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# *Educational videos from a film theory perspective: Relating teacher aims to video characteristics*

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**Abstract**

Teachers are increasingly using video in their lessons, with various aims (eg, to raise students' levels of conceptual knowledge or interest). Videos that can be used for educational purposes are numerous, ranging from instruction videos to fiction films. Such videos have different characteristics, for example regarding the amount and structure of information, and the audio-visual presentation. However, guidelines on which video characteristics can help to achieve specific teacher aims are lacking. As a first step towards composing such guidelines, we added a film theory perspective to educational research on videos. The study included seven science teachers, 13 videos, and 233 students (aged 13–18 years). We used teacher interviews, video analyses, student questionnaires and a cross-case analysis connecting all the data. Data analysis followed a grounded theory approach, including open and axial coding to structure the data, and the constant comparative method to interconnect them. The results showed that videos that posed questions were associated with an increase in students' interest, and that highly informative videos with authoritative speakers were associated with an increase in students self-reported conceptual knowledge gains. Moreover, teachers often did not have explicit aims for using a particular video, and they selected and used videos in their lessons intuitively. Stimulating teachers to use videos in a more aim oriented way may make video usage more effective. From these findings, we developed a framework to assist teachers in selecting or making videos that match their aims, and a model of possible connections between teacher aims and film types as a first step towards guidelines for teachers using educational videos.

## Introduction

Audio-visual media such as video are increasingly taking a prominent role in (online) education worldwide (Thomson, Bridgstock, & Willems, 2014). Videos are popular with both teachers and students. Teachers often search for videos on online platforms, such as YouTube Edu, Khan

**Practitioner Notes**

What is already known about this topic

- From cognitive and educational sciences: Strategies for efficient processing of audio-visual information and categorized teacher aims.
- From film theory: Categorized educational video characteristics and a method for video analysis.

What this paper adds

- A film theory perspective on educational videos as a first step towards developing guidelines that relate teacher aims to video characteristics.

Implications for practice and/or policy

- Teachers are advised to explicate the aims they wish to achieve when using video, and to base their choice of video on these aims.
- Educational researchers are advised to include film theory perspectives on educational videos to build on film research findings and to open up new research directions.

Academy and (in the Netherlands) Wiskunde Academie (which translates to Math Academy).[1] However, in educational research and practice one question keeps returning in the debate on video usage: What makes a good educational video? (Hobbs, 2006; McClusky, 1947; Schwartz & Hartman, 2007; Thomson *et al.*, 2014). This question is not new: From the 1920s on, film has been used for educational purposes. As soon as films and projectors became affordable and operable for the general public, film made its way into the classroom (Masson, 2012). Yet, after 100 years of teaching with this medium, the question of what makes a good educational video still remains largely unanswered.

What educational videos look like varies greatly: they range from knowledge clips (eg, instruction about Newton's Laws), and how-to videos (eg, demonstration of how to graph linear equations), to live registrations (eg, registration of chemical experiments), documentaries or fiction films (eg, a dramatized narration of the discovery of penicillin). Teachers' aims for using educational videos also vary, and range from instruction or raising interest, to illustrating classroom instruction or generating input for discussion (Hansch, McConachie, Schmidt, Hillers, & Newman, 2015; Schwartz & Hartman, 2007). However, it is unclear what a video should look like to help achieve a particular teacher aim (Schwartz & Hartman, 2007; Thomson *et al.*, 2014). Because guidelines are lacking, teachers have no choice but to go by intuition and experience when using videos for education, making videos' effectiveness uncertain. More research is needed to help teachers make or select videos that meet their educational aims (Schwartz & Hartman, 2007).

*Educational sciences and video*

Previous research on educational videos has mainly been conducted from an educational sciences or cognitive psychology perspective. These studies focus on factors such as efficient processing of audio-visual information (Clark & Paivio, 1991; Kester & Van Merriënboer, 2013; Mayer, 2014; Muller, 2008; Sweller, Ayres, & Kalyuga, 2011), and learning in online environments (Bergmann & Sams, 2012; Kay, 2012; Scagnoli, Choo, & Tian, in press; Van der Zee, Admiraal, Paas, Saab, & Giesbers, 2017). Most of these studies share a focus on increasing the learner's level

[1]https://www.youtube.com/edu; http://www.khanacademy.org; http://www.wiskundeacademie.nl.

of conceptual or procedural knowledge. Only a few studies investigated the diversity of teacher aims that could be achieved with video (Schwartz & Hartman, 2007; Baggaley, 2013; Hansch *et al*., 2015). Coming from the field of educational sciences, studies that investigate teacher aims give elaborate aim descriptions (eg, Schwartz & Hartman, 2007; cf. Table 1). Besides this, some studies attempt to describe kinds of videos that connect to these aims (eg, Koumi, 2006). However, these contributions remain insufficient to formulate guidelines, because the video characteristics are not researched sufficiently. In their paper, Schwartz and Hartman (2007) even call for more research on educational videos to enable describing effective mechanisms that connect video characteristics and teacher aims. We argue here that adopting a film theory perspective can contribute valuable insights for research on educational videos and thereby, ultimately, help develop guidelines for educational use of videos.

*Film studies and educational video*

In the field of film studies, videos are analysed systematically by looking closely at what characterizes them. The two main factors that are taken into account in such video analyses are the flow of information and the audio-visual presentation of that information. The first, referred to as the formal system, defines how information is selected, composed, and coloured; the second, referred to as the stylistic system, defines how information is audio-visually presented in mise-en-scène, cinematography, editing, and sound. The interfering formal and stylistic systems together shape the video's *film form* (Bordwell, Thompson, & Smith, 2017), which is typically categorized in terms of *genre* (Altman, 1998). Genres can help viewers a great deal in trying to make sense of what is presented, because they are based on filmic conventions that direct viewer expectations (Bordwell, 1985). To give an example of a well-known fiction film genre, we recognize a Romantic Comedy by the use of soft tone colours, emotional music, and many close-ups. These characteristics guide the viewer into anticipating the typical romantic comedy story to develop of a single (wo-)man searching and finding a partner.

The educational film can be seen as a genre, cueing the viewer to anticipate the treatment of some educational content that is to be learned. Educational content may range from quantum physics to psychology, and learning may involve more than gaining conceptual knowledge. Film genres are general descriptions of typical structures. To categorize educational films with respect to their variety, we propose not only to look at what binds them, but also at what distinguishes them from each other.

*Table 1: Categories of Teacher Aims and Corresponding Video Examples, Based on Schwartz and Hartman (2007, p. 338)*

| *Teacher aims* | *Sub aims* | *Description* | *Video examples* |
|---|---|---|---|
| Doing | Attitude<br>Skills | Learning attitudes and skills from presented human behaviour | Modelling, identification, demonstration, step-by-step |
| Engaging | Contextualize<br>Interest | Preparing to learn through creating contexts and developing interests | Ad, trailer, trigger, narrative, anchor |
| Saying | Explanations<br>Facts | Learning verbal or declarative knowledge | Association, chronicle, analogy, commentary, expository |
| Seeing | Discernment<br>Familiarity | Learning to notice discernment and to recognize something new | Tour, portrayal, point of view, simulation, highlighting |

*Table 2: Film Types in Educational Videos, Based on McClusky (1947, pp. 374–378)*

| *Film type* | *Video description* |
|---|---|
| Discursive | Systematic treatment of a topic for introduction, summary or background material |
| Dramatic | As narrative film type, but more emotionally loaded |
| Drill | Repetitive series of actions that are to be copied by the viewer |
| Emulative | Shows how to perform an act or skill, or shows patterns of behaviour |
| Evidential | Record of (scientific) data for study or analysis |
| Factual | Encyclopaedic presentation of an event or topic for conveying information |
| Incentive | Activates to develop character, attitudes, morale and emotional response |
| Narrative | Tells a story based on fiction or fact to inform or to give an account of events |
| Problematic | Sets a problem for discussion and supplies data for thinking |
| Rhythmic | Artistic effects that are to evoke aesthetical reactions within the viewer |
| Therapeutic | As rhythmic film type, but for the treatment of psychoneurotic patients |

Through making analyses of the formal and stylistic systems of many educational films, McClusky (1947) defined no less than 11 types of films in the educational film genre (see Table 2). In addition, he described the educational context in which these videos could be used, giving a lead to connect video characteristics to teacher aims. Film analysis of video characteristics and the descriptions of the educational film types together provided the framework we used to describe the educational videos in our study.

Connecting frameworks from the educational sciences and film studies will help make a first step towards developing guidelines for relating teacher aims to video characteristics. To this goal, we performed an exploratory study on videos in science education researching the question: Which video characteristics can be expected to help achieve which teacher aims? To answer this question, we gathered data following three research questions: (RQ1) What aims do teachers have when using videos in their lessons? (RQ2) What are characteristics of the videos that teachers select for their aims? (RQ3) How do students evaluate the selected videos in relation to the teacher aims?

## Method

### *Participants*

Seven science teachers in Dutch secondary education participated in our study: four male and three female, aged 33–52 years ($M = 43.43$, $SD = 6.91$), with 6–17 years of teaching experience ($M = 10.86$, $SD = 3.83$). The teachers formed the team of a pre-university education[2] science programme at one school in the Netherlands, which consisted of one mathematics, two biology, two chemistry and two physics teachers. A total of 233 students participated in this study (48% male, 52% female), aged 13–18 years, divided over 14 classes (one 9th grade class, and thirteen 11th grade classes).

### *Procedure*

The study included all classroom videos that the teachers had already planned to use in the school year 2016–2017, in the pre-university programme or in regular school classes. Videos used in online learning environments were not included in the study because watching these videos was not mandatory. This added up to 14 videos in total: one teacher used one video, five teachers used two videos and one teacher used three videos. One video was produced by the teacher himself (*Lieke and the drum*), the other videos were selected by the teachers from various

[2]The highest level of secondary education in the Netherlands.

online platforms. Each video was evaluated in the classroom in subgroups ranging from 23 to 49 students, which added up to 447 valid evaluations in total. For each video use we identified the aims the teacher had with its use through interviews (RQ1), analysed the video characteristics (RQ2), and conducted student evaluations through questionnaires (RQ3). Together these three types of data made up a single video case, adding up to14 video cases in our study. To address the main research question, the video cases were used for a cross-case analysis (Borman, Clarke, Cotner, & Lee, 2006).

*Instruments*

Teacher interviews

The teachers were asked to explicate their motivation for using the videos in semi-structured interviews performed by the first author. Structured open questions asked were: "Why do you use video in your lesson?", "What is the function of the video in your lesson?", "What should the video bring about in your students?", and "Why do you want this to be brought about in your students?". The responses were summarized for each video afterwards.

Student questionnaires

The students were asked to fill in a video-specific five-statement questionnaire with a five-point Likert scale (I don't agree at all—I totally agree, see Figure 1), in order to investigate whether students' perceptions of the video corresponded with the aims the teacher intended to achieve. We composed a different questionnaire for each video to match the aims of the teacher for that specific video, for example: The questionnaire statement "I can give examples of chemical industry" was composed to match the teacher aim of introducing real-life contexts in which chemical industry can be found. The statement "I want to learn more about the subject" was composed to match the teacher aim of raising students' motivation. We asked the teachers to check whether the statements indeed reflected their aims. In some cases, it was necessary to adjust the statements to better match the aims of the teachers. The students were informed about the research project at the start of the class by the first author. The teachers delivered the lesson as planned with their own introduction of the video. The questionnaires were filled in just before watching a video (pre-viewing) and directly afterwards (post-viewing). The pre- and post-viewing questionnaires for one video both consisted of the same five statements, so that pre- and post-viewing outcomes could be compared.

*Data analysis*

We started by analysing the data that resulted from the first three research questions (Phase 1 in Figure 2). Next, we gathered and connected the three sources of data for each video case by a cross-case analysis to answer the main research question (Phase 2 in Figure 2).

Teacher aims

To answer RQ1, we analysed the teacher responses. Initial answers of the teachers were somewhat vague, such as "To have a nice start" or "To elaborate on the theory" or "To show a nice example." Asking them to explain their answers resulted in more elaborate replies, such as "I

| | | | | | | |
|---|---|---|---|---|---|---|
| I don't agree at all | 0 | 0 | 0 | 0 | 0 | I totally agree |

*Figure 1: Five-point Likert scale presentation in the student questionnaires*

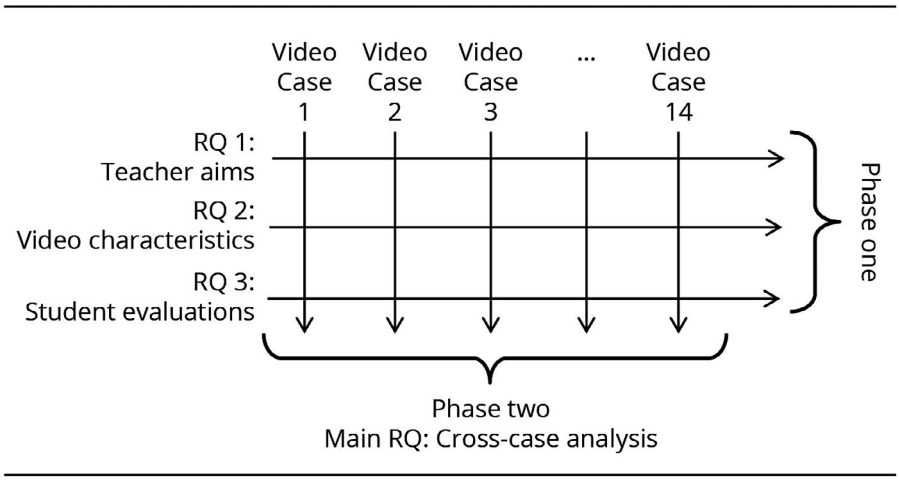


*Figure 2: Phases in the data analysis*

want to show them examples of how the theory can be applied to real life contexts, to get them excited about the topic." In the interviews, the teachers said they had difficulties explicating their motivation for using videos because they had not given it much thought before, not even when selecting the videos.

We used open coding to analyse the teacher responses (Boeije, 2010). In the process of open coding, we summarized and grouped the teacher responses to see if any similarities emerged in the responses. This led to initial categories that we used for axial coding (Boeije, 2010), to connect the teacher responses bottom up to more formal categories. We found that the categories distinguished in the model by Schwartz and Hartman (2007) for designing video for learning and assessment best matched the aims of the teachers in our study (see Table 1). Subsequently, we coded all summarized teacher responses using the categories from this model (see Appendix A). Most teachers had multiple aims for using a single video. The coding of the summarized teacher responses was conducted by the first author and an independent researcher; 41 out of 42 teacher responses were coded identically, which equals a 97% agreement and a near perfect inter-rater reliability between the two researchers ($\kappa = .97$). One case was discussed until consensus was reached.

### Video characteristics

To answer RQ2, we analysed the videos' characteristics following the method of Bordwell *et al.* (2017) to describe the flow of information and the audio-visual presentation of that information. This involved for example: what information was given in what scene, how that information was provided (in audio or visually, in images or in text), and what the image of the video looked like (eg, animation or live action, camera movements, framing). For each video, we summarized the results in a video description (see Appendix B for an example). The descriptions were used in the data analysis to code the videos as film types (see Appendix C) following McClusky (1947; see Table 2), and in the cross-case analysis (see below).

The film types are not exclusive in nature, meaning that one video could be classified as more than one type of film (McClusky, 1947). However, we treated the film types Discursive, Factual and Evidential as being mutually exclusive. These categories primarily refer to the amount of information that is given and together represent a sliding scale ranging from elaborate discursive explications at one end, to bare evidential recordings at the other. Factual films are positioned

in between. Therefore, all videos were coded as one of these three film types. Most videos were assigned two or three film types. We specified the degree to which each film type was represented in the videos, by adding the code *strong* to the film types that were clearly present in the videos, and *weak* to the film types that were only slightly present. The coding of the film types was conducted by the first author and an independent researcher on the three exclusive categories (Discursive, Factual and Evidential). Twelve out of 13 videos were coded identically, which equals a 92% agreement and an excellent inter-rater reliability between the two researchers ($\kappa = .80$). One case was discussed until consensus was reached. The coding of the other video type categories was conducted by the first author and checked by an independent researcher. There was consensus about all video types that were assigned to the videos.

Student evaluations

To answer RQ3, we calculated the mean outcomes on each statement for each video (based on answers from 19–45 students per statement per video). We then compared the outcomes of the pre- and post-viewing questionnaires for each statement of each video to calculate the mean difference. This informed us about the influence students perceived from the video regarding the aims of the teacher. We calculated the mean outcomes for each teacher aim category over the mean outcomes of all statements used for all videos regarding that teacher aim, to set the standard for each teacher aim category. Evaluation outcomes of each statement were then compared to this overall mean, determining whether the statement showed an outcome above or below average on that teacher aim category.[3] Given the diversity of questionnaire questions and the small number of students per questionnaire, we present only descriptive statistics. Hence, any reported differences should be treated as such.

Cross-case analysis

To answer the main research question, the first author used the rich data of each video case to formulate conjectures about how the video characteristics might be related to the teacher aims. In a cross-case analysis we applied the constant comparative method (Boeije, 2010), comparing video cases to identify similarities and differences. Cases that were found to be similar were grouped to identify properties specific to these groups of cases. The properties consisted of data from at least two of the three data sets (teacher aims, video characteristics, student evaluations). From these properties, we formulated conjectures for each group of video cases, for example: "Videos that are used to achieve the aim of Engaging present examples of real-life situations or phenomena." This conjecture involves teacher aim and video characteristics data. Another example is: "Videos that deal with environmental issues score above average on the aim of Engaging-contextualize." This conjecture involves data from all three data sets. After a generative round, 15 conjectures were formulated. We then continued with an assessment round to see whether the conjectures would be confirmed for all video cases in the study.

## Results

*Teacher aims*

With respect to RQ1 on teacher aims, the most frequently reported teacher aims were Engaging and Saying (Table 3). In responses coded as Engaging, teachers mentioned wanting to generate

[3]Two teachers used the same video (*Dr Quantum —Double slit experiment*) for two separate modules (CERN excursion and Grenoble excursion). In our study, we treated the double use of this video as two distinct cases. These teachers were interviewed together, and they jointly reported on the teacher questionnaire because they had also jointly selected the video. For the student evaluations, we used questionnaires with the same five statements for both cases. The video was evaluated with two different groups of students and resulted in different outcomes.

*Table 3: Number of Teacher Responses per Teacher Aim*

| *Teacher aim* | *Times mentioned* | *Sub-aim* | *Times* |
|---|---|---|---|
| Doing | 2 | Attitude | 0 |
| | | Skills | 2 |
| Engaging | 16 | Contextualize | 9 |
| | | Interest | 7 |
| Saying | 17 | Explanations | 9 |
| | | Facts | 8 |
| Seeing | 1 | Discernment | 1 |
| | | Familiarity | 0 |

students' interest in the subject of the module, wanting to introduce the subject of the module and activate prior knowledge, or wanting to present examples or situations as concrete and relevant contexts for the subject. In Saying responses, teachers mentioned wanting to raise the level of conceptual knowledge. Two teacher responses were coded as Doing, with teachers wanting students to learn how to perform a task. One teacher response was coded as Seeing, with the teacher wanting students to notice a new phenomenon (see Table 3).[4]

*Video characteristics*

With respect to RQ2 on video characteristics, the videos were quite diverse. For example, there were as many animation videos as live action videos, and about as many videos using quick camera movements and fast editing as unexciting videos.

Table 4 shows that by far most videos were coded Discursive, providing plenty of information. In total, eight videos were coded as Problematic. Five of these videos posed questions to bridge the gap to the next scene, and the questions posed were answered immediately in the following scene (coded as Weak). The other three posed questions that were leading for the further development of the video (coded as Strong).[5]

*Student evaluations*

With respect to RQ3 on student evaluations, Table 5 shows that, for all videos taken together, the mean difference between pre- and post-viewing outcomes was lowest for the aim of

*Table 4: Number of Videos per Film Type*

| *Film type* | *Strong* | *Weak* | *Sum* |
|---|---|---|---|
| Discursive | 11 | – | 11 |
| Evidential | 1 | – | 1 |
| Factual | 2 | – | 2 |
| Emulative | 0 | 4 | 4 |
| Incentive | 3 | 0 | 3 |
| Narrative | 1 | 3 | 4 |
| Problematic | 3 | 5 | 8 |

*Note.* Strong = clearly present. Weak = slightly present.

[4]The summarized teachers' responses categorized as teacher aims are presented in Appendix A.

[5]The videos categorized in film types are presented in Appendix B.

*Table 5: Overall Mean Outcomes of the Student Evaluations per Teacher Aim*

| *Teacher aim* | *Mean post-viewing score (SD for videos)* | *Mean Δ pre- and post-viewing score (SD for videos)* | *#video* | *#statem* | *#stud* |
|---|---|---|---|---|---|
| Doing-attitude | – (–) | – (–) | 0 | – | – |
| Doing-skills | 3.8 (0.08) | 0.5 (0.38) | 2 | 5 | 44 |
| Engaging-contextualize | 3.6 (0.58) | 0.4 (0.33) | 9 | 21 | 298 |
| Engaging-interest | 3.7 (0.29) | 0.1 (0.11) | 7 | 13 | 195 |
| Saying-explanations | 3.9 (0.76) | 1.2 (0.76) | 9 | 17 | 295 |
| Saying-facts | 3.9 (0.58) | 1.1 (0.80) | 8 | 11 | 267 |
| Seeing-discernment | 3.2 (–) | 0.3 (–) | 1 | 1 | 27 |
| Seeing-familiarity | – (–) | – (–) | 0 | – | – |

*Note.* #video = number of videos; #statem = number of statements; #stud = number of students.

Engaging-interest. The mean difference is highest for the aim of Saying-explanations, closely followed by Saying-facts.[6]

*Cross-case analysis*

With respect to the main research question, two conjectures were confirmed: (1) Videos that were coded as Problematic-Strong film type scored above average on the aim of Engaging, and (2) Videos that scored above average on the aim of Saying-explanations were coded as Discursive film type. T, the other conjectures were rejected because they did not hold true for all video cases. Below, we discuss for both confirmed conjectures how the data involved can be related.[7]

Eight videos in our study posed questions or problems and were coded as Problematic film type. In five of these videos' questions were used rhetorically to propel the story or argument: The question was asked only to be immediately answered in the following scene. However, three videos posed or raised genuine questions that became leading for the direction of the story (*Het Klokhuis: Figure it out! Earth*; *Het Klokhuis: Molecular cooking*; *NOAA Ocean acidification—The other carbon dioxide problem*). In these last three videos, the questions became the starting point of a quest for answers, and the videos were coded as Problematic-Strong film type. Problematic-Strong videos showed a difference between pre- and post-viewing outcomes above average on the aim of Engaging-interest, whereas Problematic-Weak and videos not coded Problematic showed outcomes on or below average. We found no link between Problematic videos and the aim of Engaging-contextualize.

Saying-explanations was the most frequently found teacher aim in our study. Three videos in our study showed post-viewing outcomes and a difference between pre- and post-viewing outcomes above average on Saying-explanations (*Dr Quantum—Double slit experiment*; *Ted Edu: Why do honeybees love hexagons?*; *Antifungal drugs: Mayor types and functions*).[8] All three videos, giving plenty of information, were coded as Discursive film type. All videos used for Saying-explanations that gave little information (Evidential or Factual film type) had post-viewing outcomes below average (*Lieke and the drum*; *Heart rhythm dance*). However, there were also two videos used for the aim of Saying-explanations, that were coded as Discursive film type, but showed outcomes comparable

[6]Appendix D presents specified data on the separate statements.

[7]The data referred to below can be found in Appendices E and F.

[8]The video *Dr Quantum—Double slit experiment* forms an exception when used in the module Grenoble excursion. This exception might be explained by the fact that the outcomes on the pre-viewing questionnaire in the Grenoble excursion were already high, leaving little space for improvement.

to the outcomes of the Factual and Evidential videos (*Het Klokhuis: Figure it out! Earth; Chemistry at work*). Taking a closer look at the characteristics of the Discursive videos used for Saying-explanations shed light on this variation.

All three discursive videos that showed post-viewing outcomes and a difference between pre- and post-viewing outcomes above average on the aim of Saying-explanations were animations. But they were animated at not quite the same level of complexity. *Dr Quantum— Double slit experiment* was the most complex animation video, showing many different camera angles, camera movements, and a moving and talking presenter. This video was produced by professional filmmakers. The videos *Antifungal drugs: Mayor types and functions* and *Ted Edu: Why do honeybees love hexagons?* were noncomplex animated videos, showing mainly static images that illustrate spoken information provided in a voiceover. Unlike the two noncomplex videos, the professionally produced video furthermore used exciting music and sound effects to enliven the video. The professional video showed the biggest influence on the students' evaluations of Saying-explanations aims of all, both on post-viewing outcomes and difference between pre- and post-viewing outcomes. A potential (speculative) explanation for this might be that students took the professionally produced video more seriously, assuming it came from an authoritative speaker.

What most discursive videos had in common is that the information is given by an all-knowing presenter. In our study *Het Klokhuis: Figure it out! Earth* and *Het Klokhuis: Molecular cooking* were the only exceptions to this rule. On the contrary, in these videos a naïve presenter functioned to raise questions and to take the viewer on a quest for answers. Similar to the presumed effect of professionally produced videos, the students might have taken all-knowing presenters as more authoritative speakers. This might explain the lower outcomes of the discursive video *Het Klokhuis: Figure it out! Earth* for Saying-explanations.

The video *Chemistry at work* was only one of the components that were used by the teacher to achieve the aim of Saying-explanations, and thus could not fully achieve the aim of Saying-explanations on its own. This might explain the lower outcomes of the discursive video *Chemistry at work* for Saying-explanations.

To summarize: Problematic videos were associated with the aim of Engaging-interest as assessed by students' self-reports, but only if genuine problems or questions were raised that functioned to lead the direction of the story. Discursive videos were associated with the aim of Saying-explanations as assessed by students' self-reports, but only when the information was presented by an authoritative speaker.

## Discussion

The central goal of our study was to introduce film theory in research on educational videos to make a first step towards the development of guidelines that relate teacher aims to video characteristics. To this goal, we explored in educational practice both the aims teachers try to achieve, and what characterizes the videos they use. We found that, first, the majority of the teachers used videos to raise students' levels of conceptual knowledge or interest, in this study referred to as Saying aims and Engaging aims (RQ1). Second, most videos used were highly informative, in this study referred to as Discursive film type (RQ2). Third, using videos was associated with an increase in students' self-perceived conceptual knowledge and minor results regarding raising interest (RQ3). And fourth, videos that posed questions that were leading for the direction of the story were associated with raising students' interest, and highly informative videos with authoritative speakers were associated with an increase in students' self-perceived conceptual knowledge (main RQ).

The most found teacher aims in our study were Saying and Engaging aims (RQ1). However, the teachers had difficulties explaining why they used a video, and how they expected the video would meet their aims. For our study, the teachers made an effort to substantiate their choices concerning video usage. In the discussion of the results with the teachers, they said to find it quite illuminating and useful for future video use to see their aims so clearly categorized. This indicated that guidelines would be very much welcomed by teachers. The fact that teachers intuitively selected videos and were hardly aware of the aims they wanted to achieve furthermore indicated that guidelines are not only welcomed but also needed, if teachers want to use video effectively to achieve educational aims.

As a first step towards guidelines for teachers, we developed the framework represented in Figure 3. This framework can assist teachers in selecting or making videos that match their aims, though it needs to be empirically tested. See Appendix G for an example of an application of this framework.

The large number of discursive videos we found in our study (RQ2) relates to the type of videos that are most commonly found on online educational video platforms. These videos look alike because makers of educational videos presumably imitate each other's videos, and because they are easy to make. Teachers probably recognize these kinds of videos as being educational and might prefer them over alternatives because of this. To help teachers find other possible video types that may better match their aims, we redesigned the model of Schwartz and Hartman (2007), and replaced the initial intuitively chosen video examples with the film types of McClusky (1947) we used in our study (see Figure 4). The results of our study only show indications for the rightfully presumed connection between the aim of Saying-Explanations and the Discursive film type, and between Engaging-Interest and the Problematic film type. However, based on the descriptions of the film types in McClusky (1947), we can presume that more possible connections could be made, as are presented in grey in Figure 4. Further research is needed to justify these other presumed possible connections between teacher aims and film types. Again, we consider this only a first step towards guidelines for teachers.

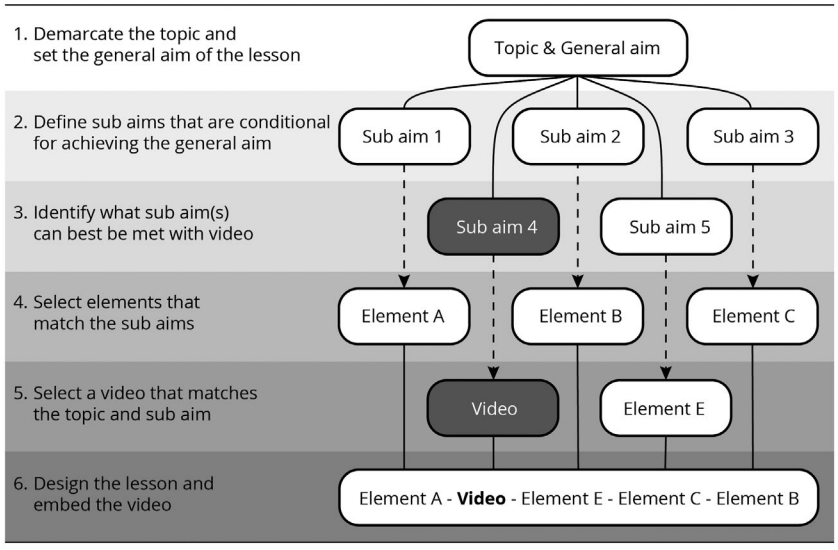


*Figure 3: Assisting framework for educators to select or make videos that match their aims*

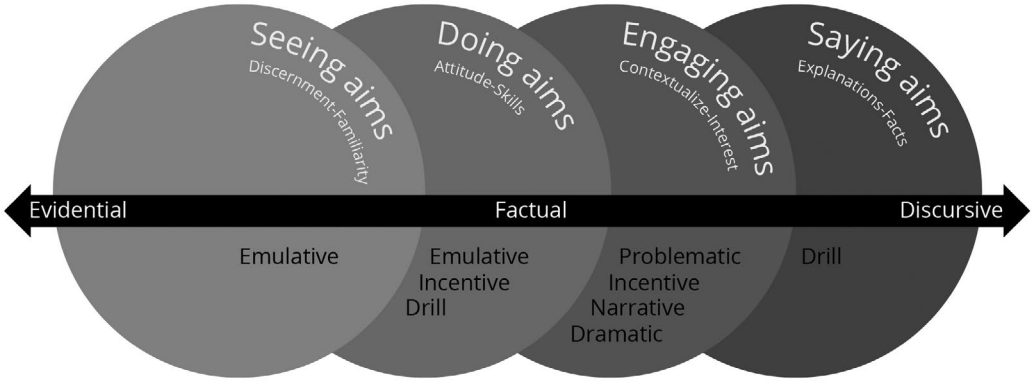


*Figure 4: Model of presumed possible connections between teacher aims and film types, with use of Schwartz and Hartman (2007, p. 338) and McClusky (1947). The teacher aims (grey circles) with presumably related inclusive film types attached (below in black) are positioned indicatively on the sliding scale of exclusive film types (black horizontal bar)*

*Limitations*

There are some limitations to our research. First, our study showed that students felt that discursive videos raised their levels of conceptual knowledge. However, we did not assess whether the videos influenced the students' actual knowledge levels. It is important to do so in future studies, because perceived (lack of) knowledge gains may not always correspond to actual (lack of) knowledge gains (cf. Muller, 2008).

Second, our study showed only minor changes in the students' self-reported interest. This is in line with previous research indicating that student interest is hard to influence with a single intervention. In addition, the degree to which an intervention influences student interest is difficult to measure accurately (Hidi & Renninger, 2006). We therefore regarded even small differences between pre- and post-viewing outcomes for this aim category as cues to further investigate the aim of raising interest in the cross-case analysis. The pre-viewing levels of interest in our study were already high. In future studies, it would be recommendable to include videos that can be expected to show more variance regarding students' initial interest.

*Further research*

Further (intervention) research is needed to better understand how video characteristics may function to achieve teacher aims. Our study shows that teachers are primarily interested in using videos for the Saying and Engaging aims. Therefore, further research on educational videos could initially concentrate on these two aims. However, subsequently broadening the scope of educational video to other possible film types is important, as it may lead to better utilization of the potential of the video medium. Film theory offers a way to describe this potential; the possible connections between teacher aims and film types presented in Figure 4 can be used as a starting point.

In our study, we used the perspective of film studies as a complement to educational sciences to describe the characteristics of the educational videos. With film theory one can analyse how characteristics of videos might influence students' perception of educational videos in great detail. Relating theories from these two fields of science opens up possibilities to formulate the needed guidelines for making and using videos in education.

**Video Links**

| | |
|---|---|
| Lieke and the drum | https://www.youtube.com/watch?v=SQr_mWkac1Q |
| Dr Quantum—Double slit experiment | https://www.youtube.com/watch?v=fwXQjRBLwsQ |
| Het Klokhuis: Figure it out! Earth | http://www.hetklokhuis.nl/tv-uitzending/2484/Zoek%20Het%20Uit%21%20Aarde%20 |
| Heart rhythm dance | https://youtu.be/EqUfgffJx_8 |
| NOAA ocean acidification—The other carbon dioxide problem | https://www.youtube.com/watch?v=MgdlAt4CR-4 |
| Chemistry at work | Not freely available online |
| Ted Edu: Why do honeybees love hexagons? | https://www.youtube.com/watch?v=QEzlsjAqADA |
| Antifungal drugs: Mayor types and functions | https://www.youtube.com/watch?v=Iez8H9y5yAk |
| ß-Lactams: Mechanisms of action and resistance | https://www.youtube.com/watch?v=qBdYnRhdWcQ |
| Het Klokhuis: Molecular cooking | https://www.youtube.com/watch?v=S8S_F4clWVQ |
| Ted talk: Religions and babies, by Hans Rosling | https://youtu.be/ezVk1ahRF78 |
| Welcome at the world heritage site of the Wadden Sea | https://www.youtube.com/watch?v=S5sQK61Rr0Q |
| How mussel banks shape the landscape of the Wadden Sea | https://www.youtube.com/watch?v=9EWkxiycA0A |

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**Statements on ethics, open data and conflict of interest**

a. There is no conflict of interest in the reported work. The data of our project are in the process of being made permanently accessible through the Data Archiving and Networked Services (DANS) of the joint institute of the Royal Netherlands Academy of Arts and Sciences (KNAW) and the Netherlands Organisation for Scientific Research (NWO), at https://dans.knaw.nl/en. Student and teacher data collection and handling was complied with local ethical guidelines regarding collection and storage of data involving human subjects. The student data were collected anonymously, the teacher data were anonymized after data collection, and all data were stored on a secured server behind a password.

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*Appendix A: Summarized and coded teacher responses per video*

| *Video title* | *Module* | *Teacher responses* | *Teacher aims* |
|---|---|---|---|
| Lieke and the drum | Acoustics | Contextualizing physics theory through a concrete lifeworld context | Engaging-contextualize |
| | | Raised interest for studying a physics phenomenon | Engaging-interest |
| | | Being able to notice a physics phenomenon | Seeing-discernment |
| | | Being able to explain a physics phenomenon | Saying-explanations |
| Dr Quantum—Double slit experiment | CERN excursion | Being able to explain why the experiment is set up the way it is, and what can be derived from its results | Saying-explanations |
| | | Knowing the difference between the two set-ups | Saying-facts |
| Het Klokhuis: Figure it out! Earth | Earthquakes | Being able to perform an analysis in research on ground layers | Doing-skills |
| | | Raised interest for knowing how to get from data to result | Engaging-interest |
| | | Being able to explain how ground layers are researched | Saying-explanations |
| Heart rhythm dance | Electric activation of the heart | Raised interest for studying heart rhythm disorders | Engaging-interest |
| | | Being able to explain what happens during heart rhythm disorders | Saying-explanations |
| | | Introduction to the subject, activation of prior knowledge | Engaging-contextualize |
| | | Knowing what a distorted heart rhythm is. | Saying-facts |
| NOAA Ocean Acidification—The other carbon dioxide problem | Geochemistry | Contextualizing chemical theory through a socio-scientific problem; introduction to the subject, activation of prior knowledge | Engaging-contextualize |
| | | Raised interest for acidification through beautiful appealing images | Engaging-interest |
| Chemistry at work | Green chemistry | Contextualizing chemical theory through a concrete industrial context | Engaging-contextualize |
| | | Being able to explain what is dangerous about chemical industry and explaining how green chemistry can become more 'green' | Saying-explanations |
| | | Knowing different chemical processes in chemical industry | Saying-facts |
| Dr Quantum—Double slit experiment | Grenoble excursion | Being able to explain why the experiment is set up the way it is, and what can be derived from its results | Saying-explanations |
| | | Knowing the difference between the two set-ups | Saying-facts |

(*Continues*)

*Appendix A: Continued*

| *Video title* | *Module* | *Teacher responses* | *Teacher aims* |
|---|---|---|---|
| Ted Edu: Why do honeybees love hexagons? | Mathematics and architecture | Raised interest for mathematics in general, and the following task in particular | Engaging-interest |
| | | Being able to explain why hexagons exist in nature | Saying-explanations |
| Antifungal drugs: Mayor types and functions | Membranes | Contextualizing chemical theory through concrete lifeworld contexts; introduction to the subject, activation of prior knowledge | Engaging-contextualize |
| | | Raised interest for the chemical functioning of antifungal drugs | Engaging-interest |
| | | Being able to explain how specific targeting functions | Saying-explanations |
| | | Knowing what specific targeting is | Saying-facts |
| ß-Lactams: Mechanisms of action and resistance | Membranes | Being able to explain how penicillin and resistance function | Saying-explanations |
| | | Knowing what antibiotics, penicillin, and resistance are | Saying-facts |
| Het Klokhuis: Molecular cooking | Molecular gastronomy | Contextualizing chemical theory through concrete examples of molecular gastronomy; introduction to the subject, activation of prior knowledge | Engaging-contextualize |
| | | Raising interest for the subject and for chemistry in general | Engaging-interest |
| Ted talk: Religions and babies, by Hans Rosling | Sustainable energy | Being able to perform a presentation of results from research | Doing-skills |
| | | Contextualizing theory through a concrete socio-scientific problem | Engaging-contextualize |
| Welcome at the world heritage site of the Wadden Sea | Texel excursion | Contextualizing ecosystem theory through World Heritage Sites; introduction of the subject, activation of prior knowledge | Engaging-contextualize |
| | | Knowing the World Heritage Site of Texel | Saying-facts |
| How mussel banks shape the landscape of the Wadden Sea | Texel excursion | Contextualizing ecosystem theory through a concrete context; introduction of the subject, activation of prior knowledge | Engaging-contextualize |
| | | Knowing the function of mussel banks in the ecosystem | Saying-facts |

*Appendix B: Example of video description of Het Klokhuis: Figure it out! Earth in the module earthquakes*

| *Film characteristics* | *Description* |
|---|---|
| Flow of information | The presenter poses questions that arise from the preceding information. The questions are leading for the video's continuation. The viewer is taken on a journey to find the answers |
| *Audio-visual presentation* | |
| Mise-en-scène | On location, unformal young enthusiastic adult as presenter, presenter turning directly to the viewers by looking into the camera, presenter takes the position of the naïve viewer |
| Cinematography | Handheld frequently moving camera, multiple perspectives, quick zooms in the shot |
| Editing | Short shots, fast editing, intermissive clips |
| Sound | Energizing exciting music, repeated sound of the explosion |
| *Film type(s)* | *Description* |
| Discursive—strong | Treatment of conducting ground research with sonar |
| Emulative | Shows how to perform an experiment on ground layers |
| Problematic—strong | Poses questions that initiate the direction of the video towards finding out what the Earth's core is made of |

*Appendix C: Film types per video*

| *Video title* | *Module* | *Film types* | *Description* |
|---|---|---|---|
| Lieke and the drum | Acoustics | Evidential** | Record of (scientific) data for study or analysis |
| Dr Quantum—Double slit experiment | CERN excursion | Discursive** | Treatment of the execution and findings of an experiment |
| | | Emulative | Shows how to perform an experiment on electrons' behaviours |
| | | Narrative | Describes the course of events of when research on the behaviour of electrons was performed |
| | | Problematic | Poses rhetorical questions to propel the story |
| Het Klokhuis: Figure it out! Earth | Earthquakes | Discursive** | Treatment of conducting ground research with sonar |
| | | Emulative | Shows how to perform an experiment on ground layers |
| | | Problematic** | Poses questions that initiate the direction of the video towards finding out what the Earth's core is made of |
| Heart rhythm dance | Electric activation of the heart | Factual** | Shows and names variations in malfunctions of the heart |
| NOAA Ocean acidification—The other carbon dioxide problem | Geochemistry | Discursive** | Treatment of the issue of Pteropods dissolving; treatment of the process of acidification; explanation of how the research on acidification is performed, and the mayor results |
| | | Incentive** | Tries to convince the audience of the impact of acidification on all life |
| | | Narrative | Describes the course of events in conducting research on acidification |
| | | Problematic** | Poses questions that initiate the direction of the video; raises the urgent problem of human life being threatened by acidification, invites discussion |
| Chemistry at work | Green chemistry | Discursive** | Treatment of process in factory |
| Dr Quantum—Double slit experiment | Grenoble excursion | Discursive** | Treatment of the execution and findings of an experiment |
| | | Emulative | Shows how to perform an experiment on electrons' behaviour |
| | | Narrative | Describes the course of events for when research on the behaviour of electrons was performed |
| | | Problematic | Poses rhetorical questions to propel the story |
| Ted Edu: Why do honey-bees love hexagons? | Mathematics and architecture | Discursive** | Treatment of a phenomenon in nature |
| | | Narrative** | Describes a fictional story of how bees came to make hexagonal structures in hives |
| | | Problematic | Poses rhetorical questions to propel the story |
| Antifungal drugs: Mayor types and functions | Membranes | Discursive** | Treatment of the topic of fungi, and explanation of functioning |
| | | Problematic | Poses rhetorical questions to propel the story |
| ß-Lactams: Mechanisms of action and resistance | Membranes | Discursive** | Treatment of the functioning of ß-Lactams |

(*Continues*)

*Appendix C: Continued*

| *Video title* | *Module* | *Film types* | *Description* |
|---|---|---|---|
| Het Klokhuis: Molecular cooking | Molecular gastronomy | Discursive** | Treatment of the concept of molecular gastronomy |
| | | Emulative | Shows how to make use of chemical processes in cooking |
| | | Problematic** | Poses questions that initiate the direction of the video towards finding ways to use chemical processes in cooking |
| Ted talk: Religions and babies, by Hans Rosling | Sustainable energy | Discursive** | Treatment of research results and conclusions |
| | | Incentive** | Tries to convince the audience of the idea that there is a relation between income and the Earth's population growth |
| | | Problematic | Poses rhetorical questions to propel the story |
| Welcome at the world heritage site of the Wadden Sea | Texel excursion | Factual** | Shows and names different World Heritage sites, and the Waddenzee in particular |
| | | Incentive** | Tries to convince the audience of the beauty of World Heritage Sites, and the importance of protection |
| How mussel banks shape the landscape of the Wadden Sea | Texel excursion | Discursive** | Treatment of mussel banks in the Waddenzee |

*Note*. ** = Coded as Strong.

*Appendix D Mean outcomes of the student evaluations for the teacher aims per video*

| *Video title* | *Module* | *Teacher aims* | *Mean post viewing score* | *Mean Δ pre and post viewing score* | *#stud* |
|---|---|---|---|---|---|
| Lieke and the drum | Acoustics | Engaging-contextualize | 3.2 | 0.4 | 27 |
| | | Engaging-interest | 3.9* | 0.1 | |
| | | Engaging-interest | 3.9* | 0.0 | |
| | | Seeing-discernment | 3.2 | 0.3 | |
| | | Saying-explanations | 2.7 | 0.4 | |
| Dr Quantum—Double slit experiment | CERN excursion | Saying-explanations | 4.7* | 2.5* | 34 |
| | | Saying-explanations | 4.7* | 2.3* | |
| | | Saying-explanations | 4.6* | 2.3* | |
| | | Saying-facts | 4.8* | 2.4* | |
| | | Saying-facts | 4.0* | 0.4 | |
| Het Klokhuis: Figure it out! Earth | Earthquakes | Doing-skills | 3.8 | 0.9* | 25 |
| | | Doing-skills | 3.7 | 1.0* | |
| | | Engaging-interest | 3.8* | 0.2* | |
| | | Saying-explanations | 4.2* | 0.8 | |
| | | Saying-explanations | 3.6 | 0.6 | |
| Heart rhythm dance | Electric activation of the heart | Engaging-interest | 4.2* | 0.1 | 49 |
| | | Engaging-interest | 4.1* | 0.1 | |
| | | Engaging-contextualize | 4.1* | 0.0 | |
| | | Saying-explanations | 3.4 | 0.4 | |
| | | Saying-facts | 3.7 | 0.4 | |
| NOAA Ocean acidification—The other carbon dioxide problem | Geochemistry | Engaging-contextualize | 4.1* | 0.6* | 26 |
| | | Engaging-contextualize | 4.2* | 0.5* | |
| | | Engaging-contextualize | 3.4 | 0.6* | |
| | | Engaging-contextualize | 4.4* | 0.8* | |
| | | Engaging-interest | 3.5 | 0.2* | |
| Chemistry at work | Green chemistry | Engaging-contextualize | 3.6 | 0.8* | 43 |
| | | Engaging-contextualize | 3.6 | 1.2* | |
| | | Saying-explanations | 2.7 | −0.1 | |
| | | Saying-explanations | 2.3 | 0.3 | |
| | | Saying-facts | 3.4 | 1.5* | |
| Dr Quantum—Double slit experiment | Grenoble excursion | Saying-explanations | 4.5* | 1.5* | 45 |
| | | Saying-explanations | 4.4* | 0.5 | |
| | | Saying-explanations | 4.4* | 1.4* | |
| | | Saying-facts | 4.8* | 1.9* | |
| | | Saying-facts | 3.2 | 0.4 | |

(*Continues*)

*Appendix D: Continued*

| *Video title* | *Module* | *Teacher aims* | *Mean post viewing score* | *Mean Δ pre and post viewing score* | *#stud* |
|---|---|---|---|---|---|
| Ted Edu: Why do honeybees love hexagons? | Mathematics and architecture | Engaging-interest | 3.8* | 0.0 | 18 |
| | | Engaging-interest | 3.7 | −0.1 | |
| | | Engaging-interest | 3.6 | 0.1 | |
| | | Saying-explanations | 4.8* | 1.8* | |
| | | Saying-explanations | 3.6 | 1.2 | |
| Antifungal drugs: Mayor types and functions | Membranes | Engaging-contextualize | 4.1* | 0.3 | 27 |
| | | Engaging-contextualize | 3.6 | 0.4 | |
| | | Engaging-interest | 4.0* | 0.1 | |
| | | Saying-explanations | 4.0* | 1.6* | |
| | | Saying-facts | 4.3* | 0.5 | |
| ß-Lactams: Mechanisms of action and resistance | Membranes | Saying-explanations | 4.0* | 1.3* | 27 |
| | | Saying-explanations | 3.8 | 0.8 | |
| | | Saying-facts | 4.3* | 0.3 | |
| | | Saying-facts | 3.9 | 0.4 | |
| | | Saying-facts | 4.4* | 0.3 | |
| Het Klokhuis: Molecular cooking | Molecular gastronomy | Engaging-contextualize | 3.2 | 0.6* | 23 |
| | | Engaging-contextualize | 3.4 | 0.6* | |
| | | Engaging-interest | 3.4 | 0.3* | |
| | | Engaging-interest | 3.3 | 0.2* | |
| | | Engaging-interest | 3.2 | 0.3* | |
| Ted talk: Religions and babies, Hans Rosling | Sustainable energy | Doing-skills | 3.9* | 0.4 | 19 |
| | | Doing-skills | 3.8 | 0.1 | |
| | | Doing-skills | 3.8 | 0.1 | |
| | | Engaging-contextualize | 4.2* | 0.2 | |
| | | Engaging-contextualize | 4.7* | −0.3 | |
| Welcome at the world heritage site of the Wadden Sea | Texel excursion | Engaging-contextualize | 3.3 | 0.5* | 42 |
| | | Engaging-contextualize | 3.3 | 0.0 | |
| | | Engaging-contextualize | 3.2 | 0.2 | |
| | | Engaging-contextualize | 2.4 | 0.2 | |
| | | Saying-facts | 3.0 | 1.6* | |
| How mussel banks shape the landscape of the Wadden Sea | Texel excursion | Engaging-contextualize | 3.1 | 0.0 | 42 |
| | | Engaging-contextualize | 3.1 | 0.0 | |
| | | Engaging-contextualize | 2.6 | 0.1 | |
| | | Saying-facts | 3.2 | 2.5* | |
| | | Saying-facts | 3.5 | 1.5* | |

*Note.* #stud = Number of students; * = Above overall average of this category (see Table 5).

*Appendix E: Mean outcomes of all videos used for the aim of saying-explanations*

| *Video title* | *Film type* | *Mean post viewing score on Saying-explanations* | *Mean Δ pre and post viewing score on Saying-explanations* | *#statem* |
|---|---|---|---|---|
| Lieke and the drum | Evidential | 2.7 | 0.4 | 1 |
| Dr Quantum—Double slit experiment (CERN excursion) | Discursive | 4.7* | 2.4* | 3 |
| Het Klokhuis: Figure it out! Earth | Discursive | 3.9 | 0.7 | 2 |
| Heart rhythm dance | Factual | 3.4 | 0.4 | 1 |
| Chemistry at work | Discursive | 2.5 | 0.1 | 2 |
| Dr Quantum—Double slit experiment (Grenoble excursion) | Discursive | 4.4* | 1.1 | 3 |
| Ted Edu: Why do honeybees love hexagons? | Discursive | 4.2* | 1.5* | 2 |
| Antifungal drugs: Mayor types and functions | Discursive | 4.0* | 1.6* | 1 |
| ß-Lactams: Mechanisms of action and resistance | Discursive | 3.9 | 1.1 | 2 |

*Note.* #statem = Number of statements calculated in the mean; * = Above overall average of this category (see Table 5).

*Appendix F: Mean outcomes of all videos used for the aim of engaging-interest*

| *Video title* | *Problematic film type* | *Mean post viewing score on Engaging-interest* | *Mean Δ pre and post viewing score on Engaging-interest* | *#statem* |
|---|---|---|---|---|
| Lieke and the drum | – | 3.9* | 0.1 | 2 |
| Dr Quantum—Double slit experiment (CERN excursion) | Weak | – | – | 0 |
| Het Klokhuis: Figure it out! Earth | Strong | 3.8* | 0.2* | 1 |
| Heart rhythm dance | – | 4.1* | 0.0 | 2 |
| NOAA Ocean acidification—The other carbon dioxide problem | Strong | 3.5 | 0.2* | 1 |
| Dr Quantum—Double slit experiment (Grenoble excursion) | Weak | – | – | 0 |
| Ted Edu: Why do honeybees love hexagons? | Weak | 3.7 | 0.0 | 3 |
| Antifungal drugs: Mayor types and functions | Weak | 4.0* | 0.1 | 1 |
| Het Klokhuis: Molecular cooking | Strong | 3.3 | 0.3* | 3 |
| Ted talk: Religions and babies, by Hans Rosling | Weak | – | – | 0 |

*Note.* #statem = Number of statements calculated in the mean; * = Above overall average of this category (see Table 5); ** = Coded as Strong.

*Appendix G: Example of using the assisting framework for educators to select or make videos that match their aims*

| *Phases* | | *Example* |
|---|---|---|
| 1. | Demarcate the topic and set the general aim of the entire lesson | The general aim is to raise the students' knowledge level on the topic of Acidification |
| 2. | Define sub aims that are conditional to achieving the general aim | a.Getting students introduced to the topic of Acidification<br>b.Motivating students to engage with the ecological problem of ocean acidification<br>c.Activating students' prior knowledge on chemical processes<br>d.Instructing new content on acidification<br>e.Having students engage with the chemical processes involved in acidification<br>f.Evaluation and reflection |
| 3. | Identify what sub aim(s) can best be met with video | Motivating students to engage with the ecological problem of ocean acidification (Engaging-interest and Engaging-contextualize) |
| 4. | Select elements that match the sub aims | a.Introductory talk by the teacher<br>b.Watching a video that illustrates the problem of ocean acidification<br>c.Recapture of previous lessons on chemical processes<br>d.Teacher instruction on acidification processes<br>e.Student experiment assignment<br>f.Evaluation of the experiments in a group discussion |
| 5. | Select a video that matches the topic and sub aim | Factual-Problematic/Narrative/Dramatic/Incentive video (see Figure 4):<br>*NOAA ocean acidification—The other carbon dioxide problem* |
| 6. | Design the lesson and embed the video | Introduce the video as a socio-scientific issue in which acidification plays a key role—Watch the video—Recapture main points made in the video in a group discussion. Refer to: To who or what is ocean acidification a problem? What causes acidification to happen? Can you describe the subsequent steps in process? What are possible future consequences of ocean acidification? What can be done to stop the oceans of acidifying? Resume with classroom teacher instruction |