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Students' Behavior and Perceptions Regarding Complementary Videos for Introductory Physics Courses in an Online Environment

Antoni Perez-Navarro [1,2,*], Victor Garcia [1] and Jordi Conesa [1]

1 Faculty of Computer Sciences, Multimedia and Telecomunication, Universitat Oberta de Catalunya (UOC), Rambla del Poblenou, 156, 08018 Barcelona, Spain; vgarciahe@uoc.edu (V.G.); jconesac@uoc.edu (J.C.)
2 eLearn Center, Universitat Oberta de Catalunya (UOC), Rambla del Poblenou, 156, 08018 Barcelona, Spain
* Correspondence: aperezn@uoc.edu

Featured Application: This works can help to choose the better and more efficient videos for professors of Physics courses.

Abstract: Digital videos have an important and increasing presence in student learning. They play a key role especially in subjects with high mathematical content, such as physics. However, creating videos is a time-consuming activity for teachers, who are usually not experts in video creation. Therefore, it is important to know which kinds of videos are perceived as more useful by students and why. In this paper we analyze students' perception of videos in an introductory physics course of engineering with over 200 first year students in a 100% online university, Universitat Oberta de Catalunya (UOC). Students had 142 videos available of several types. We followed a qualitative methodology from a ground theory perspective and performed semi-structured interviews. Results show that students found videos as the most valued resource, although they considered that videos cannot substitute text documents. Students valued human elements and found them in videos where the hands of the professor appear. Finally, students consumed videos according to the course schedule, visualized the whole video the first time, and consumed it later according to further deliveries and exams. The main contributions of this paper were analyzing the perception of students from a qualitative perspective in an introductory course of physics in engineering, obtaining the main elements that make videos useful for students and showing that videos with hands are valued by students.

Keywords: educational videos; videos with hands; non-verbal information; e-learning; physics education; STEM; sciences education

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1. Introduction

Nowadays, the use of videos is the most common type of social medium [1] and is used in class and published online [2].

However, creating videos is a very challenging task that requires many hours and resources for just a few minutes of video [3]. Teachers usually lack the skills to create videos with a professional look and the literature shows that teachers find it easier to create videos by recording their classrooms since this is the closest scenario to their abilities. Nevertheless, this kind of video is not the most useful for students since they have the lowest engagement [4] and they are often too long which lowers student engagement [5]. Thus, it is important to find out which videos are useful for students but are also easy to create for teachers.

Our main hypothesis is that creating videos filming the hands of the teacher while they are writing on a paper (or on a blackboard) satisfies those requirements, since they look similar to how teachers explain when a student attends to discuss items with them privately. We call these videos, videos with hands. We think that videos with hands also satisfy another important aspect which is the emotional link with the teacher [6], and the provision of non-verbal communication [7].

On the other hand, students of science and engineering at Universitat Oberta de Catalunya (UOC), and potentially at any online university, have greater difficulties in completing their academic program in comparison to students from other disciplines (i.e., the dropout rate is higher in those disciplines [8]). Within science and engineering, a physics course offers a stressful scenario to students because it is a challenging course for most [9], with a high load in mathematics, which is accentuated in the case of 100% online universities because of the difficulties of distance education [10].

In this work, we analyze students' perception regarding videos in an introductory course in physics in several studies of engineering at a university that is 100% virtual (UOC). This analysis will allow us to understand if students perceive videos as a useful resource. Physics is a challenging scenario in which the role of videos could be more critical. In addition, analysis of the physics course allows comparing different kinds of pedagogical videos: (1) theory videos, in which a concept is introduced; and (2) videos of problems, which present a challenge, a problem or an exercise and explain how to solve it using the tools explained in the theory videos.

To perform the analysis, a qualitative approach was taken, from the grounded theory perspective [11]. Students' perception was obtained thorough the analysis of semi-structured interviews, according to the Wengraf spectrum (referenced by [12]), following an approximation hypothetic-inductive.

This is exploratory research to understand the interaction between students and the video in introductory physics courses from the students' point of view. As far as we know, this is the first time that interviews were used as the method to learn about attitudes and perceptions of students regarding videos in a physics online course. According to Bogdan, Taylorn and Taylor (1975), this qualitative approximation involves an empathic understanding and has the ability to represent thoughts, feelings and motivations of the students [12].

The paper is organized as follows. This section presents a literature review regarding the use of video as a pedagogical tool, the importance of using human elements like hands in videos, the suitability of these videos in the specific features of physics courses and the hypotheses of the research. In Section 2 the methods are shown. In Section 3 the results obtained are shown and Section 4 presents the conceptual/causal matrix and mapping tree, discusses the gathered knowledge and analyzes if results are compatible with the hypotheses. The paper concludes with Section 5.

1.1. State of the Art

Videos can facilitate the use, entry and access to information [13]. The use of videos in schools has been very positive, having the desired effect on students [14,15]. The benefits of using videos have been well documented [16] and the inclusion of educational videos in difficult conditions for teaching can facilitate the educator's job [4].

Videos are widely used in e-learning [2] and are an extended resource at the university level for science courses. There are some existing demonstrative videos being used to teach scientific concepts [17–19]. There are two main reasons for the widespread use of this resource in science learning. The first is that: they contribute to increasing the effectiveness of knowledge transmission [20–22], as well as the performance to memorize [23] and motivate [24,25]. The second is that they facilitate bringing theory into practice and making videos is a powerful resource for acquiring scientific skills in general [9] and in physics in particular [26,27].

- In addition, from the student's point of view, video can be a crucial teaching tool in improving the follow-up of science courses in general, and physics in particular, for several reasons:

- It can make it easier for students to acquire the abstraction capacity required for this type of course [9,28].
- It helps to relate different scientific courses for better internalization and transversality [29].
- It can contribute to reducing the concept of difficulty associated with science courses [30,31].
- It can facilitate the transition and acquisition of scientific language [32].

It is important to note that the current research is addressed to online students. In this context, the lack of human contact has been considered as one of the disadvantages of online education [33]. Due to the importance of verbal and non-verbal communication, media-rich forms of communication should be promoted for all the important tasks or messages within the learning experience in order to maintain a minimum non-verbal communication.

There are many visual or non-verbal kinds of information that students can perceive during the lesson that could have a strong influence on their learning process. Among them, iconic gestures that accompany the dialogue during the communication are a very important part of information transmission. Several studies have shown that the understanding of iconic gestures involves brain activations related to semantic processing of the word [34,35]. Listeners also pay attention to iconic gestures and collect the semantic information they encode [36,37].

Other research [38] indicates that gestures also show semantic primate effects (implicit memory), showing that iconic gestures without speech (moving hands in the form of a flying bird, for example) present semantic stimuli in the spectators. Thus, these iconic gestures transmit semantic information by virtue of their form-meaning relationship. However, although they have been done intentionally to support the objects and events that they represent, they are not perceived as mere incidental accompaniments to the voice channel but are semantically processed during comprehension and as an integral part of the communicator's message [39].

Hand gestures can alter the interpretation of discourse, eliminate ambiguities, increase understanding and memory, and transmit information not explicitly integrated into the discourse [40–42].

Some studies have pointed out the importance of showing the teacher's head and his/her gestures in distance learning [43]. However, when the head of the teacher appears in the videos, there are extra elements that also play an important role in non-verbal communication such as physical appearance like clothing, hairstyle, body language, and even beauty [6] and iconic gestures like facial, body or head expression [44]. It is important to note that usually teachers are not professional actors, and all these elements can affect the effectiveness of the transmission of knowledge. Other techniques show the teacher's head as a split or double screen technique. These techniques have been found to produce a great potential for distractions since are perceived by the user with a higher cognitive load [45] and can be decontextualized from the information that is being transmitted.

Videos that contain hands can contribute to reduce the cognitive load by providing non-verbal communication which helps to connect different kinds of representation (e.g., symbolic, diagrams, concrete and idealized representations, etc.) exposed during the lesson [46,47]. In addition, they do not have the drawbacks linked to the appearance of teachers that are not professional actors and cannot be decontextualized.

Finally, instructional models have been very common in physics classes for several decades, in which problem solving is emphasized [48–51]. These practices are still present in many faculties [52] for reasons that go beyond the scope of this paper. When students' preferences are analyzed, they seem to prefer superficial learning strategies when aiming to achieve good grades in the physics courses studied in this research. A problem-solving methodology is followed, and the evaluation is problem solving centered. The videos where an exercise is done, or a problem is solved is what we call videos of problems and we think that students could pay different attention to videos more focused on problem solving (videos of problems) and to videos where theory is introduced (videos of theory).

1.2. Hypotheses

According to state of the art, the hypotheses that will guide the deductive part of our research in the context of physics courses are:

Hypothesis 1. *Online students prefer video to text documents.*

Hypothesis 2. *Online students prefer videos with human elements.*

Hypothesis 3. *Online students prefer hands as the human element to appear in videos.*

Hypothesis 4. *Online students prefer videos of problems.*

Hypothesis 5. *Online students consume videos linked to activities, deliveries or exams.*

Hypothesis 6. *Online students interact with the video when consuming it (i.e., students use the buttons play, stop, pause, move forward and backward while watching the video).*

The first three hypotheses are focused on the preferred resource by students. Hypothesis 4 is related to the kind of contents students prefer (videos of theory or videos of problems). Hypothesis 5 is related to the organization and planning of the course and Hypothesis 6 deals with the way in which students consume video. However, since the research will have an exploratory part, it is open to finding results beyond these hypotheses.

2. Materials and Methods

In this section we show the kind of videos used, the population under study, how data was collected, and the methods followed to perform the analysis.

2.1. Kinds of Videos

Two main kinds of video were created: screen capture (Figure 1), created with a Wacom tablet; and videos with hands (Figure 2) created with a camera that filmed the hands of the teacher while he was explaining. Both kinds of video correspond to the same topics and they follow the same structure and notation used within the text material provided to students. In some videos, the head of the teacher was included in a small box inside the video to allow students to see his face. Table 1 shows the number of videos created per topic and kind—94 videos with hands (nearly 10 h) and 46 tablet videos (over 7 h).

Videos are mp4 with codec H.264. Aspect ratio is 16:9 with 1280 × 720 pixels at 25 fps. Sound is in AAC LC, stereo with maximum bit rate of 128 kb/s and sampling rate of 48.0 kHz.

Table 1. Number of videos created with tablet and with hands. The number of videos of theory and problems is specified for each group (Theo/Prbl).

	Hands	**Tablet**
	Time Theo/Prbl	**Time Theo/Prbl**
Mechanics	1:54:20/1:56:26	0:17:38/3:16:26
Circuits Theory	0:50:36/0:44:58	0/0
Electrostatics	0:34:23/1:23:14	0:52:24/0:58:45
Magnetostatics	0:48:54/1:25:46	0:36:55/1:06:50
TOTAL Theo/Prbl	4:08:13/5:39:24	1:45:57/5:22:01
TOTAL Hands and Tablet	9:47:37	7:08:58
TOTAL	142 videos	16:56:35

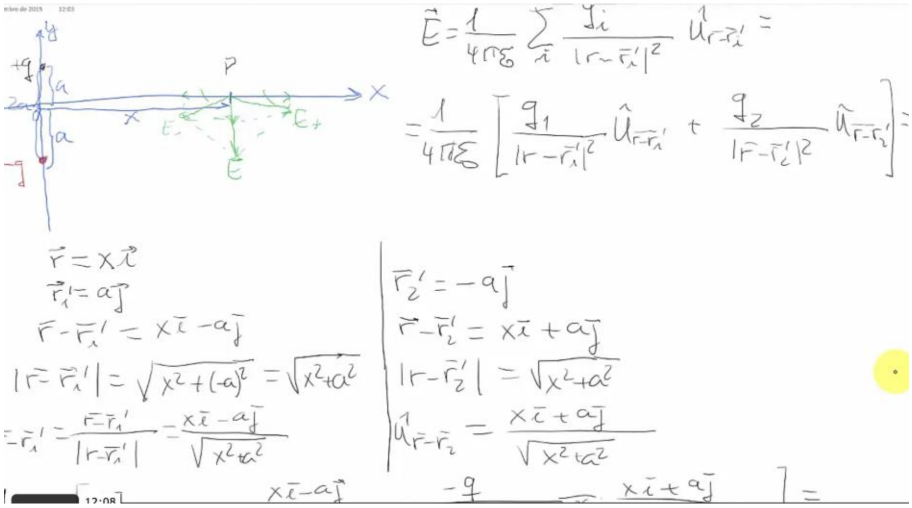

Figure 1. Example of a video created with a digitalizing table: https://vimeo.com/146556665.

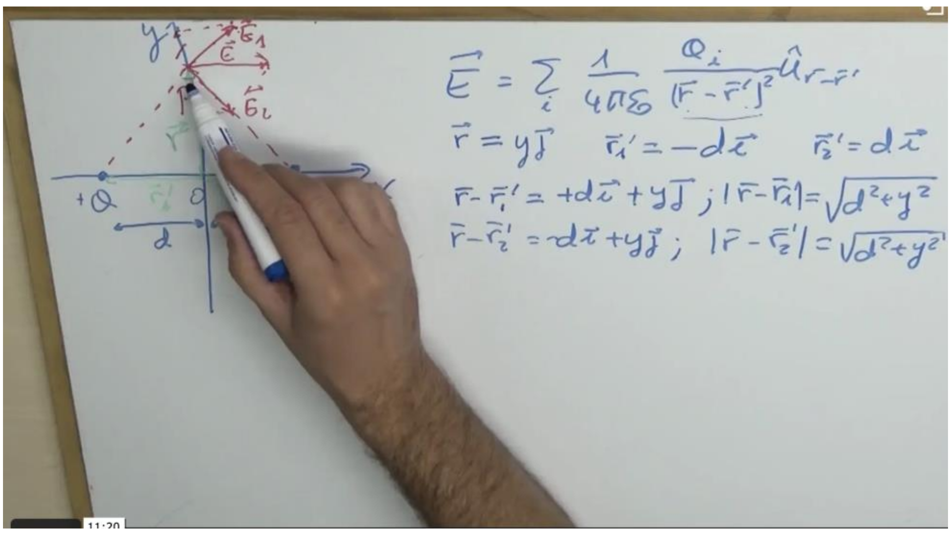

Figure 2. Example of a video with hands: https://vimeo.com/147752184.

Videos were delivered to students by two different systems—either a tool developed by UOC and named PRESENT@ [53,54] or a WordPress webpage. In both cases videos were grouped by topic and ordered following the same order as the text materials.

2.2. Population under Examination

The experiment was performed at UOC, which is an online only university. The courses chosen were: Physics I, which is part of the degree of Telecommunication at UOC (“Tl”) and Fundamentals of Physics, part of the degree of Computer Sciences at UOC (“Inf”). Table 2 shows the topics covered in every course. Within each topic, only the videos that corresponded to the corpus of the course were given to the students.

The majority (95%, 135) of the videos were recorded by the same teacher, who is the teacher of all courses, which is beneficial since students’ engagement increases when the videos have been created by their own teacher [5].

Videos were given to students at the beginning of every lesson as complementary material. Students were given access to other material, including text material with the content of the lessons, solved exams and exercises from previous semesters and Moodle tests. It is important to note that planning was given to students at the beginning of the semester in order to help students manage expectations for each week.

Throughout the semester students had four deliveries and a final exam.

Table 2. Contents of every course involved in the experiment. Contents are grouped according to the degree of the courses: Telecommunications (Tl) or Informatics (Inf). An x in a cell indicates that the related content is covered in this course.

	Tl	Inf
Mechanics	x	
Circuits Theory		x
Electrostatics	x	x
Magnetostatic	x	x

UOC has a proprietary virtual campus where students have all the materials corresponding to the course, as well as the videos with hands in PRESENT@ and communication tools. Videos are also available in Vimeo® and through a WordPress web page. However, they are protected by a password, so they are only accessible to students in the course. Watching the videos was not mandatory in any case.

2.3. Data Collection

Data collection was performed through a questionnaire and through semi-structured interviews. The questionnaire was analyzed from a quantitative perspective in a previous paper [55]. It allowed recruitment of the interviewed students following a theoretical sampling [12], since the last question of the questionnaire was the possibility of being interviewed; thus, we recruited those students who were open to giving information.

Interviews were performed following the structure given in Appendix A. The interview has a first part of indirect approximation to the environment and to the resources available in order to make interviewed students feel more comfortable and also to see if videos appear spontaneously within the students' speech. The second part went deeper into videos, trying to discover whether students like them, find them useful and why. This part dealt with Hypotheses 1, 2, 3 and 6. The next part of the interview tried to discover the relation between videos and other elements of the course (Hypothesis 5). Then, the interview focused on the distinction between theory and problems (Hypothesis 4) and in the next step went thorough students' behavior with the video (Hypothesis 6). Finally, the interview looked for students' opinions about other possible innovations and looked for any other element that students would like to add.

Nine students were interviewed. We believe that no more interviews were needed because with this number we arrived at saturation in most topics. All the interviews were recorded and all but two were performed by phone because, due to the UOC model, interviewers and students live in very distant locations. Following the indications given by Starks & Brown Trinidad [11], the interviewer acted as a listener.

2.4. Data Analysis

Data analysis was based on Starks and Brown Trinidad [11] indications for interview analysis for a grounded theory framework which includes the following: open coding (examining, comparing, conceptualizing and categorizing data); axial coding (reassembling data into groupings based on relationships and patterns within and among the categories identified in the data); and selective coding (identifying and describing the central phenomenon, or "core category," in the data). In the following paragraphs we describe how this process was followed in the current research.

Interviews were transcribed and analyzed in several steps. First, an exploratory codification by two different researchers for every interview was performed. After this first coding, a list of codes was created. Every interview was then divided into fragments in such a way that every fragment contained only one single concept. The division in fragments was performed by two researchers until a consensus was reached and a third researcher solved disagreements. Then, two different researchers coded every interview using the list of codes and the separation in fragments. Thus, every interview was coded following the same fragments and with the same codes, which allowed codification comparison.

Researchers were allowed to add a code in the case that none fit. To make the fragmentation of the interviews and the open coding we used Atlas.Ti 8.4.4®.

Codification was then analyzed and a conceptual graph with the results was obtained (see Figure 3). Codes that had nothing to do with the videos and the course itself were ignored, like those saying, "I prefer online learning".

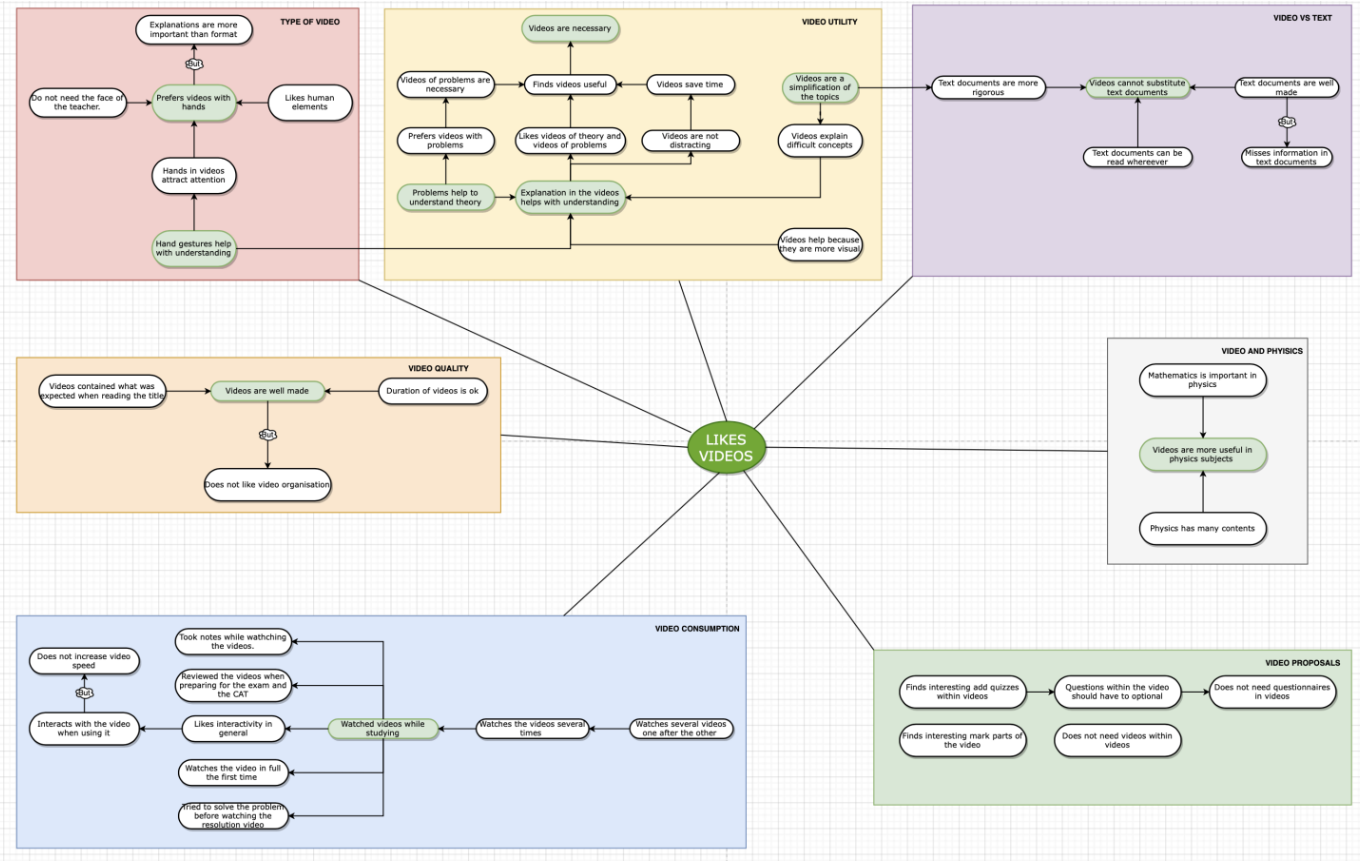

Figure 3. Conditional/causal matrix between codes related with video perception. Green nodes represent those where several arrows come in and out.

From the conceptual graph, an axial coding was performed in order to find the key elements that explain the attitude of physics students regarding videos.

Then, results and codification were compared using Microsoft Excel®. Diagrams were created using Diagrams.net (the conditional/causal matrix) and Excel (the mapping tree).

3. Results

Interviews were divided into fragments (the shortest had 25 fragments and the longest had 65 fragments). There were 153 different codes used. A total of 432 fragments were codified with those codes. The Kappa Cohen coefficient for the concordance in the codification from the two first evaluators was 0.5, which corresponds to a moderate agreement according to Landis and Koch table of kappa strength of agreement [56]. Although this is a moderate value, we think it is acceptable considering the high number of fragments and codes. However, a third person solved the disagreements until a consensus was reached.

After the coding, using the codes that appeared in at least two interviews and that referred to the goals of the current research, we created a conditional/causal matrix graph that can be seen in Figure 3.

The codes in the diagram have been grouped in the axes represented as color boxes: those that refer to the type of video (pink); those that are focused on how useful students found videos (yellow); those in which videos are compared with text documents (purple);

those that refer to video quality (light brown); those that refer to the way in which students consume videos (blue); those that refer to the specificities of physics (grey); and finally, those that refer to the future improvements that could be included within the videos (green). As the central point, there is a code shared by all the interviewers which is that they like videos. This is why "likes videos" acts as a central code, and all the other elements in the boxes help to explain why. In the following paragraphs, we will explain in detail every axe.

3.1. Video Utility

Figure 4 shows an enlargement of the axe "video utility" of Figure 3. Interviewed students found that videos helped them understand. One of the students said, "Reading without knowing what they are talking about requires a great effort. When you have already seen the video you already know what you are talking about and the reading is faster and more fluid because you already know what they are talking about. If you already have the information before, when you read it you will put together puzzle pieces". Another student said, "When I said, 'I don't understand this', the video helped me to understand it".

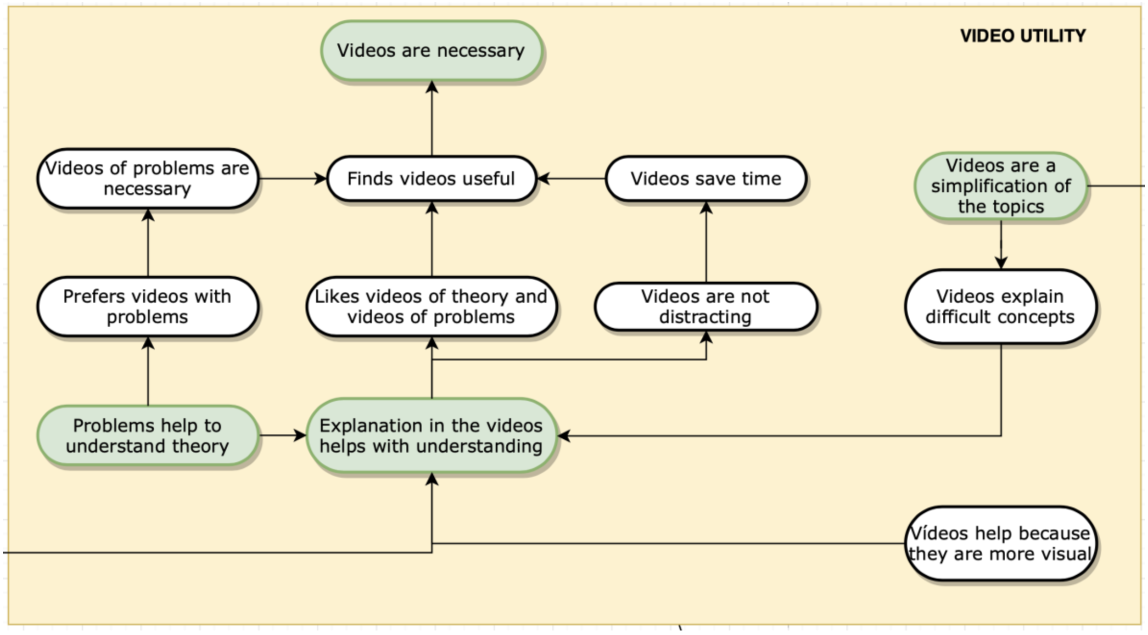

Figure 4. Enlargement of the box "video utility".

According to students' comments, the main reason that explanations in the videos helps them understand topics is that they consider videos a simplification of the topics. Some comments students said that videos are easy resources. Some sentences from students are: "videos are 'easy' resources, for dummies". They say either that videos allow to explain difficult things: "videos were very useful, with those balls (Students refer to balls and elements that were used in some videos), simple but very clear"; and they are more visual, "what I liked the most from the videos is the image that is appearing such as a outline".

Some students explicitly said they prefer videos with problems and find videos of problems necessary. In general, students liked videos of theory as well as videos of problems, as can be seen from the sentence: "Those of theory and problems are equally useful and necessary".

Regarding time, students found that videos were not distracting and saved time, as can be seen from the comment: "Videos have not taken away time; on the contrary, they have given time to me".

For all these reasons, students found videos useful and necessary. One student said, "If the videos were removed, I would think that the course has worsened". In fact, in previous research we saw that when videos were introduced in a course, the results improved [55].

3.2. Type of Video

Figure 5 shows an enlargement of the axe about the "type of video" from Figure 3. One of the elements that also helps with understanding according to students' comments is hand gestures. "The hands helped. There were gestures that helped me to understand the concept. There are all the gestures that are what you are looking for in the conversation. You look for gestures too".

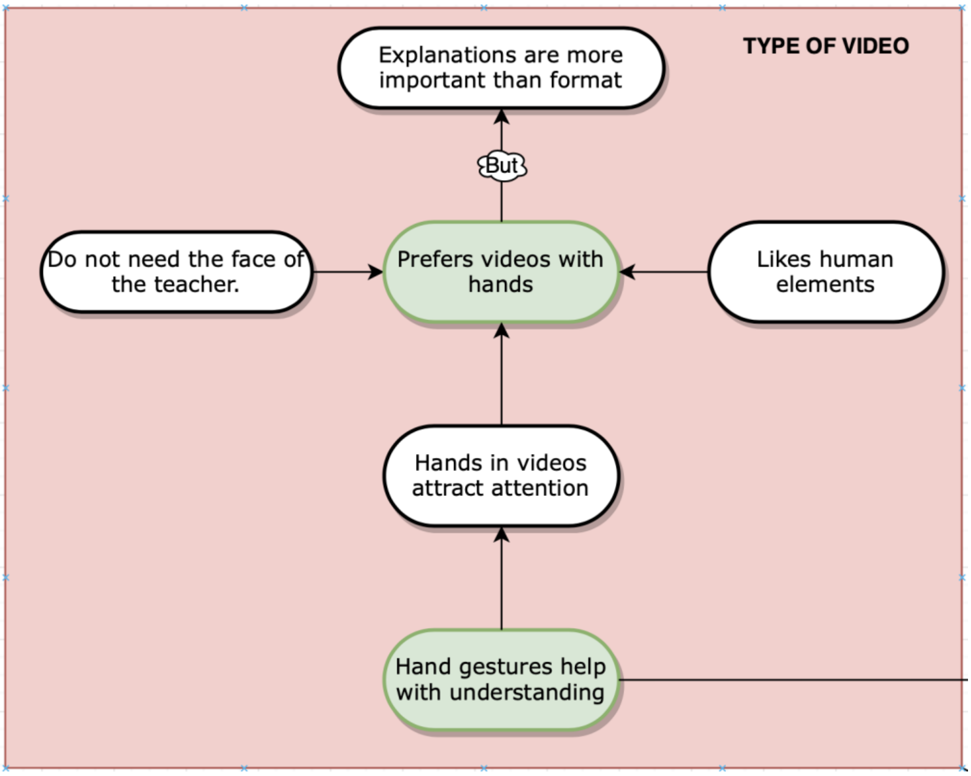

Figure 5. Enlargement of the box "type of video".

What makes hand gestures help with understanding is that they attract attention. For example, one comment was, "The videos of the hand are consumed differently. I concentrated more because you are looking at where the hand goes because the hand focuses attention on the area wherever you focus. You follow it because you think that if it moves, it is for a reason". However, one student suggested that another pointer could also help. "You could also do without the hands if they were replaced by a pointer or reference point". Nevertheless, in some cases the hands are the only way, as for example, when showing the direction of the magnetic field.

Students also stated that they like human elements. "I like the voiceover of the teacher who is doing the video", said one. However, some students also stated that they do not need to see the face of the teacher in the video. "Where the teacher comes out, he takes a piece of screen. I don't want to see your face I want to see the blackboard," said one student.

Videos with hands are preferred by students. Nevertheless, according to some students, showing the teacher's face sometimes attracted attention or increased human contact. "I would like more visual contact with the person who is making that presentation," said one student. "Not by showing him going during the whole video, but occasionally having contact with the teacher . . . he can appear at the beginning and then go out and, if there is something to highlight, appear and explain the question and return to the video". One student also linked the face of the teacher with the emotional part, saying, "If at some point someone appears it is nice. Maybe not in terms of learning, but in terms of emotion".

Many students compared the videos with other videos used in mathematics courses, created with a tool named LightScribe®, that allowed the teacher to write on a paper and record the voice while writing. Some students did not like this kind of video; others said they were acceptable. However, they were not perceived as useful as videos with hands.

Finally, it is important to note that some students believed that explanations are more important than format: "I give more importance to learning and also if the video is really giving a content".

3.3. *Video Quality*

Figure 6 shows an enlargement of the axe about the "video quality" of Figure 3. Another element that helps to explain why students like the videos is that they consider the videos well made. Contents were what they expected to find, with one student saying, "They were what you specifically needed taking into account what was done in the course". The duration of the videos was also good: "The Physics videos lasted between 2 and 10 min. Time is ok".

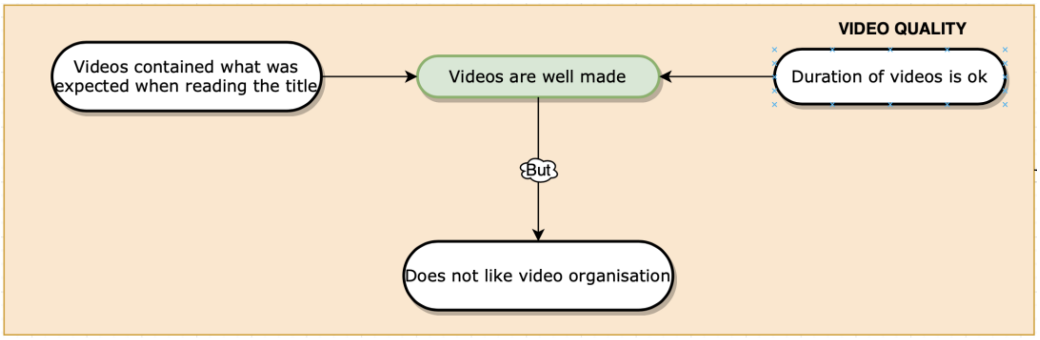

Figure 6. Enlargement of the box "video quality".

However, students did not like video organization. "What I liked least, perhaps, is the tool where videos were uploaded. I would improve the presentation environment," said one student That comment came from students that used the system PRESENT@. This system was developed by UOC to present final degree projects and was not designed to organize several videos. To simplify the organization, several PRESENT@ rooms were created to group videos of the same topic and videos were added by order.

PRESENT@ allows comments to be added within the videos, although students did not use it. Some students did not use it because they did not know they had this option. Others did not use it because they considered videos so clear that they did not need to add any comment: "no need to ask questions about the videos".

3.4. *Video Consumption*

Figure 7 shows an enlargement of the axe about the "Video consumption" of Figure 3. Students watched the videos until the end in the first visualization: "just in case the questions and doubts that appeared would be solved later in the video". Videos are watched in order: "Follow the order established by the course guide and see them one after the other according to the time available at each moment"; and videos are watched several times, "at least twice per video (one first shot and one review) but in more complicated parts of the course, up to four times".

On the other hand, videos are consumed as another element of study and usually watched while studying. For example, one comment was, "I did not frequently watch the videos, I watched them when I studied the module". Watching the videos was also related to the delivery of activities or exams. One student said, "Since I have already watched the videos, I reviewed the videos when having to deliver an activity". Activities were what we call "Continous Assessment Activities" (CAT).

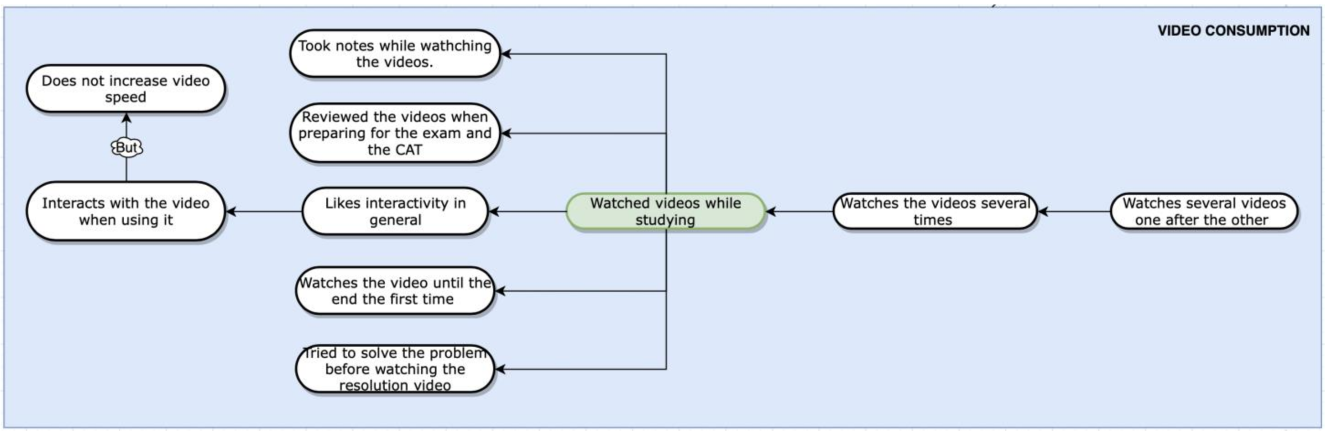

Figure 7. Enlargement of the box "video consumption".

An important behavior is that students take notes while watching the video: "Well, for example, I take notes, if there is something that interests me, I write it down, I always do that". And regarding videos of problems, they use videos as a support tool who may give them feedback and clues when needed. They usually try to do the problem before watching the video, and in case they do not know how to continue, they see the part of the video until that point. One student gives a reason for that behabiour: "Because it gives me the option to stop. Solve the problem by myself and then see how far I get by myself. When I arrive to a milestone, I can stop and watch the video to see my performance".

It is important to note that students liked the interactivity capabilities of videos, such as the possibility of stopping and jumping directly to several parts of the video. Usually, they interacted with the videos while watching them. "I use the back button and pause to return to a part that was not well understood or to take notes," said one student.

There are more interactions when reviewing the videos because in the first visualization students usually watch the video until the end. According to one comment, "In the following reviews, yes, you go more specific and go to specific points ... because you already know the content ... you go to the place you think you want to see, or you are looking for ... or you do a random search because you know that what you are looking for is in that area ... then there comes a time when you say, 'it is not giving me anything' and you start moving forward and skipping things to see if something that you did not catch appears".

Finally, in general, students do not change the video speed when watching a video.

3.5. Video Versus Text

Figure 8 shows an enlargement of the axe "video consumption" of Figure 3. Videos are the resource that students liked the most "In physics the materials are good, but with the videos, it is amazing" said one student. "The resources I liked the most are the videos," said another.

However, according to students, videos cannot substitute the text documents: "Videos can't replace text documents", or "Paper gives you knowledge. Explains everything to you".

Some of the reasons that can explain this feeling are that text documents are more rigorous. "Videos are a complement since text materials are much more rigorous," said one student. Others liked that papers are more accessible and can be read anywhere, whereas videos require more resources: "I take the paper and read it on the metro. The video needs more resources", said one student.

Although some students miss some information in the text documents, they think that text documents are well-made: "In the course, the text documents are very good". It is important to note that text documents are prepared for e-learning with some specificities like remembering simple contents that students are expected to know but maybe forgot, say how formulae are read or numbering equations: “Now, I am doing another course and the formulae are not numbered, that is a problem”.

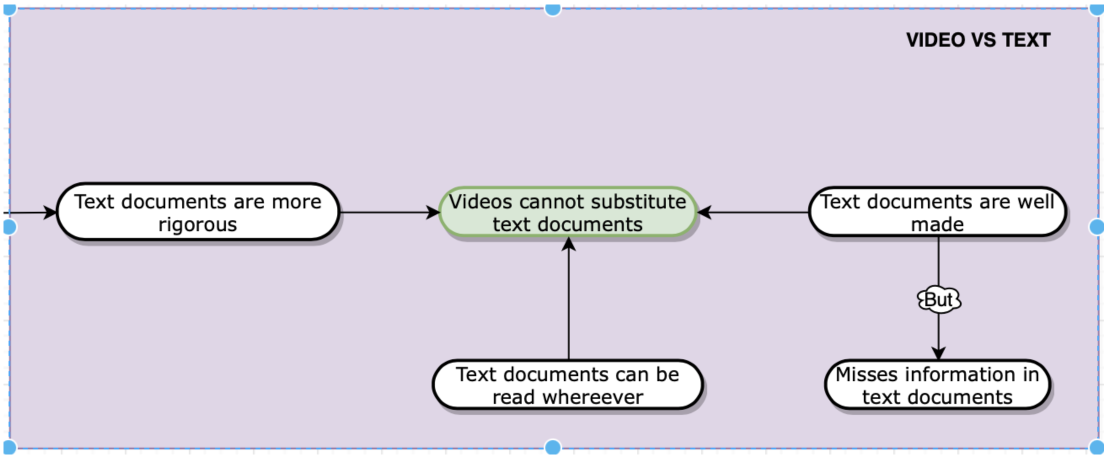

Figure 8. Enlargement of the box “video versus text”.

Text is also advantageous in that it is easier to review. “If you have a specific question, then you are not going to watch a 10 min video,” said one student. In fact, one student suggested adding transcription of the video with a summary of the important points. One single student said that, “Since the physics text was so well explained, perhaps videos were not necessary”.

One may think that the reason text cannot be substituted by videos could be due to lack of videos. However, videos covered all course topics and students perceived that they had enough videos: “the number of videos was more than enough in the course of Physics”. Thus, we can say that differences between text and videos are not due to lack of videos.

3.6. Video and Physics

Figure 9 shows an enlargement of the axe about “video and physics” of Figure 3.

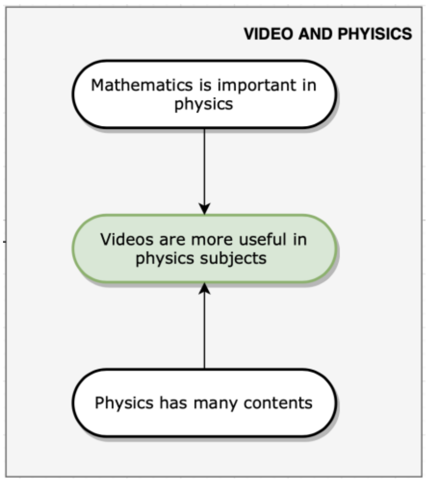

Figure 9. Enlargement of the box “video versus text”.

To analyze the relation between videos and the Physics courses, it is important to note that students say that they like the course. Students found, either, that videos are more useful in Physics courses: “Specifically for the Physics course, I really appreciated videos”. The reasons, according to them, are that mathematics are important in Physics: “At the mathematical level, I was lost. And seeing it in the videos. . . ”; and that Physics has many contents, “Maybe it’s the course that has a lot of content”.

In the UOC physics courses, students have text materials, videos, Moodle tests and solved exercises available. Students could feel overwhelmed by having too many resources, although the weekly planning helped. One student said, “I strictly followed the proposed guideline of watching the videos according to the module”. When we suggested removing some resources one student said, “No, it is better to have the resources and decide”. It is important to note that students were not expected to use all the resources, but only those that fit their way of learning.

3.7. Video Proposals

Students were asked about some innovations expected to be introduced in future videos, like tests within videos, marking some parts of the videos or including videos inside the videos to make clarifications.

Regarding tests within videos, although some students found them interesting, all of them said they should be optional. “It would be nice if you could skip them,” was one comment. Including videos within the videos is another innovation that some students perceived as unnecessary, although they found linking videos with answers to the tests as an interesting option. “It would be interesting if the videos were linked so that you would be directed to other videos based on the answers to the tests”. Some students said the reason for rejecting these changes is that they know how long the video is before starting it, and if we add elements, then the time needed to watch the video changes.

On the contrary, students found marking parts of the video an interesting option. “I find it useful to embed and share information in the video,” said one student. However, it is important to note that PRESENT@ allowed marking parts of the video and students did not use it.

4. Discussion

Interviewed students considered videos the most valued resource in the physics courses, where several resources were available such as text documents and Moodle tests. Students also perceived videos as a resource that helped them to more easily understand because the language and explanations were simpler and more visual than in text documents. These results are compatible with our findings in a previous quantitative research [55].

However, text documents cannot be substituted by videos according to interviewed students, since text documents are more rigorous, more complete and can be consumed wherever. Thus, videos are used as a resource to understand the topics and difficult steps, so they can be seen as a lubricant to better acquire the knowledge and skills described within the text documents, which are perceived as the most important resource.

On the other hand, students valued the videos with hands because of the capacity of the hand to point and focus but also to make some mimics, like in the case of the direction of the magnetic field. The hand is also valued for bringing a human element to the video. In addition, most students perceived the hands as a sufficient human element providing a social link with the teacher. This social link is something that interviewed students valued, since they are online students. Thus, students preferred videos with hands. It is important to note that videos are perceived as well-made, with the expected contents and the appropriate duration.

Regarding the way in which students watched videos, students usually used videos while studying and taking notes while watching the video. This is what face-to-face students do when attending classes. Therefore, the video can be perceived as playing the role that teachers play in face-to-face classes. The difference is that students can watch the video several times and can interact with the video and use it as a support tool that supports their self-directed learning, which is something very valued. As expected, students watched videos when preparing for an activity or an exam.

Something very specific to many scientific instructional courses such as physics is the difference between theory and problems. This distinction is also in the videos and, although students said they usually watched videos fully the first time, they also said that when watching videos of problems, they usually tried to solve the problem before watching the video. This is actually the goal of problems, and it is important to see that, although having the resolution in the video, students still try to solve them. Therefore, using videos does not interfere with the pedagogical role of problems.

The specificity of physics is also perceived by students, and they say that videos were helpful because of the role played by mathematics and the number of contents in the course.

Finally, students said they liked the possibility of adding comments within the video, although PRESENT@ allowed for this and the students did not use this option. Students said they would only accept tests within the videos if they were optional, but even so, did not perceive them as necessary. Nevertheless, comments regarding future proposals are an indication of how those innovations should be introduced for students to accept them.

After the open coding shown in Section 3, we developed axial coding to group the categories and find the most important elements related to videos in the classroom [12,57]. Considering the results of the open coding shown in the conditional/causal matrix shown in Figure 3, we proposed the categories shown in Table 3. It is important to note that some codes from the conditional/causal matrix can be found in several categories. For example, saying that, "hands act as a pointing element and attract attention" would correspond to "hands" and to "pointing elements/attract attention". On the other hand, there is a special category that is "hands". This category refers to codes related to videos with hands, but hands are a human element and are therefore also counted as so. The reason to explicitly separate hands is because of Hypothesis 3.

Table 3. Proposed categories related to the groups of the conditional/causal matrix and with the relative frequency of appearance.

Thematic Axe	Category	Relative Frequency
Type of video	Human elements	47
	Hands	14
	Pointing elements/Attract attention	13
	Explanations	2
Utility of videos	Comprehension	41
	Time	11
	Video useful and necessary	5
	Problems	21
	Theory	12
	Visual	4
Video vs. Text	Videos cannot substitute text	10
	Text useful and necessary	11
	Rigor	1
	Completeness	6
Video consumption	Several consumptions	13
	Related with deliveries	12
	Interaction	25
	Taking notes	3
Physics	Mathematics	2
	Difficult concepts	1
	Contents	1
	Quality	1
	Other resources	22

Categories are grouped in the axes shown in Figure 3. The category of video proposals was not taken into account since they are referring to future ideas and, therefore, students did not really test them.

Figure 10 shows the relative importance of the categories.

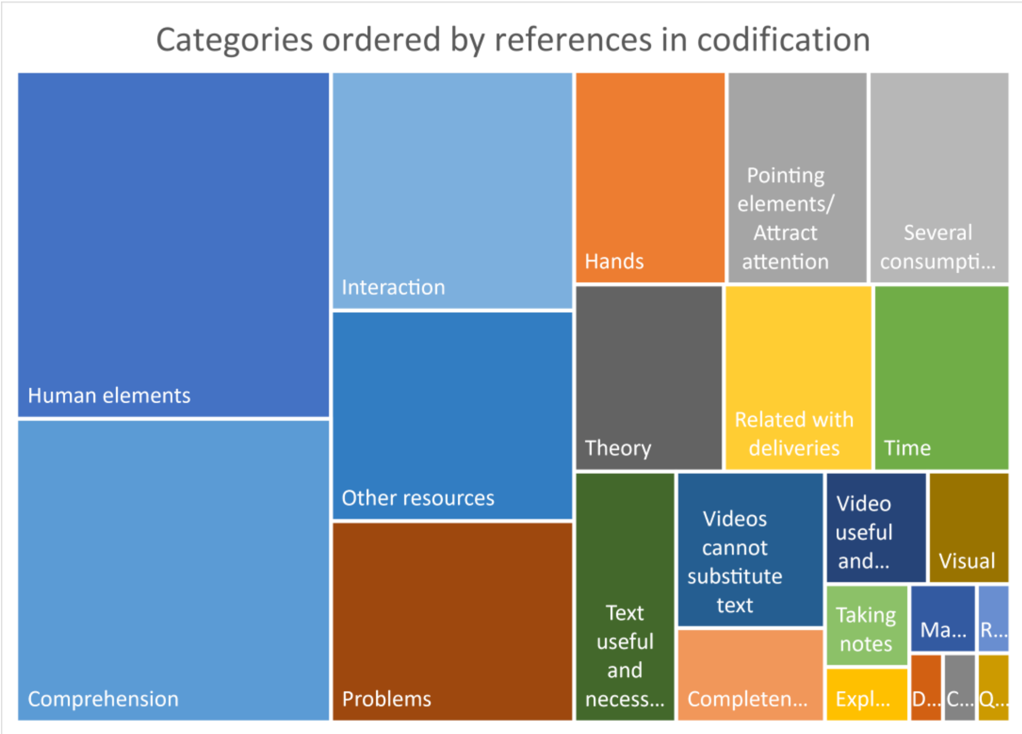

Figure 10. Mapping tree of the relative importance of every category.

Hypothesis 1, online students prefer video to text documents in physics courses, is difficult to validate. Students preferred videos because they helped them understand concepts. The idea that videos help them understand physics and mathematics in physics is under the category "comprehension" and, as can be seen, is one of the most important. However, the idea that videos cannot substitute text because of text completeness and rigor is also important. In fact, students found videos as useful and necessary as text documents. Therefore, students felt that videos complemented their physics text.

Regarding Hypothesis 2, online students preferred videos with human elements, we can see in the Figure 10 that human elements are those with the highest frequency. Online students often mentioned human contact and closeness.

We also see that hands are an important element in videos for students, which is compatible with Hypothesis 3. Online students prefer hands as the human element to appear in the video. The reason, as can be deduced from Figure 3, might be due to their role as a human element and their role as a pointing element that attracts attention. Having a pointing element or something able to attract attention in the videos is something highly valued by students.

Regarding Hypothesis 4, students preferred videos of problems where problems appeared with a high frequency in the interview, but only little higher than theory. Thus, the result of the interview is not compatible with this hypothesis since it seems that in physics both theory and problems play an important role for students, as shown in Section 3.

Hypothesis 5, that online students consume videos linked to activity delivery or exams, is compatible with results.

Hypothesis 6, that online physics students interact with videos when consuming it, is confirmed by the interview, and is something that stands out many times during the interviews.

Out of these hypotheses, we find that students speak many times about other resources they have available in the course such as text documents, solved exercises from other years and Moodle tests. Thus, although videos covered all the topics of the course, students consumed them within the ecology of resources available in the course.

Another element that has been found is the role played by time. Students perceived that although watching videos takes time, they save time because physics concepts are understood faster.

Finally, an element that shows that students felt videos work as a learning element is that they consumed them several times, and this category appears with a high frequency.

Limitations

The main methodological limitation of the current work is the number of interviews. Although we reached saturation and therefore, the obtained results should be considered as valid, a higher number of interviews could have increased confidence in the results. On the other hand, since it is an online university, interviews could not be conducted face-to-face. From an application point of view, there are some limitations due to the context of application of the research: (1) the results only apply to online learning universities since no students from face-to-face universities were interviewed; (2) the results may not be applicable in other contexts, for example within courses which less mathematical content.

5. Conclusions

In this paper we analyzed the perceptions and attitudes that online students have regarding videos in an online physics course, specifically, videos where the teacher's hands appeared in writing on a blackboard and videos where the hands did not appear. The method followed has been an analysis of interviews from a ground theory perspective. Thus, semi-structured interviews have been performed until saturation to validate hypotheses but also to look for new knowledge that would help explain the relation between students and videos in the classroom.

We found that videos are perceived as an extra resource available in physics and students use them combined with the rest of the available resources. Videos are the resource that they prefer because they facilitate and accelerate understanding of the concepts of physics and offer high interactivity. An indicator that they consider videos useful is that they watched them several times.

However, students considered the most important resource to be text documents because of their completeness, rigor and easiness to review. Therefore, we think that a physics course cannot be structured only around videos.

Online students find that human elements are also very important in an online environment. In fact, they find that hands in the video play this human role. But hands in the video also play the role of being an important element to attract attention, pointing to where the students should look, for example. Therefore, videos with hands are able to introduce a human element with an active role within the video.

Regarding the physics course, it includes theory and problems and, therefore, students have available videos of theory and videos of problems. We have found that students consume both of them and find that both are important. On the other hand, the consumption of videos is related to deliveries and exams and students watched the videos more frequently when they had these milestones.

Thus, from this study we conclude that videos play a key role in online physics courses, although they are considered a complement to other materials. Therefore, they should be augmented with other resources such as text documents according to students' preferences. Videos with hands are more adequate than videos with the teacher's face since they may address two necessary needs: provision of human element to create a social link among students and teacher and a pointing (mimic) element that focuses the attention of students or allows them to relate to relevant elements.

As future work, we plan to contrast these perceptions with the data collected from the use of the videos.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study may be available on request from the corresponding author, although it can be slightly modified and cut due to privacy reasons.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Structure of the Interview

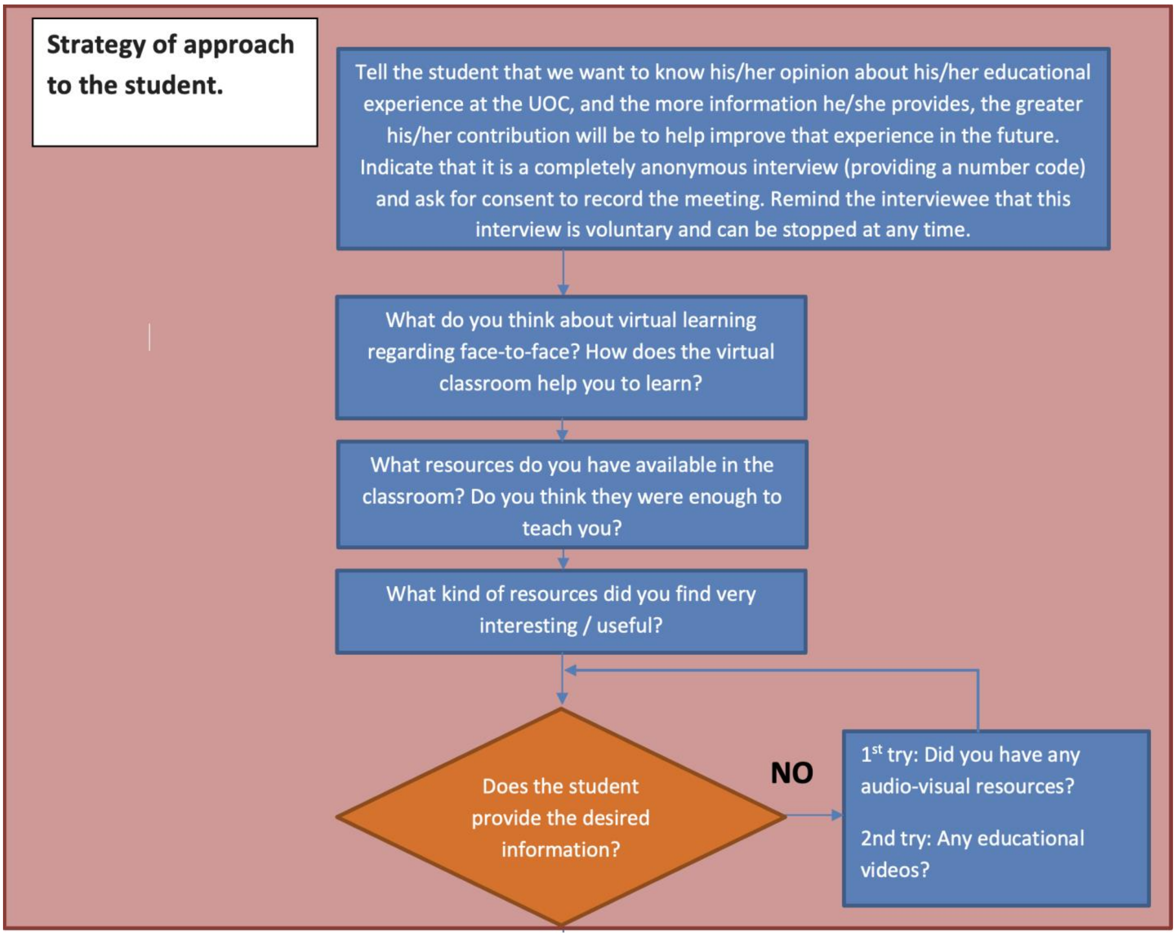

Figure A1. Structure of the interview (I).

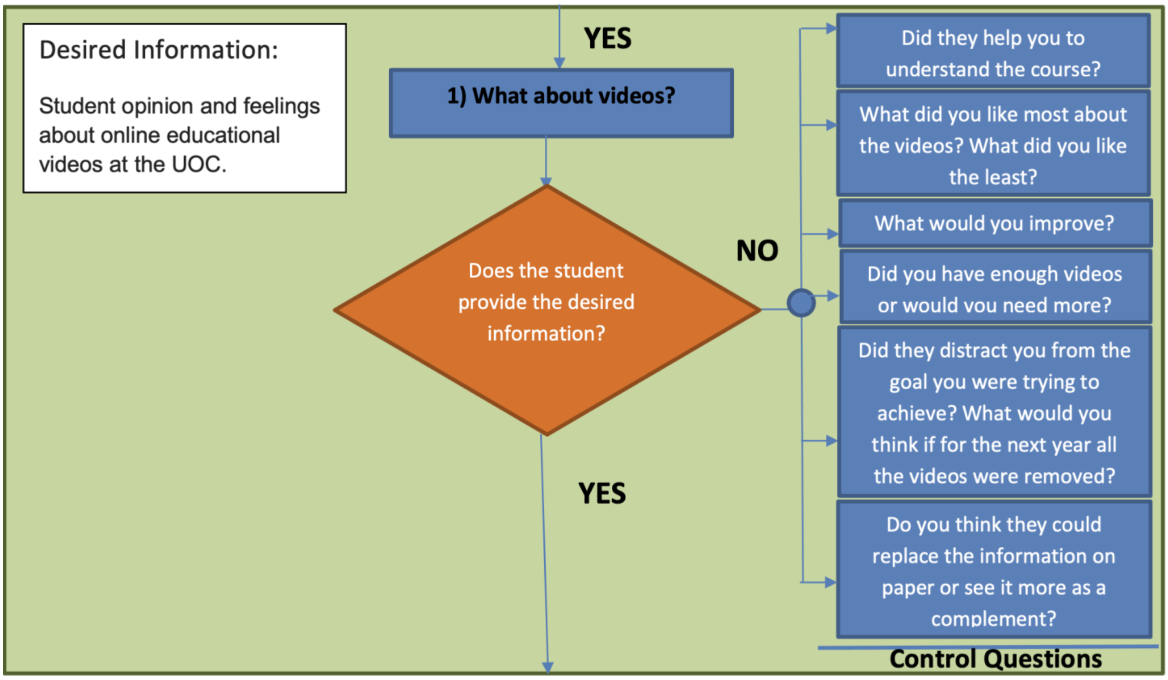

Figure A2. Structure of the interview (II).

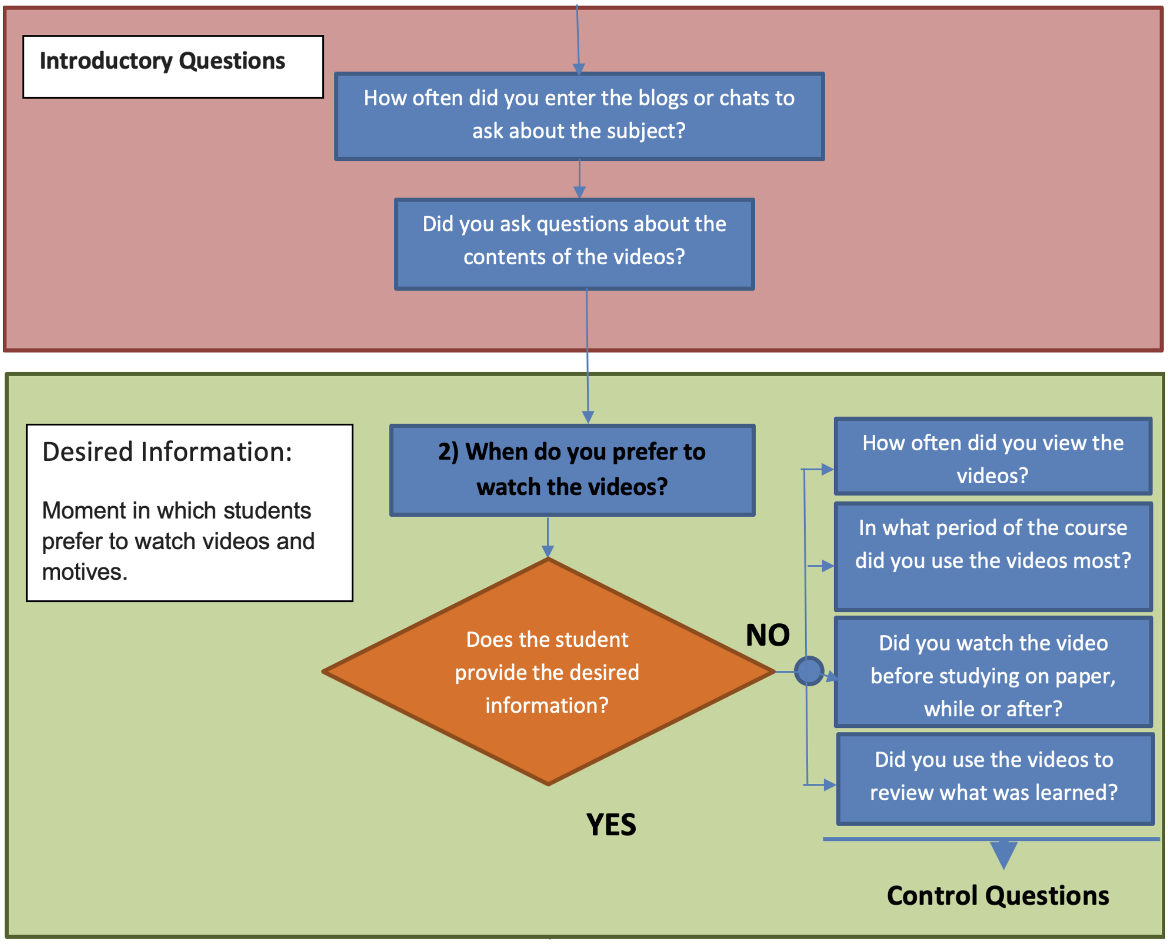

Figure A3. Structure of the interview (III)

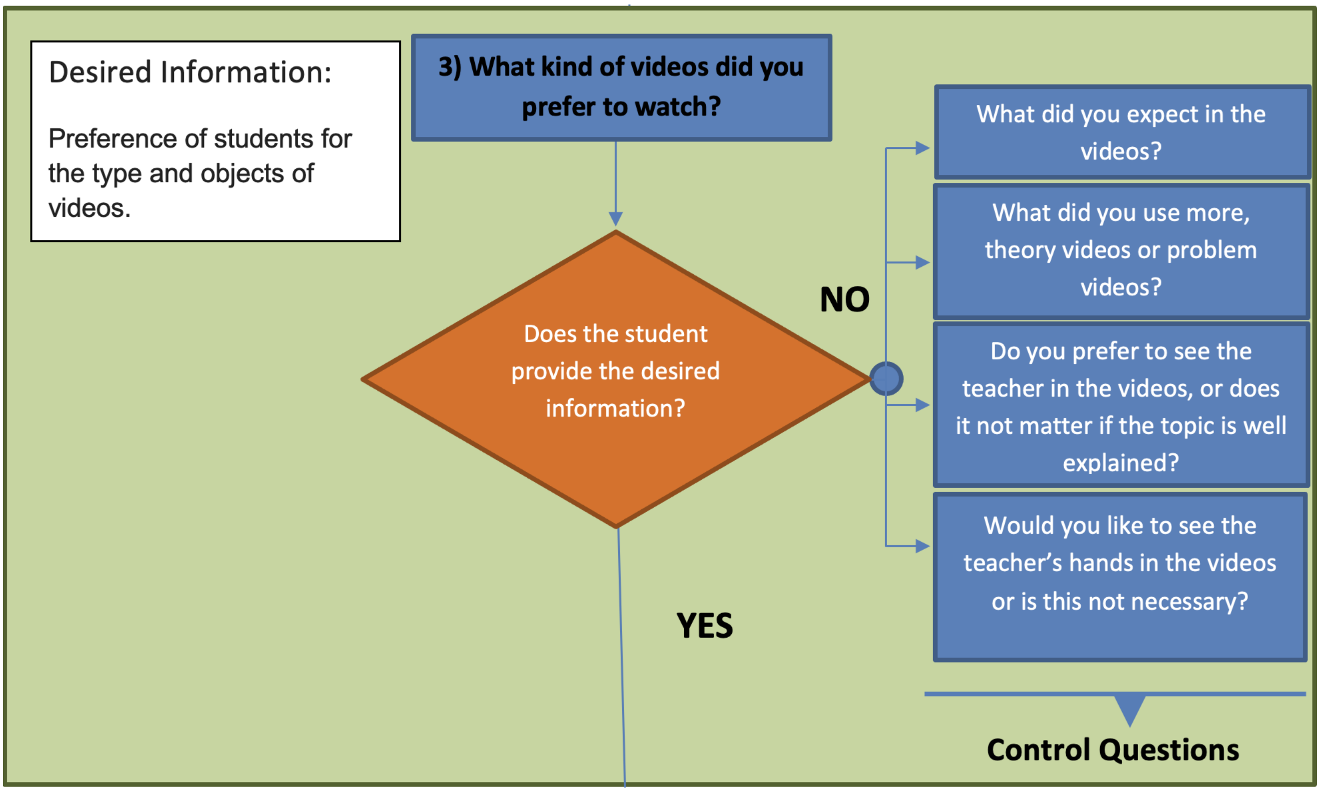

Figure A4. Structure of the interview (IV).

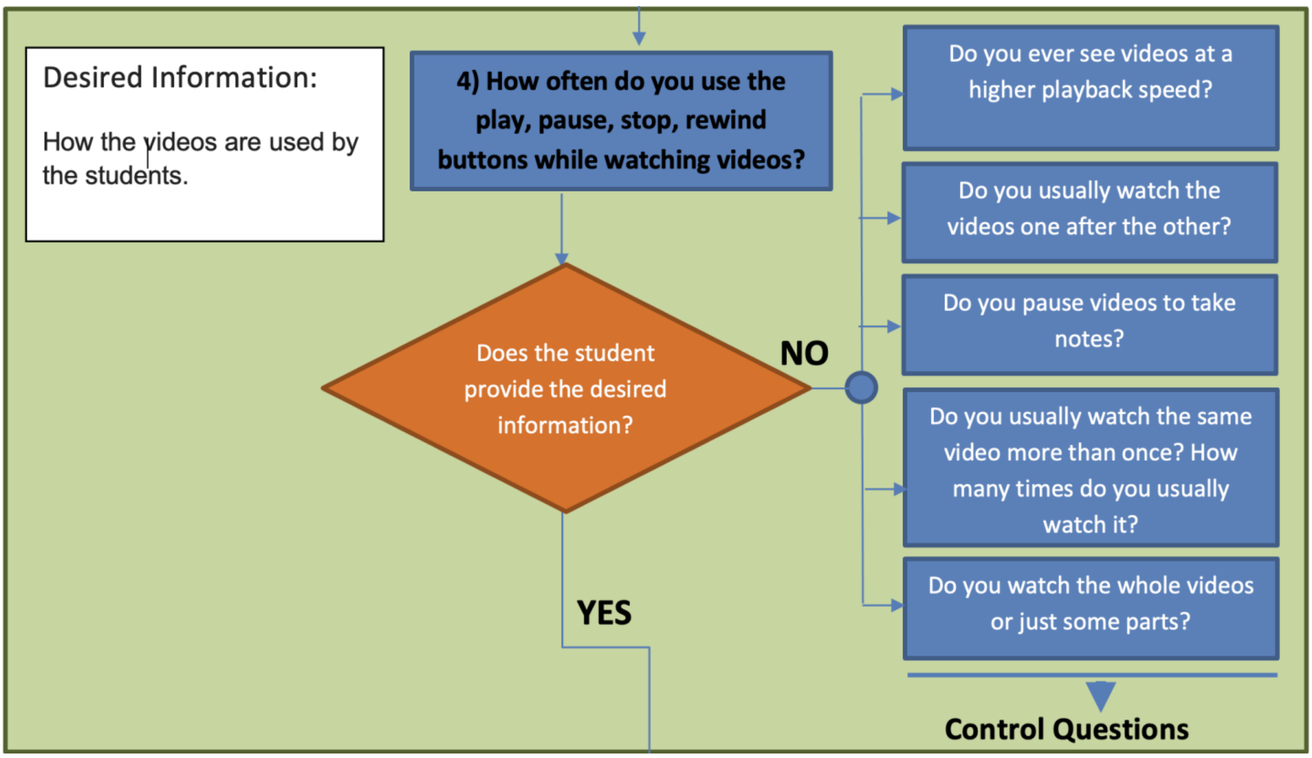

Figure A5. Structure of the interview (V).

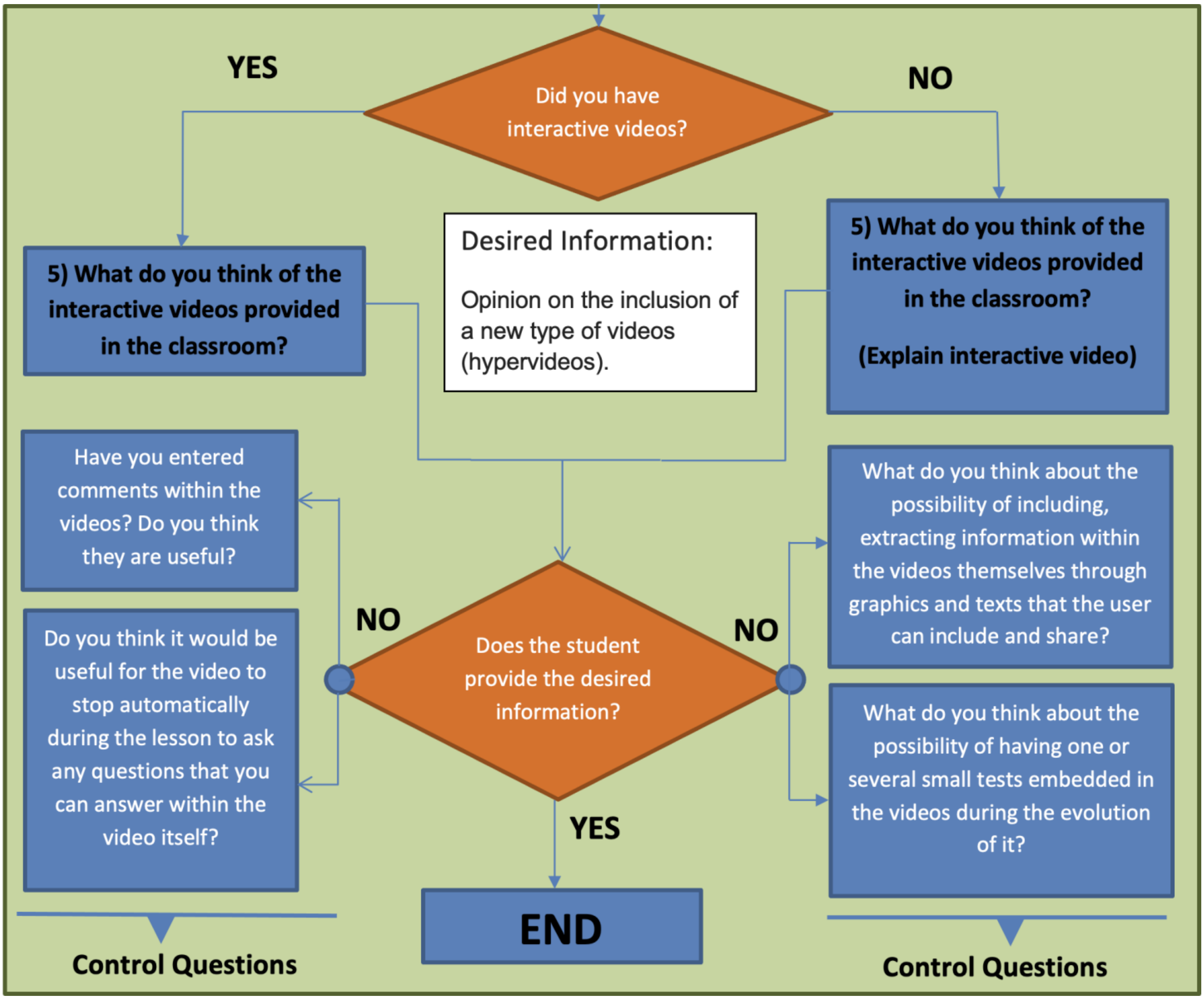

Figure A6. Structure of the interview (VII).

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