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The JuxtaLearn Process in the Learning of Maths' Tricky Topics
Practices, Results and Teacher's Perceptions

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Keywords: Threshold Concepts, Tricky Topics, Technology-enhanced Learning, Creative Video Editing.

Abstract: This paper presents a study developed in the framework of a training course for teachers of STEM areas on the JuxtaLearn process. This process, divided into eight steps, aims to improve student understanding of threshold concepts by planning, editing and sharing creative videos in CLIPIT. CLIPIT is an online platform for collaborative learning designed to support the JuxtaLearn process. We describe the training of eight teachers, and the subsequent supervision of one of them, a math teacher, made to understand how the JuxtaLearn process was applied with her students. We collect qualitative data through the observation of the teacher's work. Also, quantitative data through initial and final quizzes applied to the students, to understand their level of understanding of the tricky topic, automatic records on CLIPIT and a satisfaction questionnaire applied to the eight teachers to assess the ease of use with the CLIPIT. The results show that teachers were able to put into practice the eight steps of the JuxtaLearn process and suggest that students' engagement in creating creative videos helped them in overcoming tricky math topics.

1 INTRODUCTION

The use of video editing as an educational approach in the school environment has raised considerable interest, due to the opportunity of collaborative construction of knowledge by students (Lencastre et al., 2015). The JuxtaLearn Process uses an approach built on creative video making by students, collaborative learning and reflection to enable teachers and students to overcome the barriers presented by Threshold Concepts. By engaging student curiosity in difficult-to-learn STEM subjects (science, technology, engineering and mathematics), JuxtaLearn supports students along a creative process to a deep and thorough understanding of topics that have been identified by their teachers as particularly problematic (Adams et al., 2013; Adams and Clough, 2015; Adams, Hartnett, and Clough, 2015).

In this paper, we use the term Tricky Topic to refer to these Threshold Concepts, because they are complex concepts identified by teachers we worked with based on their professional practice and may not correspond to the Threshold Concepts already documented in the literature according to Meyer and Land (2006). For more info about Threshold Concepts and Tricky Topics, please confer Cruz et al. (2016).

This study reports on the application of the Juxtalearn process as part of a teachers' training course. Teachers were tutored in the application of the JuxtaLearn process and would then use the process with their students. As part of this study we wanted to evaluate the application of the Juxtalearn process in these real contexts. To support the Juxtalearn process, including the sharing of videos by students, the Juxtalearn project developed the CLIPIT, a learning collaborative platform [http://clipit.es/uminho/] (Llinás et al., 2014). We also wanted to understand how teachers used the CLIPIT and the extent to which video editing has helped to improve the learning of Tricky Topics of a group of students.

We divided this text into five sections. In section 2, we present a framework for the JuxtaLearn project and the CLIPIT platform. Section 3 describes the adopted methodology and the procedures for data collection. In section 4, we present the data collected, the CLIPIT tools that assisted the teacher in JuxtaLearn process and we show the main reflections on the work carried out. In section 5 we present the conclusions and suggestions for future work.

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2 BACKGROUD

2.1 The JuxtaLearn Process

The JuxtaLearn process consists in eight steps (Figure 1) and is user-centred.

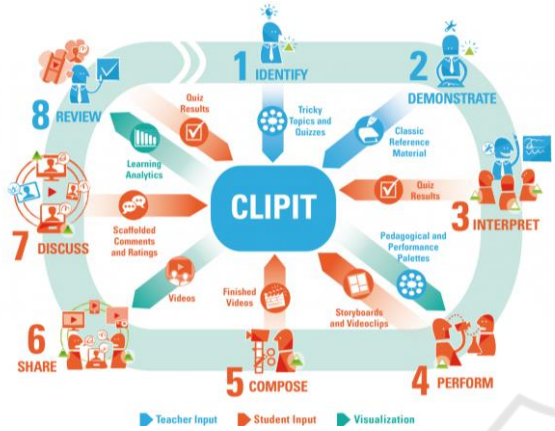

Figure 1: The JuxtaLearn Process.

In step 1 (Identify), the teacher identifies the Tricky Topics based in his/her previous experience with students. Each Tricky Topic can be divided into smaller Stumbling Blocks.

In step 2 (Demonstrate), the teacher creates one or more Standard Teaching Activities (STA) around the Stumbling Blocks.

In step 3 (Interpret), students perform a diagnostic quiz to determine their level of understanding about the Tricky Topic.

In step 4 (Perform), students create a storyboard to explain the Tricky Topic. This is followed, in step 5 (Compose), by the process of video editing and in step 6 (Share), by sharing those videos.

The goal of step 7 (Discuss), is to promote discussion among students, allowing the social construction of knowledge and promoting the consolidation of the concept.

In step 8 (Review), students return to the quiz from step 3 to re-assess their understanding of the Tricky Topic. The comparison between the results obtained before and after the video creation provide a strong evidence of the level of understanding developed as part of the learning activity.

2.2 The CLIPIT Platform

The CLIPIT platform was developed to support the collaborative activities of the Juxtalearn process. CLIPIT offers two separate interfaces, one for students and the other for teachers. Teachers can access to three interactive tools: (i) Tricky Topic Tool, (ii) Problem Distiller Tool, and the (iii) Quiz Tool. The student can access the information provided by the teacher, share materials with colleagues, communicate with classmates and/or the teacher through forums or internal email.

The Tricky Topic Tool was designed to help identifying Tricky Topics and break them down into Stumbling Blocks, using examples from practice to illustrate the sort of problems students have, and examples of teaching activities which help explain those Stumbling Blocks (Figure 2).

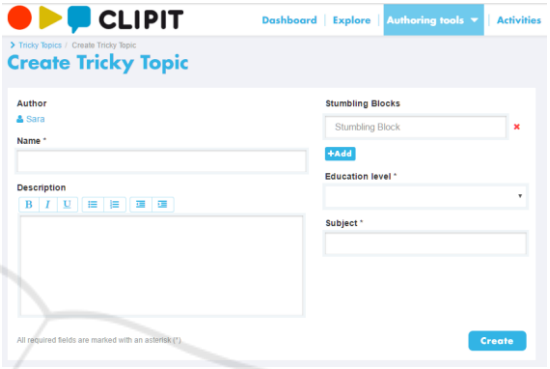

Figure 2: The Tricky Topic Tool.

After registering a Tricky Topic in the Tricky Topic Tool, the teacher can then describe the students' problems with that Tricky Topic using the Problem Distiller Tool (Figure 3). It offers the teachers a set of examples of common problems that students face when trying to understand a topic.

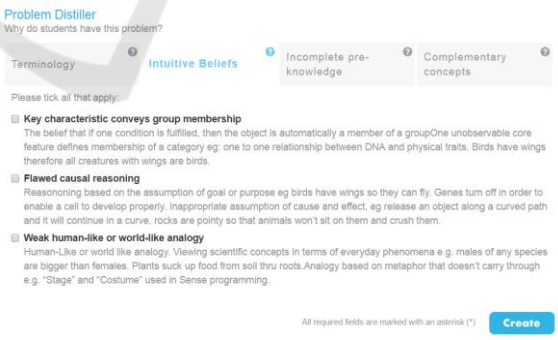

Figure 3: The Problem Distiller Tool.

The problems referred in the Problem Distiller Tool (Figure 3) are organised around four categories: (1) **terminology**, (2) **intuitive beliefs**, (3) **incomplete pre-knowledge** and (4) **complementary concepts**.

Regarding the **terminology**, the problems already listed in Problem Distiller Tool are: One term refer to multiple concepts, scientific use of

everyday language, obscure scientific terminology, one concept has many scientific names, and one term refers to various concepts.

The problems of understanding can also result from **intuitive beliefs**. The Problem Distiller Tool provides a set of options that help to structure the reasoning of the teacher in regard to each particular problem: key characteristic conveys group membership, flawed causal reasoning and weak human-like or world-like analogy.

An **incomplete pre-knowledge** can also give rise to problems of understanding. The Problem Distiller Tool presents two options for this type of problem: underpinning understandings and understanding of Scientific method, process and practice.

The difficulty in **complementary concepts**, on Problem Distiller Tool essential concepts, can also be a problem for the understanding of the Tricky Topic by the student.

With the Quiz Tool, the teacher can create the questionnaires about Tricky Topics and make them available to students (Figure 4).

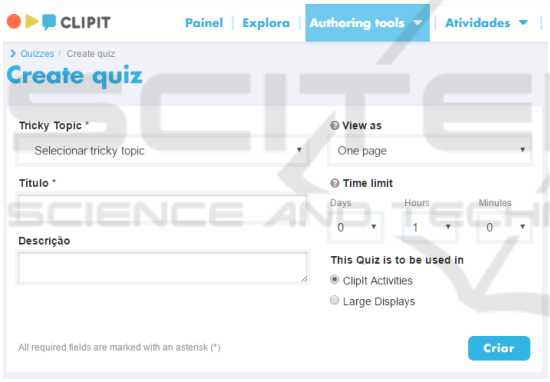

Figure 4: Assistant to the creation of a quiz.

A JuxtaLearn Quiz is linked to a Tricky Topic and its Stumbling Blocks so that when students take the quiz online, gaps in their understanding are revealed. Each quiz question is weighted based on how many Stumbling Blocks it addresses, and the student results are then displayed as a Radar chart visualization which makes it easy to identify the problem areas (Figure 5).

This radar representation allows the teacher to analyse the level of understanding of the student in regard to the concepts presented in the quiz. It can thus support the teacher in planning an intervention in the classroom that helps the student to overcome those difficulties. As we can observe in Figure 5, the student was only able to answer correctly a small part of the questions involving operation priorities when using addition, subtraction, multiplication, and division.

Figure 5: Example of a Radar obtained in CLIPIT.

For the creation of activities and their respective tasks, CLIPIT offers teachers an activity assistant (Figure 6).

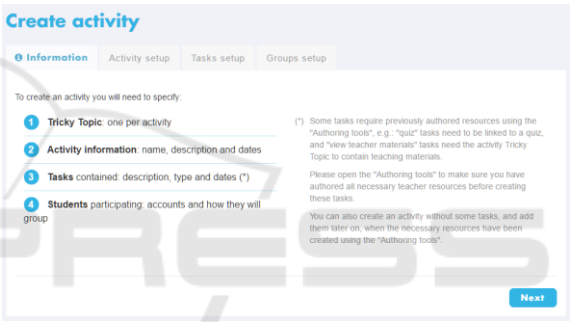

Figure 6: Assistant to the CLIPIT for the creation of activities.

The teacher has the flexibility to adjust the activities to the available time and student's level. In CLIPIT students can answer quizzes about the Tricky Topic, upload a storyboard, a video or other documents that support the work they performed. In this process of sharing and collaborative construction, students can improve their awareness about their own strengths and areas of improvement. Videos and quizzes can also be shared in the communal space of the school to promote engagement around those videos with a broader community. Using a mobile application, students can rate, create comments or simply bookmark videos (Otero et al., 2013).

The students also have space for discussion with other members of the group or classmates. The teacher has thus the possibility to see what students share, launch discussions on a topic, follow the development of the student's work and offer them feedback about improvements in any of the steps in the process (Llinás et al., 2014).

3 METHOD

3.1 The Training Course

To promote JuxtaLearn's learning process, we have developed a training course for teachers of STEM areas. The objectives were:

- To promote the teacher's reflection on creative video editing to understanding the bordering concepts of STEM areas.
- To identify common Tricky Topics associated with STEM areas.
- To understand the difficulties that students face in the teaching-learning process of STEM areas.
- To check the level of the students' learning about concepts considered complex in STEM areas.
- To motivate teachers, making them aware of the potentialities of the JuxtaLearn process.

The training course had a duration of 25 hours. During eight sessions, we presented the advantages with concrete examples of resources already developed within the scope of the Juxtalearn project. All activities carried out by teachers and students were supported by CLIPIT.

3.2 Data Collection

We collected a broad range of data during the training course: questionnaires, direct observation, automatic recordings on CLIPIT. The training course was accomplished by eight teachers. To illustrate the process and present the results achieved by students, we selected as an example one of the Tricky Topics called "numerical expressions with rational numbers not negatives".

Based on their teaching practice, teachers wrote the tricky topic in the Tricky Topic Tool. With the support of the Problem Distiller Tool, teachers were encouraged to think about the problems that students usually have in a Tricky Topic. Throughout this process, teachers created one or more activities in CLIPIT with tasks for students to perform. The diagnostic quiz and the final quiz were created by teachers and answered by students in the CLIPIT. All these data were recorded in CLIPIT and subsequently analysed.

The assessment of the students' evolution in regard to their level of understanding about the Tricky Topic was based on quantitative data, more specifically through the comparison between the results obtained by each student in the diagnostic quiz and in the final quiz. These questionnaires are connected to the Tricky Topic and to their Stumbling Blocks, so each question on the quiz is designed to enable us to evaluate the knowledge in at least one of the Stumbling Blocks.

Following the guidelines of Bogdan and Biklen (2007), and to protect the identity of the learners involved, we named each teacher by Ti – teacher of order i (i=1, …, 8). The perception of teachers in relation to how the process of video editing has contributed to the understanding of the Tricky Topic were based on qualitative data, collected during the training sessions through direct observation.

At the end of the process, the data collection included a Satisfaction Questionnaire to all teachers, the System Usability Scale (SUS) from Brooke (1996). This questionnaire evaluates the teachers' satisfaction with the platform and the ease of use. The questionnaire consists of 10 questions, 5 in the affirmative and 5 in the negative, with a Five-Point Likert Scale, where 1 is "strongly disagree" and 5 is "completely agree". In this questionnaire, the evaluation is made by an average score within the range of 0 - 100 points.

Based on the data collected and the theoretical frameworks we made a content analysis (Bardin, 2013), which we will describe below (very succinctly).

3.3 Participants

We had eight STEM teachers attending the training course, all females, aged between 36 and 51 years old.

4 RESULTS

The training course began with a contextualization of the JuxtaLearn process. We then presented the CLIPIT and its role as a learning platform. We provided the teachers with access to CLIPIT and we explained them how they could create the activities and tasks for their students. Next, we inform about the assessment process of the training course.

As a motivation to attend our training course, the teachers said that they want to "*learn how to use the CLIPIT*" (T2, T4, T6) and then "*teaching their students to use it*" (T1). While teachers of subjects "*that presents many complex concepts for the majority of the students*" (T8), wish to learn how to use a new "*methodology that will help the students (...) in understanding complex concepts*" (T5), with "*innovative approaches*" (T8).

4.1 CLIPIT Tools

Teachers used the Tricky Topic Tool to insert the Tricky Topics and their Stumbling Blocks in the CLIPIT. For example, for the Tricky Topic "numerical expressions with not negative rational numbers", teachers identified the following Stumbling Blocks: subtraction of rational numbers, addition of rational numbers, multiplication of rational numbers, division of rational numbers and the priorities of operations.

The Problem Distiller Tool helped the teachers to reflect on the causes of the students' problems with the Tricky Topic. According to the data collected, the students usually have problems in understanding this concept because they have: "*Difficulty in applying the priorities of numeric expressions: Students have difficulty in simplifying powers in the first place, then calculate what is in parentheses; recognize the priority of multiplication and division in relation to the addition and subtraction; recognize that when they arise multiplications and divisions or additions and subtractions must be carried out in the order in which they appear from left to right"* (P7, P9, P10).

Teachers have made use of CLIPIT QUIZZES to create a questionnaire on the identified Tricky Topic. The questions could be: "check box", "multiple choice", "numeric" and "true or false". For the Tricky Topic "numerical expressions with not negative rational numbers", teachers have created thirteen questions. For each question, the teacher had to assign a degree of difficulty, and each one of these questions had to be connected to (at least) one of the Stumbling Blocks (Figure 7).

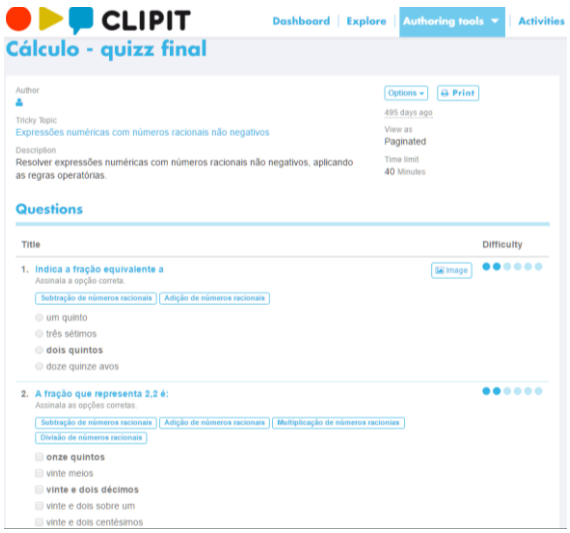

Figure 7: Screen of CLIPIT with part of the quiz created.

To deliver tasks to their students, teachers have created in the activity wizard of CLIPIT one or more activities. There, students created tasks with different periods of start and end in accordance with the JuxtaLearn procedure and the working times of students. This period is flexible and can be adjusted in CLIPIT. For the work with students on the Tricky Topic "numerical expressions with not negative rational numbers", teachers created three activities, with different tasks that allowed guiding the work of the students. In Figure 8, we present one of those activities.

Figure 8: Print Screen with part of a quiz.

Based on the results obtained in the quiz the teachers divided the students into working groups.

4.2 Students Outcomes

Applying a Flipped Teaching approach (Newman et al., 2016), the students started by exploring the materials shared by teachers about the Tricky Topic and the respective Stumbling Blocks. The students were given a week to study and to ask questions to the teacher (if they wanted to). They then performed the quiz. Based on this diagnosis, the students, organised in groups, created storyboards and instructional videos on the topics.

For the Tricky Topic "numerical expressions with not negative rational numbers", students created three storyboards. They started with a sheet of paper in 4, 6 or 8 parts and in each of them they described the scenes they wanted on their video (Figure 9).

Two of these three initial storyboards, were then translated into instructional videos, on the themes: "division of rational numbers not negatives" and "priorities in numerical expressions with not negative rational numbers". For the collection of images, students used their smartphones. Video edition was performed in the class computers and

then shared in CLIPIT to promote the discussion around the concepts.

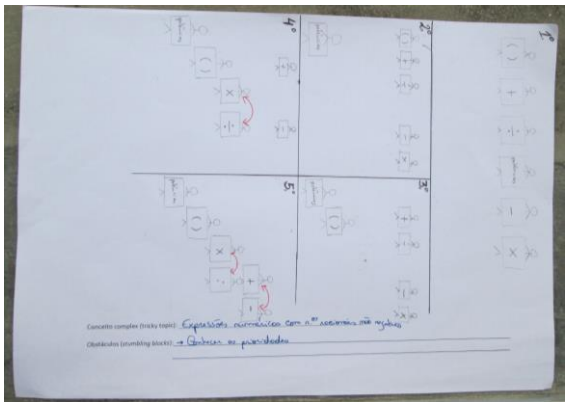

Figure 9: Storyboard created to explain the priorities in operations.

In the end, students responded the quiz, again, and compared the results with those obtained in the diagnostic (initial) quiz. Table 1 shows the data obtained by the group of students who worked the Tricky Topic: "numerical expressions with not negative rational numbers".

Table 1: Comparison between the initial and final quiz.

	Initial quiz (%)	Final quiz (%)
A1	46%	62%
A2	85%	77%
A3	69%	77%
A4	38%	85%
A5	0%	85%

The data show that the majority of the students improved their results from the initial quiz to the final quiz. We can observe the case of student A1, which achieved a score of 46% in the initial quiz. The analysis of the radar (Figure 10) obtained in this initial quiz (in blue) indicates that the student answered well only part of the questions. In the final quiz (in red), A1 obtained a score of 62%, improving the overall score from the initial quiz and evolving in regard to the different Stumbling Blocks.

Comparing the results obtained on the radar of the initial quiz with the ones obtained on the final quiz (Table 2) we can observe that the student A1 managed to hit more questions that involve the knowledge of priorities and knowing how to add, subtract and multiply rational numbers. However, between the initial and the final quizzes, this e student maintained the same number of right answers to the questions that involve the division of rational numbers.

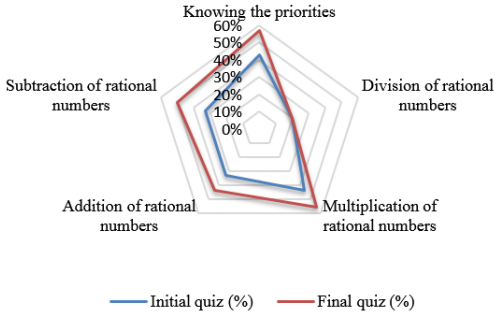

Figure 10: Radar from student A1.

Table 2: Comparison between the initial and final quiz of student A1.

Stumbling Block	Initial quiz (%)	Final quiz (%)
Knowing the priorities	43%	57%
Division of rational numbers	20%	20%
Multiplication of rational numbers	44%	56%
Addition of rational numbers	33%	44%
Subtraction of rational numbers	33%	50%

On the other hand, the student A2 obtained a score of 85% in the initial quiz, but in the final quiz obtained 77%, a lower score than in the initial quiz.

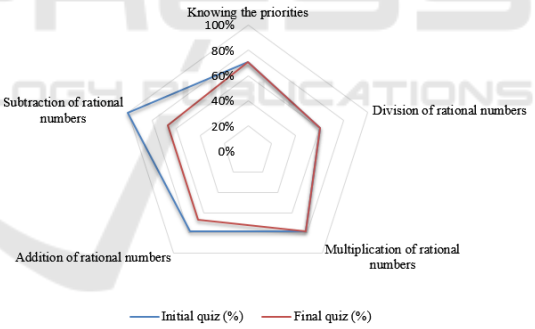

Figure 11: Radar obtained by A2.

Comparing the results obtained in the two radars (Table 3), we comprehended that the student has failed answers that were correct in the initial quiz: "subtraction and addition of rational numbers".

These are only two examples of the data collected. One from a student that improved his performance, and the only one who didn´t. We just want to show the kind of info the teacher can get on the radar.

In short, each teacher has chosen a concept within her area and created the learning activities in the CLIPIT. As they were learning CLIPIT features, teachers were also applying JuxtaLearn learning

process with their students.

Table 3: Comparison between the initial and final quiz of student A2.

Stumbling block	Initial quiz (%)	Final quiz (%)
Knowing the priorities	71%	71%
Division of rational numbers	60%	60%
Multiplication of rational numbers	78%	78%
Addition of rational numbers	78%	67%
Subtraction of rational numbers	100%	67%

4.3 Teachers' Acceptance of the Process

Teachers considered the training course as "*interesting and that students also enjoyed*" (T1). The fact that its "*evaluation focused on the implementation of the different stages of the platform in the context of classroom was appropriated*" (T5). The "*sharing experiences and materials between the different groups of training*" (T3) and "*the fact that CLIPIT allowed the sharing of ideas and materials on a same complex concept*" (T7) were some of the positive aspects reported.

The teachers' satisfaction regarding CLIPIT was confirmed by the SUS questionnaire. The average classification on a scale from 0 (not at all satisfied) to 100 (very satisfied) was 59.4 points, corresponding to a qualitative evaluation of 'Good' according to Bangor, Kortum and Miller (2009).

Regarding the CLIPIT, teachers expressed their satisfaction by mentioning that "*it is an excellent platform for sharing resources*" (T3) and "*experiences*" with the students (T7). One teacher said that "*with the power to create, edit and share educational videos produced by the students, it is a way to foster creativity and motivation to study and learning more complex concepts*" (T1). Another teacher said that the CLIPIT "*is a platform that takes time and dedication to be understood*" (T5) but that can "*promote the reduction of subject failure*" (T3). Regarding the ease of use with the CLIPIT, teachers expressed their opinion through expressions like *"the tool could be more intuitive, making it easier to use*" (T4) and admitted to know the "*objectives of the platform but not sure if able to apply [them]*" (T5). Teacher T1 even told that she enjoyed to do this training course, that she "*liked to learn more about video and visual resources that encourages creativity and students' motivation study/understanding of specific concepts*" (T1). Additionally, all teachers expressed interest in leveraging this training to a more advanced level, so that they "*may have a better control and a better understanding of CLIPIT tools*" (T7) and get to know more "*especially in the several tools that allow to create and edit videos*" (T3). If continuous training isn't possible, at least they would like to be able to "*have a periodic update*" (T5).

5 CONCLUSIONS

This paper presents a study in which we coached eight teachers in supporting their students overcoming Tricky Topics with the support of the JuxtaLearn process.

Firstly, with the teachers, we identified the Tricky Topics that their students have, and we put the Tricky Topics into the CLIPIT, the online collaborative platform. Then, we presented the teachers the eight steps of the JuxtaLearn process, and we coached them in the implementation of these phases with their students. The first conclusion is that the eight teachers were able to put into practice the whole JuxtaLearn process with their students, guiding them to produce storyboards and suitable instructional videos, collaboratively. During the training course, we observed that the teachers used the CLIPIT platform to support their work with the students. Automatic data from CLIPIT also supports this conclusion. Regarding the satisfaction with the ease of use of the platform, the SUS questionnaire shows that the teachers evaluated the platform as 'Good', and think that they can use it regularly.

Overall, the teachers believe that the implementation of the JuxtaLearn process was good and all teachers who participated in the sessions successfully completed the training course.

The results show that four from five students (presented in this paper) have been able to improve their scores from the initial to the final quiz. The results suggest that the JuxtaLearn process helped them to improve the understanding of the Tricky Topic "numerical expressions with not negative rational numbers", as 80% the students have improved the scores.

With this study, a new issue has emerged. We found that with our support the teachers were able to implement with success the whole JuxtaLearn process, and recognised its benefits. They used the CLIPIT and admitted that the students took advantage from its use. They saw that the video edition motivated the students to work the math concepts, which itself is an added value for the teaching of mathematics. Recognising the gains, as

they recognised, will the teachers without our support and stimulus be able to continue using the CLIPIT and the JuxtaLearn process with their students in the future? This is something that we have already explored and that we will present in a future article.

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