Designing a Video Course. The Case of the Online Course of Mathematical Olympiads

Lucía Rotger(✉) and Juan M. Ribera

University of La Rioja, Logroño, Spain
{lucia.rotger, juan-miguel.ribera}@unirioja.es

Abstract. Current secondary and university students use their technological devices not only in playtime but also in study time. Our proposal makes use of this fact to create educational content that can be viewed on any smartphone or computer. These videos can be used to teach new concepts, mathematical procedures or problem-solving resolutions. Although there is a wide variety of educational videos and MOOCs, on many occasions these videos do not fit in terms of content or notation. With this in mind, in this article, we define the detailed process that we should follow if we are interested in creating our own educational videos. We devote special attention to giving advice on video creation from a methodological point of view. This process is enhanced with an example of learning unit collection that we created at the University of La Rioja. The project that we present is a collection of math Olympiad problem-solving strategies that can be used as complementary learning materials.

Keywords: Educational videos · Video creation · Mathematics education · Mathematical olympiads

1 Introduction

Nowadays, our Secondary School students use many social networks. First we want to put emphasis on the use of Instagram due to its popularity. In this social network, users create and share stories of their own experiences in diverse ways, for instance, they can upload videos that are deleted after one day. On the other hand, there are more elaborated videos that are usually viewed and shared through YouTube. The main topics of these videos in particular are opinions, game strategies and music.

As we have just pointed out, short videos have become another source of information and tutorials for our students (Tan 2013). Currently, the majority of university students use videos predominantly to cover the content (Howard et al. 2017). Moreover, (Trenholm et al. 2012) showed that students enjoy and value online learning. This is the reason why we want to take advantage of the interest shown in this communication channel for the transmission of teaching content in mathematics. For this purpose, we should study the main features of those videos that attract students.

L. Uden et al. (Eds.): LTEC 2019, CCIS 1011, pp. 79–89, 2019.
https://doi.org/10.1007/978-3-030-20798-4_8

2 Video Creation Process

The use of video requires the application of a different teaching methodology from the usual live lectures. We can differentiate three processes which involve teaching contents at organizing our standard face-to-face lectures: the structuring and timing of the sessions in which we are going to impart this content, the teaching on these sessions and the subsequent reflection of the effectiveness of our teaching organization proposal. These three processes are closely related and are a sign of the dynamism of our lectures. In fact, what happens often is that our initial planning is not analogous to the final structure of the sessions that we impart. Moreover, in many cases we make some modifications in the structure of the teaching sessions once we have taught that lesson, especially when that content has not been correctly comprehended by our students, to keep it in mind in future courses.

In the case of the creation of video teaching content, those three processes are modified when organizing the videos through which we want to present that content. Thus, we differentiate three new processes related with the production of teaching content in the video. Planning, structuring, timing, and preparing video pills constitute the first process. The second one consists in the recording of formerly designed video pills. The last one is the edition of raw videos recorded during the second process.

The first process has higher relevance in terms of the organization of the video sequences, even more relevance that in the face-to-face teaching. In this process, a large number of decisions are made that are associated with the teaching content and how that content is created. In addition, the difficulties brought about the modification of the video sequences once they have been recorded and edited makes necessary to analyze concisely all the possible difficulties that the students may find when they visualize the contents.

Afterwards, the video recording of the content differs in some aspects from the teaching methodology of the face-to-face lectures. For instance, in our on-site lectures we have exclusively one opportunity to release our teaching content while, when recording, we can make as many recordings as we want to until we get a correct presentation of the planned teaching content. Even so, this causes more pressure on the teacher who is being recorded. Typically, teachers who are recorded try to achieve perfection on its content presentation. Recording video content process also makes us take into account other details related to verbal communication that we usually do not consider in face-to-face sessions. In these classes, non-verbal communication is more widely used than in video lessons. Those examples show a clear difference between these two teaching processes. What makes recorded material very rewarding is the fact that it can be used as many times as desired, enabling the students to review the explanations and the teachers to reuse video lessons.

Finally, video edition is a very useful process that allows us to perfect our teaching pills in different ways. On the one hand, the editing process can be useful in order to select the best versions of our recordings, allowing us to choose our best speeches. On the other hand, our recording viewings may reveal the need to add visual elements or graphics that make a clearer presentation of the contents. These graphic elements can be added in the editing process and can be part of the previous sessions planning.

In addition, the teacher can observe the necessity of graphic elements after viewing all recordings of the content. This process, as has seen shown, is closely related to the reflections made by teachers after their classes. In the design of video lessons, one of the most important processes is the creation of teaching content.

In the following sections, we will discuss in detail the factors that have to be taken into account in the process of generating video teaching content.

2.1 Planning

The preparation of lessons in face-to-face lectures needs not only contents but also methodology. When we are interested in the creation of teaching videos, the planning process has an even greater relevance. In this case, we should pay more attention to the communication of contents by making a point to make an exposition of contents that are as clear and self-contained as possible. To achieve that, the first thing we should know is the aim of each one of our video lessons. Here we present some objectives related to each part of the teaching-learning process (motivation and introduction, presentation and explanation and finally application):

- Short texts that aim to guide or motivate a mathematical definition or basic practical examples that contribute to the understanding of a certain concept or situation.
- Graphic animations that allow contextualizing some concepts. In this way, we can have both symbolic and graphic elements for content presentation.
- Real examples of the use or application of some mathematical proceedings. We can present the most characteristic examples.

In addition, we should take into account a greater number of factors than in face-to-face teaching. An example of that is the analysis of the situation, the planning, the timing of the process and the creation of complementary documentation.

First, we should select the topic of our videos, while we determine the technical equipment that we have. The technical features of the equipment are closely related to the methodology that we will follow for the presentation of the content in our videos. It is very important to maximize the use of the technical features of recording and edition equipment to allow our presentation to be as clear and didactic as possible. We can found an example of this previous analysis in videos of mathematical calculations, since the correct visualization of the steps followed in the resolution is needed to understand the process. Therefore, a previous study of the recording form it is necessary, especially, to provide the most comfortable visualization of each resolution step. A common problem found in mathematical teaching videos is the partial covering of the steps or the writing of the formulas. These blocks prevent having a general overview of the process followed.

Once we select the subject and analyze the situation, we sequence and sketch our content, organizing the information. This previous work has multiple applications in obtaining a quality video teaching material. In the first place, the sketching content process will allow us to organize our content by selecting the right order to present it. In addition, sketching will allow us to separate those contents that can be set apart from others, thus enabling the production of self-contained recordings. In the same way, it will facilitate to show existing connections among different parts of our teaching

content. An example of the importance of the sketching process can be seen in the recording of the mathematical procedure known as conversion factors. This recording can be used not only in the teaching unit of measurements, which belongs to mathematics, but also in teaching units of physics and chemistry. Therefore, it is useful in different moments of the educational process.

In parallel to the sequencing and schematization, we would create a script, but we may require other complementary materials besides the recordings. This need is one of the factors that should be taken into account in the planning of the video teaching contents. Not only is it important to have a well-defined scheme and sequence, but also to take into account all the details that we want within the recording. It depends on the teachers' knowledge of the subject, the conciseness of the script and its length. For example, in our face-to-face sessions, we usually have special cases planned to present the mathematical contents in a meaningful way. In addition, another element that can facilitate the comprehension of the video contents is the creation of graphics or visual elements. Moreover, we can mention the visual elements in the recordings and then add these elements later on in the video-edition process. Teachers should prepare these graphic elements previously to mentioning them when it is appropriate in the recording.

The selection of the recording methodology of the content is also part of the planning process. Depending on the content and on the financial availability, we recommend different content recording methods. Here we present some possibilities:

- Directly recording to teacher with a good quality camera. This recording method is the one that most resembles classroom teaching. In this type of recordings, sound quality requires especial attention since the farther the teacher is from the camera the worse the audio quality of the recorded content is. In this case, we recommend the use of complementary microphones to solve any sound issue. Another detail to consider is the added difficulty that we may found when we are recording the teacher and the blackboard at the same time. To solve any problem that this situation may bring, we recommend using a secondary support camera when the teacher is using the board.
- Screen recording. This method is also known as Screencast, a name that is similar to the trademark of the software that we recommend to perform this task, Screencast-O-Matic. When we use this type of software we can capture the contents on the computer screen while we are commenting in the screen movements. With this recording methodology, you can use elements of live lectures (such as a PowerPoint) combined with audio, videos, subtitles, visual demonstrations or interactive components (Farkas 2007). The possibility of re-visualizing the recordings helps to adapt them to the different learning paces of the students. Since we can split the video and audio of a recording in the edition process if necessary, we could record the sound separately from a video that has already been recorded. We recommend this content recording method for the acquisition of using procedures for mathematical programs such as Geogebra constructions, data statistics collection and handling and arithmetical calculations.
- Document camera. This recording device mixes aspects of teacher's camera recording with the screen recording. In this case, recording with a document camera enables to record videos of the movements that are made throughout a sheet of

paper from an overhead perspective. Thus, it is possible to record both handmade operations and sequences of actions of manipulative elements of mathematics. This recording method is widely used because it is the most similar to the notes taking recording. If no camera of this type is available, you can use a camera on a tripod so that you can record from above.

2.2 Recording

In consonance with the video requirements that students are used to nowadays, Pérez-Navío et al. (2015) recommend some characteristics that we can adapt to the math videos recording process:

- Creating videos of approximately 5 min in length. Several studies show that people begin to lose interest in videos when they last longer than 10 min.
- Introducing narrative elements. In this aspect, it is important for the video to include a summary at the beginning of the content that we are going to explain. We also recommend the inclusion of another summary at the end of the video with the main ideas covered in it. In the particular case of procedural videos, it is advisable to sequence correctly the steps followed in the resolution of the exercises and problems.
- Introducing symbolic elements such as tables, graphs and other forms of presenting mathematical content while we narrate the explanations needed. They can be added in the edition process as additional digital graphic elements. We can also consider the use of physical manipulative materials to support our explanations.

All these recommendations show how important the previous planning is to the teaching content recording.

In addition, we should take some aspects related to verbal communication into consideration. In order to get closer to the students and be as clear as possible, we recommend:

- Speak slowly, taking care of your diction, especially on those words that are specificaly mathematical. Define new and abstract terms using a more familiar vocabulary. Even write these terms or leave them on the screen.
- Avoid double negations and passive voice in the resolution of procedures and in the steps of transitions in operations.
- Vary the tone of voice, putting emphasis on the main points or the most important mathematical properties used in the resolution processes.
- Use nouns instead of pronouns to refer to the elements that appear in the presented content. In this way, we will improve the acquisition of new mathematical terms.

2.3 Edition

Last but not least, we will elaborate the final phase of the creation of videos with mathematical content: the edition process. The main purpose of the edition process is to add the visual and graphical complements that we have previously recommended and

that help to facilitate knowledge building. (Lucas et al. 2015). Furthermore, the editing process should be used to check on other visual and narrative elements.

Concerning the visual aspects, we should examine the frames, the composition, the lighting, etc.; this means that we would check if everything on the screen can be read. In the same way, the teacher should take care of the movements in front of the camera avoiding oscillating and other rough movements. The controlled use of gestures also prevents monotony in our speech. Hand gestures are the most frequently suggested ones, although the teacher should avoid performing repetitive or excessive gestures (Cáceres and Martínez 2017).

On the other hand, concerning the narration, we should verify the use of affirmations that indicate the beginning and end of the topics explained. These affirmations are a guide in the scheme and link the parts of the presentation (Cáceres and Martínez 2017). The use of these narrative elements will aid the students to realize what the purpose of the video that are visualizing is and to relate it to other visualized contents.

For the edition of the video content, we recommend paid software such as Camtasia like other authors such as Abassian and Sieben (2015). There are free alternatives, such as OpenShot, which can be used for editing short videos. However, they frequently cause problems when working with high quality or long duration videos.

2.4 Evaluation

There are different methods that we can use for the evaluation of the students visualizations of the video, many of them related to the Flipped Classroom or inverted class (https://www.theflippedclassroom.es/). It is necessary to implement these evaluations in order to check not only the visualization but also the meaningful learning of the contents. One of the tools we have used to get this feedback is the EdPuzzle platform. In this platform, we can enrich the edited videos as well as use other existing videos in the network. Thus, we can enrich our video recordings by adding audio explanations throughout the recording or references to the web. Another interesting action provided by the platform is the possibility to incorporate questions throughout the video. The use of these questions can be multiple: the evaluation of the video viewing, the evaluation of some strategy or procedure displayed in the video or the demand for further reasoning by the student. These multiple options allow us to register both the viewing of the video and to check the comprehension of the contents. Moreover, this platform offers the possibility of checking the number of visualizations of the video by every student, thus allowing us to know the most difficult aspects of the displayed content. A methodological proposal using EdPuzzle in the classroom can be checked in Orcos Palma et al. (2018)

Based on our experience, we recommend recording our own content before exploring the web for more content that satisfies our interests, especially in the case of mathematical learning content. Some factors such as differences in notation or the degree of the abstraction of the vocabulary used in these videos can generate a contradictory effect among the students. In addition, some educational videos in mathematics show procedures which are formally incorrect as Beltrán-Pellicer et al. (2018) analyzed.

3 An Implementation Case

We will illustrate the implementation of the characteristics of educative videos presented and studied previously with an example of use that we have developed.

The Online Course of Mathematical Olympiads is a course that includes a collection of learning units and their evaluations developed by a group of mathematics professors at the University of La Rioja. This course is currently formed by a set of 12 learning units that present different classic methodologies for solving math Olympiad problems. This online course aims to be complementary to the Seminar on Mathematics Problems that takes place weekly at the University of La Rioja.

3.1 Planning

In a first meeting, we established the contents that we wanted to cover in the recordings made by the members of the project. We singled out the topics that can be found among the classic problems of mathematical Olympiads. In this way, we tried to cover the ins and outs of the varied range of mathematical problems that students may be confronted with in a Mathematical Olympiad.

Once we determined the topics, we also defined the format of the video learning units that we want to create. We decided to design a minimum of four videos per learning unit: introduction and motivation for the use of the problem-solving strategy, theoretical elements associated with the problem-solving strategy, examples of a direct application of the problem-solving strategy, and examples of application of the problem-solving strategies in a real Mathematical Olympiad.

At the same time that we planed the sessions, we developed the teaching content of the mathematical problem-solving strategies. This educative content consists in slide presentations that supplement the video recordings, the collections of problems that we used in the videos, and the formative texts with theoretical content that summarize the contents studied in the learning units (Table 1).

Table 1. Mathematical topics in the Online Course of Mathematical Olympiads.

Pigeonhole and maximal principle	Induction principle
Plane geometry	The Theorems of Ceva and Menelaus
Game theory	Modular arithmetic
Series summation	Probability and combinatory
Polynomials	Recurrences relations
Inequalities of real numbers	Functional equations

3.2 Recording

In this phase, we assign the corresponding recordings to the teachers explaining the topics that they had planned in the first phase of the project.

Recording methods were of different types, depending on the content. It was possible to use existing recording equipment in the University consisting of two video

cameras. In addition, it was possible to use computer screen-capture software, being able to observe the resolution processes by the teacher on the screen. All the recordings made by the group had followed the previous recommendations (Fig. 1).

Fig. 1. Example of recording method: two video cameras, a microphone and a computer in order to check the content scheme.

3.3 Edition

In order to make all the content available to learners interested in it, it was convenient to edit the recordings using video editing software. We purchased some licenses of the payment software Camtasia since our recordings were high-quality videos. Besides, we plan a workshop with the members of the project to know how to use the software and its possibilities. In this sense, teachers edited their own videos working with the software mentioned above (Fig. 2)

It was advisable to perform a revision of the content to correct the errata. This was also a good moment to suggest improvements by the colleagues of the innovation group. Subsequently, we had to re-record some of the videos because of the need to complete some examples or the correction of some errata found after the visualization. Additionally, revision task checked introduction and conclusion had the same style.

3.4 Evaluation

The process of evaluation of the educational contents was arranged in face-to-face lectures by solving math problems in a written test. In this test, we evaluated the problem-solving processes presented in the videos. In this way, we review not only the visualization of the videos but also the significant learning of the problem-solving processes.

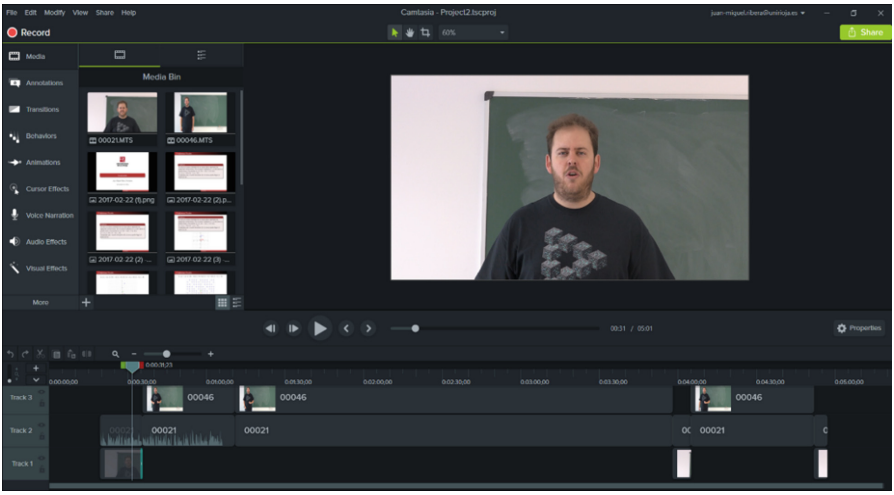

Fig. 2. Example of edition method using Camtasia software.

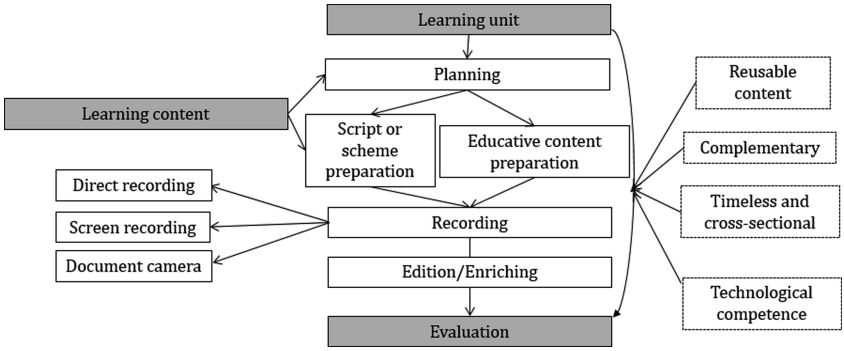

Fig. 3. Diagram of the video creation process.

On the other hand, students gave us their feedback concerning the learning units. We make emphasis on the fact that the students' visualization allowed us to unify the format among the different sequences. At the same time, we received positive answers related to the application of our educational course.

Moreover, we have proposed one open problem per learning unit to allow students to be able to self-evaluate their learning. These problems are proposed in one video and the solutions are provided in another video. The characteristics of these types of problems allow the students to practice the mathematical procedures they have learned in different ways since partial solutions are available on many occasions.

4 Conclusions and Future Work

The use of video has become a resource to be taken into account in mathematics teaching. Since devices allow audiovisual content visualization, it may be useful to provide teaching content that can be visualized, adapting it to the different learning rates of the students.

We present the following diagram that summarizes all the factors to be taken into account in the creation of video teaching content (Fig. 3)

At the moment, after having recorded 12 learning units, we are evaluating the usefulness of the content created. To do this, we establish some research evidences that evaluate students' perception and interest. Furthermore, a large number of students who have provided their feedback confirm its application.

On the other hand, we are also investigating other content recording methodologies. We are interested in determining the most valuable recording methodology for students. Moreover, we are interested in creating other recordings within other recording methodologies.

Thus, the analysis presented here has been a good starting point to achieve an adequate design of the learning unit.

Acknowledgements. The present research was partially supported by the project "Mejora y ampliación del Curso Online de Olimpiadas Matemáticas (MACOOM)" of the proyectos de Innovación Docente de la Universidad de La Rioja.

References

Abassian, R., Sieben, J.: Creating math videos: comparing platforms and software. PRIMUS. **26** (2), 168–177 (2015)

Beltrán-Pellicer, P., Giacomone, B., Burgos, M.: Online educational videos according to specific didactics: the case of mathematics/Los vídeos educativos en línea desde las didácticas específicas: el caso de las matemáticas. Cult. Educ. **30**(4), 633–662 (2018)

Cáceres, P.A., Martínez, S.: Plan Docencia en Red 2017–2018 de la Universitat Politècnica de València (2017)

Farkas, M.: Social Software in Libraries: building collaboration, communication and community online. Information Today Inc., Medford (2007)

Howard, E., Meehan, M., Parnell, A. : Live lectures or online videos: students' resource choices in a first-year university mathematics module. Int. J. Sci. Math. Educ. (2017) https://doi.org/10.1080/0020739x.2017.1387943

Lucas, S. et al.: Utilización de recursos software y mini-videos docentes como herramientas didácticas en asignaturas de ingeniería industrial. XXIII Congreso Universitario de Innovación Educativa en las Enseñanzas Técnicas (2015)

Orcos Palma, L., Blázquez Tobías, P.J., Curto Prieto, M., Molina León, F.J., Magreñán Ruiz, Á. A.: Use of *Kahoot* and *EdPuzzle* by smartphone in the classroom: the design of a methodological proposal. In: Uden, L., Liberona, D., Ristvej, J. (eds.) LTEC 2018. CCIS, vol. 870, pp. 37–47. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-95522-3_4

Pérez-Navío, E., Rodríguez, J., García, M.: El uso de mini-videos en la práctica docente universitaria. EDMETIC. Revista de Educación Mediática y TIC, **4**(2), 51–70 (2015)

Tan, E.: Informal learning on YouTube™: exploring digital literacy in independent online learning. Learn. Media Technol. **38**, 463–477 (2013)
Trenholm, S., Alcock, L., Robinson, C.L.: Mathematics lecturing in the digital age. Int. J. Math. Educ. Sci. Technol. **43**(6), 703–716 (2012)