure

The session needs to be planned using FROG. I contacted with Stian Håkleiv, one of the developers of FROG software, in order to obtain a server link to create and share the session with the class. Once the link was provided, I created a session that should last about 80 minutes. This 80-minute session was divided in 60 minutes to do the Spaced Learning session (with the stimuli-break structure) and 20 extra minutes to answer the pre-questionnaire and post-questionnaire (both necessary to evaluate the experiment results).

The created blocks are detailed in the Table 3.1.

Name	Duration [minutes]	Description
Pre-questionnaire	10	It contains the link of the Google Forms pre-questionnaire.
Stimuli 1: Watch this video!	7	It contains the NGDLE (I) video embedded from YouTube platform. Students need to watch it and can take notes at the same time.
Stimuli 1 Quiz	4	It contains a question: what do you remember from the video? Students must write down everything they can remember from the video without looking their notes.
Stimuli 1: Watch video again	5	It contains the embedded video NGDLE (I) again so students can review the information. *It is shown simultaneously to Video Notes 1 block.
Video Notes 1	5	It contains questions about the video so the students can complete their notes by looking for the answers in the NGDLE (I) video.

Break 1: Pictionary	10	Instructions to play Pictionary for each group. Both groups are asked to draw in cute style animals which name starts with the letter that I say to them during class. Group 1 should click on the link to draw it online with YouIDraw and Group 2 should use paper.
Stimuli 2: Watch this video!	8	It contains the NGDLE (II) video embedded from YouTube platform. Students need to watch it and can take notes.
Stimuli 2 Quiz	4	It contains a question: what do you remember from the video? Students must write down everything they can remember from the video without looking their notes.
Stimuli 2: Watch Video Again	5	It contains the embedded video NGDLE (II) again so students can review the information. *It is shown simultaneously to Video Notes 2 block.
Video Notes 2	5	It contains questions about the video so the students can complete their notes by looking for the answers in the NGDLE (II) video.
Break 2: Next Level Pictionary	10	Instructions to play Pictionary for each group. Both groups are asked to draw with their non-dominant hand professions that start with the letter that I say to them during class. Group 1 should click on the link to draw it online with YouIDraw and Group 2 should use paper.
Stimuli 3: Review Questions	5	It contains review questions of both NGDLE videos. Students can use their notes to answer them.
Stimuli 3: Competition Time (Kahoot!)	9	It contains the link to Kahoot! to start the competition. In this case students cannot review their notes.
Post-Questionnaire	10	It contains the link the Google Forms post-questionnaire.

Table 3.1: Block list from the Spaced Learning session using FROG

Authorization document

As the analytics of the students will be used for the experiment results, they need to be aware of the use of their data. Therefore, I provide them an authorization document explaining that the ones who sign it agree to the fact that their analytics will be used for a TFG for academic use only. The document is voluntary so if any student does not agree her or his data will not be collected.

Pre-questionnaire: Forms

The pre-questionnaire consists in 3 parts. At the first one, student need to choose the group that they were assigned to. At the second one, student need to rate their level of familiarity with various statements related to NGDLE in order to have a measure of their previous knowledge. They need to rate each concept from “Very familiar” to “Not at all familiar” in a 1 to 5 scale. The last part is an open question about their past experiences related to the concepts of the second part. The complete pre-questionnaire can be found in annexes 1.

Post-questionnaire: Forms

The post questionnaire consists in 3 parts. At first part, students need to select their group. At the second one, students need to rate from “Strongly Disagree” to “Strongly agree” in a 1 to 5 scale their level of agreement with statements related to their sensations during the experiment. The third part consist in two open questions related to their personal evaluation of the session and the use of software to lead a Spaced Learning session. The complete pre-questionnaire can be found in Annexes 2.

3.1.2 Implementation

As it was planned, the session was at 20th of February at 6pm. The number of participants was 9, and all of them agreed and signed the authorization document.

The professor of the subject explained to me that students had studied the Spaced Learning method, so they were familiar with the structure of the session. We were answering doubts and clarifying what they need to do all along the session. Also, before the session started, we explained to students the structure of the lesson and we assigned a group to each student. Group 1 was formed by 4 students and Group 2 by 5, they were assigned randomly.

During the session, some issues happened:

- FROG text boxes to answer the questions seems to be collaborative. That was an unexpected behaviour as soon as students tried to answer the questions using FROG textbox, they all can see the same textbox, as if it was a Google Drive collaborative document. The issue was communicated fast, so I asked students to reply to the questions on a separate local software as Microsoft Word or Notepad. The issue was detected in no more than a minute, so the planned times were not affected for this issue. Even so, they needed to switch windows to answer the questions which could affect their performance.

I had the opportunity to talk about this issue after the session with one of FROG developers. He explained that the issue was that the block was not in the correct level (it should be at the bottom line instead of the top line). The issue was hard to detect as testing environment does not reflect it. Even so, the issue was a design mistake but not a software problem.

- A student's laptop runs out of battery during the session. The student pertained to Group 2. His battery stopped working by the third part of the session. He could play Kahoot! and answer the post-questionnaire as I lend him my own computer, but he loses his notes and this fact affected to his experience of the class. He also could not answer the recall questions of stimuli 3, so he did not do the recall part before the Kahoot! competition, so it is also possible that his performance was affected by this fact.
- One of the students from Group 2 was reading about another topic during a break interval after finishing the drawing. This type of facts breaks the structure of the session, as all students mean to experience this resting time in order to avoid being saturated of information. Therefore, this issue could affect to his learning experience.

These were the problems that me and the teacher could notice during the session. In the post-questionnaire students can transmit any other problems that they could detect during the session.

3.2 Second phase of the experiment

The second phase of the experiment did not require as much material or time as the first one. The second phase was at 6th of March and students did not know that they will do a recall questionnaire that day. They were not warned about the questionnaire in order to avoid that they study for it. This phase lasted about 15 minutes and students were not allowed to check their notes to answer the questions.

The goal of this phase of the experiment was to check how much students could recall from the previous session in order to check if they effectively learned the content. The recalling questionnaire consisted in three parts. At the first part, students needed to select their group from the first experiment. The second part consisted in 10 questions where they needed to select the correct option. The last part consisted in one very specific question. This last question was difficult as it was very specific (it was related to one example). It was created in order to check if someone could remember that much from the video, but questions to measure if they could recall the session were the ones at the second part. The complete recall questionnaire can be found in annexes 3.

4. RESULTS & DISCUSSION

During both part of experiments information was collected in order to check the performance and experience of students during the experiment. The results that were collected correspond to the pre-questionnaire, the Kahoot! competition, the post-questionnaire and the recall questionnaire. Students were asked to answer more questions during the session, but these were not to analyse them but to help students to review the information.

The complete tables with the results of each of the questions can be found at annexes, at this section I will comment the general results and discuss them.

4.1 Analysing the results

In order to analyse the results, I used Excel tables to compute the results per group and globally of all students in each question. The short questions were grouped in tables to take them into account during the analysis and interpretation of the results.

Pre-questionnaire Analysis

At the pre-questionnaire it was measured the level of familiarity with concepts related to the content of the session in order to evaluate the prior knowledge of the participants.

In order to analyse the scale questions from pre-questionnaire I attributed a weight to each partition of scale. In the Table 4.1 there are the weight of each step of the scale.

Scale	Weight value
Very familiar	5
Familiar	4
Neutral	3
A little familiar	2
Not at all familiar	1

Table 4.1: Weight attributed to each scale step in the pre-questionnaire

In order to obtain an indicative measure, I computed the mean of each question applying the corresponding weight for each of the groups. Doing that, we obtain a score from 1 to 5 that represents the level of familiarity of each group from each of the question. All the tables and graphics from each group and question can be found at Annexes 4.

The short question was about any experience related to NGDLE. Is needed to consider that all students were assisting at previous classes of the subject, so at least all of them have experience with the concepts worked in class, some of them related to NGDLE. A

part of that, 3 students from Group 2 have done more related work or studies related to it. Therefore, it is very likely that they have more prior knowledge about the subject than the others.

Looking at the results we can notice that Group 2 is more familiar with them than Group 1, as in all the concepts Group 2 reports more familiarity than Group 1 in average. We will need to take this into account to interpret the results of this experiment, because prior knowledge is one important factor to evaluate a learning process.

Evaluation during the session (Kahoot!)

At the end of the session, students were asked to put their notes aside and participate in a game to evaluate their knowledge at the end of the session. In order to evaluate their results, there were 11 questions and each group earned a point if the answer was correct or 0 points otherwise. The average mark of Group 1 in a scale from 1 to 10 was 7.04/10 and the average mark of Group 2 was greater: 7.82/10. Also, the top 3 players were from Group 2. The correct answers from each group can be checked in Annex 5. Therefore, the performance of Group 2 was better than Group 1 in the evaluation questionnaire.

Post-Questionnaire analysis

After the session, students were asked to answer a short questionnaire about their own perspective and sensations of the experiment. The weights attributed to each step of the scale are in the Table 4.2.

Scale	Weight value
Strongly Agree	5
Agree	4
Neutral	3
Disagree	2
Strongly disagree	1

Table 4.2: Weight attributed to each scale step in the post-questionnaire

Looking into the results, in average both groups agree in that the lesson was easy to follow and that they were able to effectively learn the material. They also agree that the breaks were helpful and that they were able to concentrate better after the break time. Even so, in average they feel neutral about if the format of the lesson (online software) was helpful to effectively learn the material.

On average, Group 1 found more difficulties to pay attention to the second video than Group 2, and they also found more difficulties to remember the content from the second video than Group 1. Group 2 also found the break activities less boring than Group 1 and more disruptive.

About the results of the short questions, in general both groups agree that online software can effectively lead a Spaced Learning lesson. As strong points of the session both groups refer to the structure of the class and the material used to do it. As weak points, they refer to the content of the video (too much information and hard to memorize, too formal language, low audio, no new or interesting content).

Recall questionnaire Analysis (6th March)

Two weeks after the session, some questions related to the content were given to the students. The test consisted in 10 test question (which counted 1 point each one) and an additional short question, very specific. In a scale from 1 to 10, the average mark of the whole class was 7.67 and the median was 8, but none of the students could remember the short question.

We can see a significant difference in the average mark of the groups. The average mark of Group 1 was 6.75 and the average mark of Group 2 was 8.4. Therefore, there has been a remarkable difference between the performance of the two groups. Even so, none of the students could remember the short question. It was a very specific concept and some of the participants could remember the general idea of the concept but not the specific words and relations.

4.2 Interpreting the result

Looking into the results of the experiment, we can extract some facts that can help to interpret them.

- Group 2 had more prior knowledge related to the content than Group 1. Therefore, we need to consider that both groups were not balanced.
- Group 2 shown better scores in class evaluation than Group 1.
- Group 2 evaluated more positively the breaks than Group 1.
- Both groups were able to pass both exams, the recall and the in-class evaluation.

Looking at these facts, we can see that the performance and the experience of the session was better for the students from Group 2 than students from Group 1. It could be because Group 2 had more prior knowledge about the content, so they were able to easily learn the new material as they had the basis. Even so, it could be also because the difference introduced between groups. Group 2 get away from the screen during the break times, so they show better opinion about the break times and, they found out easier to remember the content of the second video (which was shown after the break time) than Group 1. Therefore, it could be that getting away from the screen during break times help students to more effectively learn the material by breaking the monotony of the session. Even so, it is needed to consider that the number of students is too low to extract an appropriate conclusion of the experiment. What we can say is that the average mark of both groups at the recall questionnaire was high (7.7), so it seems that they were able to recall the information from the session using long-term memory. Therefore, it shows that the Spaced Learning method has been effective for the students to learn the material as none of the students had fail the recall questionnaire.

5. LIMITATIONS & IMPROVEMENTS

After doing the experiment, in order to evaluate it is important to consider the limitations that I found doing and planning it. Furthermore, I will propose some improvements that would be helpful in order to improve the experiment but also the software in order to plan a Spaced Learning session.

5.1 Limitations

There were some limitations in the experiment and in the software used. I list them in order to be able to find out some possible improvements based on them.

Experiment

The experiment had some limitations that should be considered to correctly interpret the results and to improve them in possible future experiments.

- Low number of participants.
- Not enough participants to do a control group (a group not using Spaced Learning).
- The pre-questionnaire shown that the Group 1 and 2 were not balanced, as one had more previous knowledge about the content than the other.
- Some students were distracted during the session. The distractor activities were boring for some students, so they did other things as they ended the drawing. That could alter the break time as the distractor activity means to reduce the cognitive charge in order to improve the attention in stimuli time.
- During the experiment, students needed to use another software to answer the questions as FROG questions were not in the appropriate level within the software. This could distract students and reduce their attention as they needed to be switching windows.

Software

During the planning of the session I found some limitations in the learning design tool that I was using as well as the software to create the content of the class.

In one hand, I spent about 5-6 hours to create the content of the class and planning it, and this time does not include the time that I spend figuring out how the software works. This amount of time used for just one session of 1 hour limits the number of teachers that would implement this method, as they might not want to use this amount of time for a single session. In the other hand, during the planning of the session I found some limitations in the software that I used.

- **FROG does not measure the time in a real time session.**
The software allows to plan times for each task but when the session is played, teacher needs to click on 'next button' in order to go to the next part of the session. This is an important limitation as in a Spaced Learning session the time needs to be carefully measured during the session (I needed to use my own chronometer to measure the times).

- **FROG does not allow to block other applications.**
Some of the students can get distracted with their computers during the session. Some online exam software blocks other applications in order to avoid copying. It will be helpful to have this functionality in a software to avoid distractions.
- **H5P not supported in webserver.**
H5P is integrated in teaching online platforms as Moodle. It is a helpful learning tool that allows to create different types of activities and it is intuitive to create content. Also, it is visual attractive to students. In the FROG server this type of activity appears, but it does not work.
- **Limited analytics.**
It would be interesting to have more analytics about the students in order to study their interaction with the software. Analytics that FROG implement are limited, it would be interesting to track clicks for example and even tracks the attention of the student using a camera. Some exam software allows to track the user using a camera and even send a warning to the teacher if the student 'disappears' during the exam session. It will be useful to be able to track more information, either for research reasons or to avoid copying.
- **Not user friendly.**
The environment is not yet very attractive or intuitive. Not being intuitive is a problem to the teacher, who can feel disoriented using the software. Not being attractive could decrease the attention of students. Constructing an intuitive and attractive environment should be a must in order to use a LD tool.

5.2 Improvements

Either the experiment or the software, both could be improved. Some features are easier to improve than others, and some software functionalities are still under development so are likely to be included in the future versions of FROG.

Experiment

There are some improvements that can be done to the experiment in order to obtain more reliable results:

- A representative number of students.
- A third group without using Spaced Learning as a control group.
- The pre-questionnaire could be used to create balanced groups. There is one person in TIDE that is developing an algorithm to create balanced groups using different criteria and already applied to FROG software. The details about this group formation algorithm can be found in the paper by Amarasinghe, Hernández-Leo, Jonsson (2017), *Intelligent group formation in computer supported collaborative learning scripts* [3]. As the algorithm is already applied in FROG it could be used to create more balanced groups based on student's prior knowledge.
- More exciting activities in break times. E.g. one point for each drawing guessed by the group, then more paintings mean more points. This would reduce the probability

that students start doing other things after ending the drawing as they would have a motivation to keep drawing.

- Eliminate all possible distractions in the session. Some students were doing other things as they ended the drawing. This fact breaks the structure of the session so the session should be stricter to avoid this type of distractions. Ask them to keep away mobile phones, notes of other subjects and keep watching what are they doing all along during the session are examples of possible improvements to avoid distractions. It also could be useful to use a software that blocks other applications during the session as it is hard to control such large number of screens. Also, maintaining a strict silence during the class would help to avoid other distractions.
- Not using Microsoft Word, Notepad or other local software to answer the questions (as this would be uncomfortable for the students). Text boxes to answer the questions should be in the same window as the questions.
- Ratio content/time little lower. Most of negative points that students write were related to the amount of information per time. They consider it was too much to process.
- Using another method or software to share the content to students. Most of weak points of students were related to the video and it was a part that takes a significant amount of time to create. Therefore, it could be better to include in the video the person that is talking as some students suggested. The video could also be replaced by a person explaining the content alive, but it would be more difficult to be aware of the duration of the explanation.

Software

In order to implement Spaced Learning, it would be interesting constructing a software that allows to do it easily for teachers. The main goals are that the software should be intuitive for teachers to create content and allows them to construct an attractive environment for the student in order to keep their attention.

It would be useful to create a software that have all good points that we found in FROG and edCrumble and expanding their limitations.

Main features

This is a list of the main features that I considered the software could improve in order to assist a Spaced Learning session.

- **Allow planning a session and playing it, in real time.**
The software should measure the time and reproduce next activity when the time of the previous one is over. A chronometer also would be useful for students to know how much time they have.

I had the opportunity to talk with one of FROG developers about this limitation. He explains me that at the beginning they implemented to measure the time and automatically move on to the next part of the session. After doing some experiments, they found out that some teacher does not like that behaviour of the software as they feel that they do not have the control of the class. Even so, they are thinking to at least incorporate a chronometer.

Maybe for some sessions controlling times is not so important, but for a Spaced Learning class is essential to control the intervals of time as it is one of its bases. In the next paragraph is detailed a pseudocode to implement a real time session.

Pseudocode

total_duration = sum of all activities time, total duration of the session

accumulated_time = accumulated time of activities already ran and running at the current time

current_activity = activity running right now

while (current_time is less than total_duration of session)

```
{
    if(current_time is greater than the acumulated_time)
    {
        current_activity is equal to next activity;
        acumulated_time= acumulated_time + current_activity duration.
    }
}
```

- **Intuitive to create a session.**

The main target of learning planning tools are teachers who can be not familiar with programming. Therefore, this type of software should be user-friendly in order to allow less-experienced users to create content. The structure could consist in series of blocks and each block contains one or more activities, very similar to session structure from edCrumble.

Blocks structures

Using block programming style, it should be intuitive for teacher to plan a session. Each block created refers to an activity. The user would see for each activity a coloured block with the activity name. All blocks could be configured double clicking them and selecting the following parameters:

- Name of block = name that will figure in the block.
 - Type of activities = theory explanation / exercise / rest time / other: specify (select one or more)
 - Duration of block = specify in format hh:mm (hours:minutes)
 - Colour of the block = colour scale selection.
 - Description of the block = short description of what the activity is about.
 - Activities = file/video /iframe/ game/H5P package/ quiz/ link /textbox (select one or more). For each activity select:
 - Name of the activity
 - Type of content
 - Short description of the activity
- **Include Spaced Learning templates**
It will be extremely useful that the software saves some Spaced Learning templates (for standard time sessions like 1 hour or 2 hours). This way, user will only need to “fill the gaps “with the content they think it is useful.

Spaced Learning templates

Spaced learning templates would consist in the structure of a Spaced Learning session with some examples of resting intervals. They would consist in two types of blocks: stimuli block and resting block. The blocks will have the following parameters for one-hour session.

1) Stimuli Block 1

- Name of block: Stimuli block 1.
- Type of block: theory explanation + exercise.
- Duration of block: 13 minutes.
- Colour of the block: red.
- Description of the block: first stimuli, in this block is recommended to explain content to students and some review activities to recall the theory.
- Activities:
 - 7-minutes video (description: theory explanation).
 - 6-minutes recall exercises (description: review exercises about the video e.g. write all important concepts you can remember from the video, fill the gaps, etc).

2) Resting block

- Name of the block: Resting block.
- Type of block: resting time.
- Duration of the block: 10 minutes.
- Colour of the block: green.
- Description of the block: break time, in this block is recommended to make a relaxing activity, as playing one of the proposed games.
- Activities:
 - Game (description: disruptive activity to reduce cognitive charge of the student,).

3) Stimuli 2

- Name of block: Stimuli block 2.
- Type of block: theory explanation + exercise.
- Duration of block: 13 minutes.
- Colour of the block: red.
- Description of the block: second stimuli, in this block is recommended to explain content to students and some review activities to recall the theory.
- Activities:
 - 7-minutes video (description: theory explanation)
 - 6-minutes recall exercises (description: review exercises about the video e.g. write all important concepts you can remember from the video// fill the gaps, etc).

4) Resting block (same details as 2nd block).

5) Stimuli 3

- Name of block: Stimuli block 3.
- Type of block: review questions + evaluation.
- Duration of block: 13 minutes.
- Colour of the block: red.
- Description of the block: third stimuli, in this block is recommended to do review questions and an evaluation exam.
- Activities:
 - 5-review questions (description: questions about the content in order to review the concepts using the notes).
 - 8-minutes test (description: evaluation of the concepts, is recommended to ask students to not use their notes in order to evaluate the performance of the session).

- **Include basic games for break times**

One of the bases of a Spaced Learning session are the break times; therefore, it would be interesting to include basic games for these periods. Simple games that do not require too much explanation to students or to the software will be useful. For example, Pictionary, tic-tac-toe or battleships. It would be interesting to give points to the user in these games in order to keep the motivation high.

Game example: Pictionary

- User will be given a random draw (from a data set with drawings and related words to it) and need to guess the word related.
 - User will see the length of the word with blank spaces, letters will be appearing if the user is not writing the correct word (1 letter appearing every 15 seconds).
 - If user could not guess the correct word before all letters appear, he earns 0 points.
 - If user could guess the correct word, he earns points and see another word.
 - Points are earned in function of the velocity to guess the drawing and the total number of correct drawings answered in the amount of time of the duration of the activity.
 - All scores from all users will be add to a global ranking with all player's results.
- **Allow to create content within the application**
Basic content should be able to be created within the software. For example, simple quizzes, text boxes or recording a video.

Create content

The user should select the button "create content" in order to get to start creating. In this menu, several options will be shown, represented by icons and name. Some of the options that could be included are:

- Record: allows to record a video with a webcam. User can directly record the video through this option and then upload the result to the template.
- Quiz: allows to create a quiz based on a question bank or creating new questions. This tool should contain basic question types such as short answer, multiple choice and true/false. User could exchange the questions between quiz as each time a quiz is created, it will be also created an associated question bank. This

way, user could select some of the questions of the quiz by importing them from another quiz. Quiz settings such as punctuation of each of the questions could be set in the same editing menu where questions are created. The user would need to select the type of question to add and then precise its punctuation within the quiz.

- **Allow to export content**

The content should be able to be exported within sessions of the user and sharing it with partners. This way, some questions from a quiz could be used for different sessions optimizing the time to create it.

Exporting sessions

Exporting a single content from a session to another session of the user could be made by a personal repository of all the activities saved. For example, each content could have the option *Save it in repository...* so, the user could manage his activities saving them in different repositories. To export content with other users, it could be useful to give the option to download just this activity and add it in the working session.

This could be made not only for full activities but for just parts of it, for example the question banks. This way, the user could select to use some questions from the quiz made for other, so he could create a new quiz mixing questions from different quizzes.

- **Allow uploading H5P packaging**

Some educative platforms like Moodle allow to create content with H5P packages. It would be useful to integrate H5P in this software as it allows to create learning content in a very intuitive way, and it allows to show attractive activities to students. It also includes simple games like memory, which could be used for break times. A FROG developer explains me that this functionality is running in development mode, but not yet in several servers as the one I was using. Therefore, it is very likely that we will be able to use this functionality in all FROG servers very soon.

Optional features

There are some features that I consider are not indispensable but could be useful to incorporate in the software. Here I include a list of some options that could optionally be included in a software that supports Spaced Learning sessions.

- **Creating H5P packages within application.**

As it was mentioned before, H5P is a tool that intuitively allows to create interactive content that could be used for educative proposes. Therefore, it could be very useful to allow to create this type of content inside the application. Some educative platforms such as Moodle include a plugin that allows teachers to create this type of content within the platform, which could be very practical for teachers who want to include this type of content in the session. By allowing the user to create them inside the tool, it will not be necessary to create it using another interface, then downloading and then uploading. Furthermore, it would be faster to visualize the results integrated in the session using the previsualization tab.

- **Version for Beginners Vs Advanced users.**
It would be interesting create a simple version with basic features (simple quiz, text, videos) and an expert version with more complex features (e.g. creation of groups based on capabilities).
- **Allow users to upload their own learning templates**
The main idea is that users can exchange learning templates using a link, so only the user that have it can view it. Even so, some templates could be added as examples or templates as public for all users so they can use it. If a user wants to share his content with the community, he should accept the Terms and Conditions associate to share it and then wait for an administrator to validate it. By doing that, the sharer will be aware of what use can be done of his content and the inappropriate content would not be published.
- **Allow to block other applications**
In order to avoid distractions, it should be possible to define the session or part of it 'exclusively'. That means that the software should check the other applications running and block them in order to keep the attention of the student in the session. Some exams software applies this functionality, an example is *Safe Exam Browser*.
- **Interoperability with other platforms**
The learning planning tools are likely to be used simultaneously with other educative platforms such as Massive Open Online Courses (MOOCs) platforms. For example, most schools and universities use MOOCs to give a course entirely online or use other educative platforms as a complement. These types of platforms include well-known products such as Moodle, Coursera, edX or Future Learn. Therefore, it could be very useful that the software could have interoperability with some of these platforms. For example, creating a specific plugin to be used inside the platform or allowing to import-export simple components as questions banks from the software to the platforms. This could be very useful for teachers who already work with these types of platforms as they will not need to create again the whole quizzes from zero.
- **Balanced groups forming**
In order to help teachers to create balanced groups based in different criteria. In order to simplify this function, it could be developed an activity type called *Group Formation*. In this activity, the user should select the criteria to form groups, for example based in a result of a pre-questionnaire. Therefore, the teacher would need to only set the number of desired groups and the criteria that will be followed. In future implementations could be included more complex approaches such as cultural diversity groups or demographic constraints based on a template questionnaire supporting them.

6. CONCLUSIONS

Developing this work allowed to me to see from first perspective the limitations and problems found in order to develop a Spaced Learning session using a LD Tool as FROG and other available software tools.

6.1 Personal evaluation

I think that this work results very useful in order to be able to detect the pros and cons that a teacher will find planning a Spaced Learning session. I think that this was a good way to find all the limitations and the future possible improvements considering the results of the experiment.

I think that is very impressive that there is a learning method with neuroscientific bases and with proven results but that is not well-known. While doing this work, I talked about this method with friends, family and work partners and all of them does never hear about it. Even so, most of them show interest about it as they wanted to know more about a method that could help them to learn faster and effectively than conventional methods. I think that some teachers, schools or universities can feel insecure about applying new methods but also maybe it will be helpful that they receive a complete explanation about it to balance the pros and cons to apply it.

Also, I had the opportunity to test a couple LD tools while planning a real class session, which gives me a new perspective about software designing. I think that these tools could became very useful for teachers who gradually adopt this software to plan sessions, but I also think that software developers have the responsibility to design them in an intuitive way, so teachers feel comfortable by using them. Maybe if these types of software are developed in a friendly environment, in a not far future they could became a normal tool in schools and universities from all around the world. I also think that this type of technologies can became engaging for students as they could help to maintain student's motivation and attention during classes.

Finally, I really enjoyed this work as I think is related to lots of disciplines such as learning, software development and human-computer interaction. I think keeping investigating in these relations between different knowledge fields could result in very interesting outcomes as each discipline provides different points of view to the same problem which can be rewarding.

6.2 Further work

Based on the limitations that I found out doing this work, there is further work to do in the future.

It will be very useful to develop a software more intuitive and with more features that support Spaced Learning sessions. Furthermore, not only for this method but other ones that result to be useful in order to improve learning also making it easy for teachers to plan it. In addition, these learning methods should be promoted so the teachers could discover them and consider using it. This could be reached with projects like IlluminatED, which main aim is to introduce these methods to teachers.

Also, edCrumble and FROG are still in development. Some of the features proposed are likely to be included in new versions of the software. According to the conversations with them, developers will be working in make it more user-friendly and finishing some of the limitations commented below. Therefore, they could become a very good tool to implement these methods in class.

Finally, the results of the experiment were not conclusive, so another experiment with some improvements would help to prove if the approach is correct or not. The experiment could indicate that the students keeping away from the screen during break times made a better perform in the learning procedure. This approach could be used to introduce another optimization to Spaced Learning method, so it could be important to keep investigating it.

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Annexes

Annex 1. Pre-questionnaire questions

Pre-questionnaire

* Necessari

Please select the group you were in. *

Trieu una opció ▼

Rate your level of familiarity with the following statements *

	Very familiar	Familiar	Neutral	A little familiar	Not at all familiar
Education Technologies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Learning Analytics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Higher education learning systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Educational Data Mining (EDM)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Learning Management System (LMS)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Briefly describe any past experience you have related to the topics above (E.g. having studied, worked, completed projects related to the topics)

La vostra resposta

Annex 2. Post-questionnaire questions

Post-questionnaire

* Necessari

Please select the group you were in. *

Trieu una opció ▾

Rate your level of agreement with the following statements *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The lesson was easy to follow	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was able to effectively learn the material	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was difficult to pay attention to the second video	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was able to remember as much from the second video as from the first	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was able to concentrate better after the break time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The format of the lesson (using online software) was helpful to effectively learn	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The breaks were helpful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The break activities were boring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The break activities were disruptive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What were the strong points and weak points of the lesson? *

La vostra resposta

Do you feel online software can effectively lead a Spaced Learning lesson? Why or why not? *

La vostra resposta

Annex 3. Recall questionnaire questions

Recall Questions

What can you remember from NGDLE class? Please, do not use your notes. This questionnaire won't count toward your final grade.

* Necessari

Please select the group you were in. *

Trieu una opció ▼

What is the meaning of NGDLE? *

- Next Generation Digital Learners Ecosystem
- Next Generation Digital Learning Environment
- Next Generation Digital Learners Employment
- Next Generation Digital Lego Environment

Why is NGDLE Next Generation? *

- Because it must be informed by the new learning centered model
- Because it will affect next generation of students
- Because it will necessary use new technologies
- Because it will be 100% online

Which of these concepts are dimensions of NGDLE? *

- New Technologies, Accessibility and Progress
- Personalization, Collaboration and Universal Design
- Sociology, Analytics and Personalization
- Analytics, Exchange and Progress

Which of these has positively influenced the adoption of collaboration as NGDLE dimension? *

- Learning Analytics
- The development of robotics
- MOOC platforms
- The tsunami of social networking

What are the 3 Components of a NGDLE Environment ? *

- Learners, Personalization tools and Social Media
- Learners, Instructor tools and Content
- Open source software, Statistics and Analytics
- Learners, Open source software and Content.

Personalization in NGDLE is... *

- The least important aspect of user experience
- A design feature and has nothing to do with interoperability
- Covered with universal design and minimal changes
- The most important factor shaping user experience

In the Educase Annual Conference, 3 of the top 10 NGDLE approaches were about... *

- New frontiers
- Academic Assessment
- Personalization
- New Learning Tools

What does the Lego Approach refers to? *

- Using different applications to cover all NGDLE dimensions
- Using a single application to cover NGDLE dimensions
- Exchanging information between instructors
- Constructing new methods for teaching

The walled Garden problem refers to the issue of *

- Course being private communities
- Copyright content inside courses
- Students not interacting with teachers
- Not enough personalization tools in a course

What solution was proposed for the walled garden problem? *

- Entirely public courses
- Entirely private courses
- Courses with both private and public parts
- Using open source software

In the NGDLE session, an example of interoperability was presented that described how 3 components exchanged information about a student. (1) What were the three components? (2) Why did they exchange information? *

La vostra risposta

Annex 4. Results of Pre-questionnaire

Question 1: Education analytics

Education Analytics	Group 1	Group 2	Total
Very familiar	0	1	1
Familiar	0	2	2
Neutral	1	1	2
A little familiar	3	1	4
Not at all familiar	0	0	0
Results	2,25	3,6	2,93

Question 2: Learning Analytics

Learning Analytics	Group 1	Group 2	Total
Very familiar	0	0	0
Familiar	0	2	2
Neutral	0	1	1
A little familiar	4	2	6
Not at all familiar	0	0	0
Results	2	3	2,5

Question 3: Higher Education Learning Analytics (HELA)

HELA	Group 1	Group 2	Total
Very familiar	0	0	0
Familiar	0	2	2
Neutral	2	3	5
A little familiar	1	0	1
Not at all familiar	1	0	1
Results	2,25	3,4	2,83

Question 4: Educational Data Mining (EDM)

EDM	Group 1	Group 2	Total
Very familiar	0	0	0
Familiar	0	0	0
Neutral	1	2	3
A little familiar	2	3	5
Not at all familiar	1	0	1
Results	2	2,4	2,2

Question 5: Learning Management System (LMS)

LMS	Group 1	Group 2	Total
Very familiar	0	0	0
Familiar	0	2	2
Neutral	2	1	3
A little familiar	0	2	2
Not at all familiar	2	0	2
<u>Results</u>	2	3	2,5

Annex 5. Results of Kahoot competition

Questions	Group 1	Group 2	Total
Q1	4	5	9
Q2	4	5	9
Q3	2	4	6
Q4	2	4	6
Q5	2	3	5
Q6	3	4	7
Q7	2	3	5
Q8	4	4	8
Q9	4	4	8
Q10	1	2	3
Q11	3	5	8
Average	7,05	7,82	7,43

Annex 6. Results of Post-questionnaire

Question 1: The lesson was easy to follow

Lesson easy to follow	Group 1	Group 2	Total
Strongly Agree	1	0	1
Agree	2	3	5
Neutral	0	1	1
Disagree	1	0	1
Strongly disagree	0	1	1
<u>Results</u>	3,75	3,2	3,48

Question 2: I was able to effectively learn the material

Effectively learn the material	Group 1	Group 2	Total
Strongly Agree	1	0	1
Agree	1	4	5
Neutral	1	0	1
Disagree	1	1	2
Strongly disagree	0	0	0
<u>Results</u>	3,5	3,6	3,55

Question 3: It was difficult to pay attention to the second video

Difficult pay attention to the second video	Group 1	Group 2	Total
Strongly Agree	0	0	0
Agree	2	1	3
Neutral	1	2	3
Disagree	1	2	3
Strongly disagree	0	0	0
<u>Results</u>	3,25	2,8	3,025

Question 4: I was able to remember as much from the second video as from the first

Remember same from the 2nd video as from the 1st	Group 1	Group 2	Total
Strongly Agree	0	0	0
Agree	1	4	5
Neutral	1	0	1
Disagree	2	1	3
Strongly disagree	0	0	0
Results	2,75	3,6	3,175

Question 5: I was able to concentrate better after the break time

Able to concentrate better after the break time	Group 1	Group 2	Total
Strongly Agree	0	0	0
Agree	2	3	5
Neutral	2	2	4
Disagree	0	0	0
Strongly disagree	0	0	0
Results	3,5	3,6	3,55

Question 6: The format of the lesson (using online software) was helpful to effectively learn

Format of the lesson helpful to effectively learn	Group 1	Group 2	Total
Strongly Agree	0	0	0
Agree	2	3	5
Neutral	1	1	2
Disagree	0	0	0
Strongly disagree	1	1	2
Results	3	3,2	3,1

Question 7: The breaks were helpful

The breaks were helpful	Group 1	Group 2	Total
Strongly Agree	2	1	3
Agree	1	3	4
Neutral	1	1	2
Disagree	0	0	0
Strongly disagree	0	0	0
Results	4,25	4	4,125

Question 8: The break activities were boring

The break activities were boring	Group 1	Group 2	Total
Strongly Agree	1	0	1
Agree	0	0	0
Neutral	0	1	1
Disagree	2	1	3
Strongly disagree	1	3	4
Results	2,5	1,6	2,05

Question 9: The break activities were disruptive

The break activities were disruptive	Group 1	Group 2	Total
Strongly Agree	0	0	0
Agree	0	3	3
Neutral	1	0	1
Disagree	1	1	2
Strongly disagree	2	1	3
Results	1,75	3	2,38