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Video as a mediating artefact of science learning: cogenerated views of what helps students learn from watching video

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Abstract

"Doing" science in the form of practical work is one pedagogical approach to learning science alongside others such as talking science, writing science, reading science and representing science. However, scientific ideas cannot always be illustrated through practical work or field trips, therefore, different kinds of activities are needed to represent these ideas. This study focused on the power of cogenerative dialogues for teachers to learn about their students and their video preferences for learning science in a secondary science classroom. The analysis of the use of video as a mediating artefact drew on an interpretive approach framed as authentic participant-centered inquiry and employed multiple theoretical frameworks to generate perspectives on the affordances and constraints of learning from video. Through a cogenerative dialogue intervention we found that video could afford the learning of scientific ideas, however, some videographic features were distracting to students and constrained their learning. We argue that video clips as cultural artefacts are inscribed with emotion that structures students' opportunities to engage with scientific ideas. However, to accept the authoritative information presented in videos as facts uncritically was a missed opportunity to shape students' epistemological understanding that scientific knowledge is evidence-based and subject to critique. The implications for designing pedagogical approaches that encourage a critical stance to explore the ongoing social construction and communication of scientific ideas are discussed.

Keywords: Learning science, Video mediated science learning, Communication of scientific ideas, Cogenerative dialogues

To access the executive summary of this paper in Maori, please check the supplemental materials associated with this article by clicking on this link (Additional file 1).

Introduction

Globally, most science curricula aim for students to develop conceptual, procedural, and epistemological understandings (Abrahams & Millar, 2008; Moeed, 2016; Hodson, 2014; Millar, 2010). There is considerable agreement among educational researchers that all three aspects are essential for learning science at secondary school. The relative importance of each of these aspects in relation to students' learning, concerns, and doubts is debated in the Western science education journals, while innovations and challenges that confront the Asia-Pacific region, such as increasing student diversity, tend to be left out of the international debates (Martin & Chu, 2015).

A recent focus of school science education curricula has been to develop scientifically literate citizens able to make informed decisions about the socio-scientific issues that arise in their everyday lives (Bull, 2015; Hodson, 2014; Kampourakis, 2016). Such citizens, according to the *New Zealand Curriculum* (Ministry of Education, 2007), 'can participate as critical, informed and responsible citizens in a society in which science plays a significant role' (p. 17). Bull (2015) added that curricula that aim to develop such citizenry would provide opportunities for students to:

- develop capabilities to engage with the practices of science
- engage with some "big ideas" in science in a range of contexts
- appreciate science as a human endeavour
- connect their science learning with their life outside school. (p. 1)

However, the changing nature of New Zealand society raises issues for this curriculum goal. The New Zealand citizenry, which until recently comprised mainly European and indigenous Māori and Pacific peoples, is becoming diverse with one of the fastest growing groups identifying as Asian. Further, shifting characteristics within Asian ethnic groups, are generating complex patterns of mixed ethnicity (Ho, 2015). Also notable is that the New Zealand population has proportionately more Asians than does Australia's population (Spoonley & Butcher, 2009). Additionally, the projection for New Zealand's Asian population in exceeding that of Māori, Butcher (2010) suggested, raises issues for New Zealand's bicultural framework embodied in public documents such as the *New Zealand Curriculum's* aim of developing a critical, informed and responsible citizenry through science education.

For the New Zealand context it is important for teachers and teacher educators to consider student diversity when implementing the curriculum. The *New Zealand Curriculum* states that: "By studying science students are able to, use scientific knowledge and skills to make informed decisions about the communication, application, and implications of science as these relate to their own lives and cultures and to the sustainability of the environment." (Ministry of Education, 2007, p. 28). Cogenerated insights afford the opportunity to communicate in science, a key objective of the Nature of Science Strand of the *New Zealand Curriculum* as well as for teachers to get to know their students better. The current challenge is that the New Zealand teacher profile has a majority (71%) of teachers of European Pākehā ethnicity, 10% identifying as indigenous Māori and 3% Pacific and, similarly, very few teachers of Asian descent (4%)(Ministry of Education, 2017). The fact that the teaching profile does not currently appear to be following the trend of the New Zealand population, particularly of increasing Māori, Pacific and Asian ethnicities, may potentially impact teachers' capacity for addressing student diversity with culturally appropriate resources.

In the past five or more decades hands-on practical work has been considered to be the preferred pedagogical approach in science education, with teachers arguing that it is motivational for students, and students saying that practical work is less boring than writing (Abrahams, 2009; Moeed, 2016). However, there is little evidence that students learn what the teacher intends them to learn through engaging in practical work (Abrahams & Millar, 2008; Hodson, 1990, 2014; Osborne, 2015). Osborne (2015) argued that if the role of the teacher is to help students learn

science ideas and how scientific knowledge is generated, then doing science is only one pedagogic approach alongside talking science, writing science, reading science, and representing science. There is an assortment of pedagogical approaches that are accessible to teachers, depending upon what they want their students to learn. Hodson (2014) clarified that a different kind of activity is required depending upon whether the intended outcome is learning a concept, acquiring a scientific procedure or skill, developing some aspect of the Nature of Science based on science as a way of knowing, or generating scientific literacy in order to make informed decisions about socio-scientific issues. However, some science ideas cannot be replicated in a school laboratory or through field-based learning experiences, so using video clips along with practical work to deliver the curriculum can enable access to science ideas that may not be illustrated through other pedagogical approaches. Video clips, which we take here to mean short sequences, sometimes extracted from a feature-length video, are a more recent response to this issue.

Given this, the focus of this paper is to examine cogenerated insights into video as a mediating artefact of science learning. Mediating artefacts, as defined by Patchen and Smithenry (2014) in their analysis of classroom participation structures using cultural historical activity theory, offer transformative possibilities for classroom learning. This is particularly relevant because using videos has increased in schools as digital resources have become more accessible (Leask & Pachler, 2013). Further, through video there is potential for developing an epistemological understanding of the *concept of evidence* in science, and the opportunity for small group discussion (Bennett et al., 2010). In this paper we are specifically interested in how helpful students find video, including those adopting a documentary style in meeting the curriculum goals of using scientific knowledge and skills to make everyday decisions as stated in *New Zealand Curriculum* (Ministry of Education, 2007). Video as an instructional tool falls into the broad field of multi-media instruction defined by Mayer and Moreno (2003) as 'presenting words and pictures that are intended to foster learning' (p. 43). With the development of technology there is an increasing interest in the use of multimedia as an instructional tool integral to curriculum to teach science in schools (Berk, 2009; Everhart, 2009; Mayer, 2001; Pace & Jones, 2009). Videos can be used in flipped or inverted classrooms where students access videos prior to attending the class (Tucker, 2012). In this study videos were not used as in a flipped classroom, rather their use was more traditional where the video was shown in the classroom and discussion followed.

Berk (2009) identified 20 possible outcomes for learning from video clips at the college level. Of interest to our study is the association he drew between cognitive and emotional impacts of video that he suggested might arise from 'specific visual scenes, the actors, and/or the background music' (p. 2). He reviewed five different explanations of how videos are processed, and he noted the potential of video clips 'to communicate with learners at a deeper level of understanding by touching their emotions' (p. 3). Pace and Jones (2009) pointed out how viewing video that incorporates contextual examples provides an opportunity to build scientific literacy, a common goal of curricula. Interestingly, they recommended taking account of the characteristics of video that can afford student access to scientific ideas. Their useful list of common characteristics of science videos includes that they: are

introduced with a question or problem; are filmed in multiple locations; include narrators and experts; make use of the tools of science; and contain both narrative and expository elements.

Classroom-focused research on the use of multimedia, including video, is emerging and is positioned as augmenting and becoming a central component of curricula, particularly in relation to practical work in science. Hennessy et al. (2006), in their study of integrating the use of multimedia simulation in secondary science in the UK, examined the affordances for learning and found that although there were some generic principles, 'teachers integrated the use of technology and structured activity in markedly different ways, to support diverse pedagogical approaches and communication styles' (p. 724). A New Zealand study (Otrel-Cass et al., 2011) investigated using Information Communication Technologies (ICT), including video for instruction in primary level science classrooms. Otrel-Cass et al. suggested ensuring learning from ICT requires teachers to 'unpack the scientific ideas to identify specific pedagogical strategies that exploit the opportunities of each ICT' (p. 2). They referred to Hennessy's (2006) argument that it is important to 'investigate the "messiness" of the digital tools being used in science classrooms' (p. 2).

Otrel-Cass et al. (2011) also advocated matching pedagogy to the culture of the learning context shaped by the physical and cognitive attributes and the digital tools employed. In particular, motivation is needed initially to get the students to engage in learning and it is needed throughout the knowledge construction process (Moeed, 2016). Schunk (1991) argued that motivation can influence "what, when, and how students learn" (p. 299). Engagement, enthusiasm, perseverance, attention, and on-task behaviour are useful indicators of motivation (Pintrich & Schunk, 2002). Interest, and enjoyment are emotions that can be experienced when students watch educational videos. Motivational scholars posit that interest is about fascination, being curious, getting involved and becoming engrossed. Enjoyment is the satisfaction that comes from participating in a fun activity (Ainsley & Hidi, 2014; Izard, 1977). In science classrooms videos are often used as a pedagogical tool for affective reasons. Ideas used in blended learning courses can increase student engagement and enhance learning experiences (Stockwell et al., 2015). Conversely, videos can be used in non-optimal ways for non-educational reasons to fill time, or to keep students quiet, for rewarding good behaviour, or to give students a break from learning (Hobbs, 2006).

Relevant to the research presented here is the construction and use of documentaries. Two sets of discourses and practices that play an important role in students' everyday lives are media and science (Driver et al., 2000). Films have been used as a visual teaching tool since the middle of the twentieth century and as technology has developed so has its use not just for teaching purposes but also as *ecotainment.* Further Driver et al. (2000) asserted, "science television achieves much of its cultural effect by the authority that the people in front of the camera project" (p 287). They argued that there is a vital correlation between the "construction of authority and the necessary appeal to people's everyday lives (p. 287)". The David Attenborough video clips in the present study demonstrated his enthusiasm, and projected him as an authority of the content being presented (Pearce, 2015). Similarly, Nanson (2015) talks about David Attenborough answering questions about

climate change during a presentation and asserted that "his words carried tremendous authority" (p. 327) and Brockington (2017), highlighted the influence of celebrity status of the presenter.

In a commentary on wildlife documentaries, Frost (2017) specifically draws attention to David Attenborough's Planet Earth series which generally features animals but no humans and makes the point that where humans are featured it is as a threat to wildlife. Pearce (2015) in her thesis on animal representation in nature documentaries by David Attenborough similarly commented that animals have become "a commodified visual product to be consumed by viewing audiences" (p.11). She further pointed out the absence of scientific language in a commentary "loaded with colonial ideology" (p. 99). While Attenborough leverages off the universal appeal of interesting natural phenomena, when selecting for diverse students, such as in the Asia-Pacific region, it is salient to remember that this is framed by a British naturalist with a colonial view of nature and of indigenous peoples.

To conclude, the use of video provides opportunities to engage students in thinking and learning about science ideas that might not otherwise be accessible to them through practical work and other pedagogical approaches. Additionally, the *New Zealand Curriculum* (Ministry of Education, 2007) requires development of key competencies of t*hinking*, *participating and contributing*. Videos such as those used in this study were selected to encourage thinking, participating and contributing to discussion about science ideas. Specific features of multimedia highlighted in the literature that are relevant here in making sense of student video-watching experiences include: a documentary style in terms of explanatory quality and match to curriculum requirements; the passion of the presenter(s) for science; use of real-life contexts; and simulations and time-lapse sequences of scientific processes not possible to replicate in a classroom setting. Because all these features potentially contribute to providing a context for learning more about science, it is important to examine students' cogenerated insights of the videos used.

Methodology

Our research is framed as authentic inquiry (Tobin, 2015), incorporating hermeneutic phenomenology. Alexakos (2015) provided a useful explanation of authentic inquiry in his recent primer on doing authentic inquiry research on teaching and learning as 'interpretive, participant-centered, emergent from the research as the research happens, and contingent on what is learned. It is dialectic, since it attempts to draw connections and interrelatedness, arrive at multiple views, and explore contradictions' (p. 4). In adopting an interpretive approach, we employed multiple frameworks in the spirit of multi-logicality to enable us to make nuanced claims about the insights of social life in the classroom that we gained through cogenerative dialogues (cogen) (Roth & Tobin, 2005). Cogen was an alternative space for different members of the classroom community to consider the activity of watching a video in science lessons. The potential of cogen is to 'provide interesting insights into many aspects of the social lives of the participants, not only what is said, but also non-verbal interactions into the emotional content of the interactions between participants' (Tobin & Roth, 2006, p. 191). Indeed, Shady (2014) argued: "cogen could be utilized as a cultural bridge that has the potential of

connecting urban minority students with their immigrant teachers, therefore increasing student access to science learning" (p. 34). In her study Bayne (2012) pointed out the importance of selecting participants to ensure difference in the cogenerative dialogues and found that through carefully constructed cogen, "a landscape of difference and diversity unfolded" in which multiple realities could be acknowledged (p. 243). To demonstrate the potential of the transformative role of cogen, Teo et al. (2017) integrated cogen in participatory action research. Drawing on Roth and Lee's (2007) review of Vygotsky's neglected legacy of cultural-historical activity theory, we wondered, how the object (a video) mediates the activity (video watching) realised by students. Or put another way, what affords and constrains learning science from watching videos and critiquing the information presented particularly for developing understandings about the nature of science?

In order to respond to these questions we examined what is happening in the cogen and why it is happening. This phenomenological hermeneutic stance follows the work of Tobin and Roth (2006), and it traces what is happening when viewing the video from participants' accounts of the activity. Collins' (2004) theory of interaction ritual chains is essentially a theory of the production of solidarity, and it was useful for tracking emotional resonances in the cogen as a lens for unpacking the thread of emotionally generated accounts of viewing video reproduced across cogen. Structural resonance is an important feature and can be traced through interaction ritual chains in which speakers overlap one another in quick succession, building on the previous speaker. Anticipating the previous speaker's responses enables the generation of new knowledge of how video mediates learning. In interpreting the unfolding dialogue, we valued the multiple voices (polyphonia) and multiple meanings (polysemia) and the contradictions and differences that inevitably arise in considering all views. The dramaturgical turn of adopting voices to express emotions associated with various genres of video can become ritualised and available as a semiotic resource for others when discussing the emotions they experience when viewing different videos. Thus, participation is structured through utterances becoming resources for others to use that reflect a dialectic relationship between structure and agency (Sewell, 2005).

In our research we adopt the authenticity criteria as interpreted from Guba and Lincoln (1989) by Tobin (2006) as a means of monitoring the impact of our study in a classroom. Through our study we hope to understand how using video as an alternative pedagogical approach can encourage students' thinking, participating and contributing to discussion about science ideas. We take an educative stance that respects the different participant perspectives brought to the fore during cogen. We also aim to trace ontological shifts in using video clips to teach science. Our aim is to catalyse tactical improvements for this classroom and for the research process.

Cogen were typically held at the conclusion of a lesson, with three to seven students, the teacher, and the researchers participating. In the study the teacher was positioned as a co-researcher as were the students; however, for clarity in this account they are referred to by their primary roles of teacher and students. Over a two-month period, eight cogen associated with 12 lessons were conducted. This paper draws on three of these cogen that are relevant to student perceptions of

the influence of the presentation style on their viewing of video. In the first cogen three students and three teachers participated. In later cogen student numbers increased to seven, which included the initial three students. The teacher and researchers worked with the students to develop mutually agreed participation protocols which included attentive listening, sharing opportunities to talk, mutual agreement about issues discussed before moving to another topic, and being respectful of others. A video record of each lesson and the cogen was set up as part of the usual teaching and learning activities of the school, developing good practice in which evaluation and research into one's own teaching are important components. Approval for the video recording of the class session and the cogen followed school protocols that included permission from all students and parents. Those not agreeing to be videoed followed a school protocol of choosing to sit outside camera range.

In the cogen all participants had the opportunity to raise lesson events salient to them in the generation of local theory about science learning in this classroom (Roth & Tobin, 2005). The researchers used videos of these reflective sessions to analyze how students and the teacher raised issues about learning scientific ideas to identify what these issues were, and how the students and teacher responded. Where necessary, the researchers referred back to the specific events in the video recording of the class session. Video footage of cogen was analysed using the software package, Studiocode, which enabled the footage to be sorted into broad themes arising in the discussion. Transformative instances were noted, such as when students assumed the role of the teacher or an expert to highlight what helped, as well as what did not help them to learn. Particular attention was given to contradictions in what was said, and the accompanying gestures and the prosodic features of the exchanges.

Participants

The setting was a science class in a multi-ethnic secondary school in a major city in New Zealand. The study school was a large ($n = 1000+$) urban coeducational school in a high socio-economic community. Twenty-four 14 to 15-year-old students in their second year (Year 10) of secondary school participated in the study. The class comprised 25 students – 10 girls and 15 boys; one student did not want to participate. The ethnicity of the teachers and students of the class in this study was not representative of the diversity of the New Zealand population, although the school's profile was 16% Maori, 71% NZ European/ Pākehā, Pacific 3%, Asian 7%, and 3% other ethnic groups.

The male teacher at the time of the study was in his 7th year of teaching, all of it at the study school. He had researched his teaching from his first year and was interested in teaching his students "how to learn" rather than telling them "what to learn." Cogen appealed to him as another means of gaining students' perspectives on his science sessions.

The two co-researchers were experienced teacher educators, one specialising in science education, and the other in mathematics education. Both have been classroom teachers and both studied science at the university level, one majoring in biology and

the other majoring in earth sciences. Previous studies undertaken by the researchers have included a focus on student perspectives and classroom processes.

Video resources

During the study the science topic was reproduction of plants and animals. The use of video clips in approximately one out of three lessons provided alternative learning experiences of scientific concepts as part of practical activities or investigations. While the school had an extensive library of educational videos, including the David Attenborough video suggested in the science department teaching schemes, teachers increasingly accessed video directly from the Internet as shorter video clips. The clips used in the study included, "The Sneaky Reason Why Plants Bear Fleshy Fruit," featuring David Attenborough, and accessed from the Smithsonian Channel that Mr. G. (the teacher) selected because it showed examples from nature not easily accessible to students during their practical work. He thought the brevity of the video clip, compared to the original hour-long video, and the specific focus on the biological process would appeal to the students. The presenter, Sir David Attenborough, whose name is synonymous with natural history programs produced by the BBC over seven decades, would be familiar to these students as an authoritative figure on the natural sciences (see Table 1).

Findings: Unpacking the use of video clips in classrooms to explain scientific ideas

In science classrooms teachers commonly use video along with practical work to provide an illustration from "real life" not afforded through textbook learning, and where direct experience is not possible. This is not to suggest that it is the only instance of video use in science classrooms; teachers use video for all sorts of reasons as the Berk (2009) article has reported. Moreover, video as a form of instruction is sometimes used by teachers to enhance science learning through appealing to students' sensitivities and through aligning

Table 1 Video clips used in class to explain scientific ideas

Video Title	Description	Presenter	Comment	Associated Episode from cogenerative dialogue
The Sneaky Reason Why Plants Bear Fleshy Fruit	A 2:53 min clip from an hour long video on how plants disperse their seeds.	David Attenborough	Mr. G. chose the shorter clip from a longer video both accessible on the Smithsonian Channel because it focused on the process of seed dispersal.	Episode 1: *"You Can't Not Like David Attenborough"* From Cogen 2 out of 8
Pollination and Fertilization	A two minute clip on pollination and fertilization	Four Australian actors	Mr. G. chose this video because it was short and complemented his lesson on pollination that included examining stamens of a flower through a microscope and a whiteboard diagram of a flower.	Episode 2: "*The Four Same Actors"* From Cogen 4 out of 8 - two weeks later
The Sneaky Reason Why Plants Bear Fleshy Fruit Pollination and Fertilization	As above	As above	Continued discussion about different constructions of video used in class with a focus on styles of presentation and content	Episode 3: *"They Get Outdated"*From Cogen 6 out of 8 - 2 weeks on

with experiences in their peer culture of watching video for recreation. We took up Hennessy's (2006) call to investigate the "messiness" of digital tools, specifically video clips, being used in science classrooms. To do this we explored participant views, through cogen including the students, their teacher and the researchers, about the affordances and constraints of video as a form of instruction. We explored why surface level features may not be useful pointers to gauging potential student engagement with scientific ideas presented through video. We took the stance that students and the teacher brought previous individual and collective experiences to viewing video, as is the case for all classroom experiences, and these experiences mediate the activity of video watching. Specifically we argue that cultural artefacts such as video clips are inscribed with emotion that structures students' opportunities to engage with the scientific ideas.

Spanning the two-month intervention students' experiences of watching video was a recurring topic that arose within six of the eight cogen sessions. This was in response to the general question, "What helps you to learn science?" In the other two cogen sessions learning from video during science lessons was not talked about. To examine the use of video clips to teach science, we present cogenerated dialogue from three episodes each of which occurred in a different cogen. We see cogen as an intervention as they prompt teachers to make changes to their practice directly related to the use of video in their teaching, reflecting our catalytic stance of improvement to collective experiences. Further, we suggest that through the emergent and contingent evolution of interactive structures in student narratives about viewing video, we can gain insights into what affords and constrains students' emotional engagement with the different forms of video mediating students' access to the scientific ideas.

The following conventions (Ritchie et al., 2011) are used in transcripts of the episodes that are discussed next (see Table 2).

What follows are three selected episodes of cogenerated dialogue followed by an analysis and discussion.

Episode 1: "You Can't Not Like David Attenborough"

In the following episode, four of the students (Kelly, Ricky, Mike, and Tim), Mr. G. and two researchers (Authors 1and 2) discuss the specific features of a David Attenborough video in response to a general question about what helped them to learn science.

Table 2 Conventions used in the transcript

Symbol	Meaning	Example
#	Bounds utterance said quickly	#building up again causing the mountain to grow again#
_	Underline for emphasis	Seven
:	Stretched-out sound	si:de
||	Bounds overlapping talk	V: |Wow| M: |Oh| no it was 10 actually
()	Inaudible	
(.)	Untimed brief pause	
(.4)	Timed pause	
(())	Comments or observations	Ye(h)ah ((laughing))

01	Kelly	I like David Attenborough films I don't know I used to |watch them| when I was a kid umm ((looks up)) all the DA movies and (.) they amazingly taught me a lot umm of the stuff because it's in a form which gives you examples and it's not just umm stuff to remember it's like (.) how it happens in real life rather than like in a text book which is just drawn pictures and stuff
02	Tim	|mmm|
03	Ricky	() yeah and the amazing thing with those sort of like movies is that they're actually showing |real life examples| ((gesturing with hands to emphasise the point in synch with his speech)) and it's really cool like how they like film some of the things as it's forming
04	Kelly	|yeah|
05	Mr G	Mmm (nodding) so that time (.) time-lapse photography ((circular gestures))
06	Mike	I've always liked the plants () ((in time-lapse))
07	Author 1	What I noticed was that everyone you know for quite a few parts of that were engaged or looking you know like everybody in the whole class ((laughs)) was looking yet in that |earlier YouTube that wasn't yeah| () but I didn't know if the |length of it| of the YouTube or something different
08	Kelly	|that ()| ((Kelly not really watching))
09	Mike	|no|
10	Mike	((very softly)) I personally think that it's more cos you can't not like David Attenborough ((laughter)) and |um| and the 45 sorry the 55 54 s thing on the YouTube wasn't very like good at saying ah this is how the seed forms ((he demonstrates with a wavy gesture)) this guy gives examples he's got a cool way of talking he's actually |quite engaging| it's interesting seeing how like it actually happened in real time
11	Author 2	|that's good|
12	Tim	|mmm|
13	Ricky	It's just a different form of doing it basically

The collective affirmation of David Attenborough videos centers on their videographic features such as time-lapse photography, images of real life examples, and explanations of scientific concepts that these students talked about as helping them learn. For instance, Kelly shared that when she was a kid she used to watch David Attenborough, and she attributed her learning from these experiences to the real-life examples provided on video and not found in textbook illustrations (turn 1) to which Tim agreed (turn 2). Ricky continued this theme of "bringing nature to life" by elaborating on "filming some of the things as it's forming" (turn 3), to which Kelly agreed (turn 4). Mr. G clarified the process as time-lapse photography (turn 5). In this sequence the speakers reinforced each other's utterances by overlapping the previous speaker to affirm aspects of what each was talking about: Tim (turn 2) affirmed Kelly's point "used to watch them" (turn 1); Kelly (turn 4) affirmed Ricky's point about "real life examples" (turn 3). This cascade of affirmations indicates the centrality of emotions through what Collins (2004) termed an "interaction ritual chain" (p. 3). Author 1's observation (turn 7), perhaps more as a researcher than an equal cogen participant, pulled the focus back to a comparison with the class's earlier viewing of a short YouTube clip, creating a breach in the fluidity of the conversation. However, Mike's response to this breach restored the conversational thread and confirmed his preference for the more comprehensive David Attenborough video. In an ensuing interaction ritual chain, the overlapping speech continued with Author 2 (turn 11), also in a more "researcherly" manner, affirming Mike's point that "you can't not like David Attenborough" (turn 10),

followed by Tim (turn 12) affirming a later point made in the same turn by Mike that David Attenborough is "quite engaging" (turn 10). Ricky concluded this sequence by summing up the contrast between David Attenborough and the YouTube clip that the students had viewed in class as "a different form" of explaining how a seed forms (turn 13). The chain appeared to indicate a consolidation of positive energy towards David Attenborough videos. Further evidence of this is the collective burst of laughter arising from Mike's statement about liking David Attenborough (turn 10). The students' response to David Attenborough's presentation style showed how they see him as an authoritative figure who followed the norms of scientific argumentation in line with the work of Driver et al. (2000).

Key to our argument about video as artefacts inscribed with emotional energy is the use of "voices." Here, Mike adopted a different voice to his usual speaking voice, with accompanying gestures to say, "ah this is how the seed forms" (turn 10). This was the first instance of "a voice," in this case to mimic David Attenborough's commentary, perhaps by assuming his role. Through this semiotic resource, Mike intensified the emotional resonance of his point that David Attenborough as a presenter had a "cool way of talking" and "is quite engaging" (turn 10).

In subsequent episodes we show how this emotional energy was reproduced across time through different students' ritualised use of "voices" expanding their capacity to act and in turn transforming the culture of the cogen into a space amongst equals to build critique with their teacher and peers of the digital tools used in their classroom for science learning.

To sum up our argument so far, we take the stance that emotional engagement, both positive and negative, is a critical component of learning environments and mediates students' learning, in this case from watching a video. Across several cogens we illuminate the generation of classroom culture through the unfolding collective critique of video as tools for science learning. We show how the inclusion of "fun" features, the quality of explanations, the relevance of the information, and the presentation style were salient to students, engendered their emotional engagement, and mediated their access to the scientific content of the video. However, in selecting a video for teaching reasons a teacher needs to be purposeful in knowing what they intend the students to learn from watching it. Being aware that videos and cogen together provide the ideal opportunity to encourage students to critique the science ideas being presented, thereby providing students the opportunity to understand that scientific evidence is open to critique and to alternative theories. Further that science is not about accepting facts, but knowing that scientific theories are subject to change when new evidence is found to support the new theory.

Episode 2: "The four same actors"

The following transcript is of a conversation in a cogen 2 weeks later about using video in science lessons. In this episode the students continued to build their passion about David Attenborough videos through a shared mood fuelled by the further use of voices, by Mike and also by Kelly, who adopted "a voice" to add to the critique.

01	Mike	You know like Australian ones that are like ahhhh the four same actors and put just like a moustache on them, a hat and silly glasses ((using a silly voice and gesturing to an imagined moustache on his face))
02	Tim	()
03	Ann	Like the plant one we watched the other day () it went on for ages () it was quite interesting like changing the topic changing what it was about that one's good
04	John	()
05	Mr G.	|That detracts from|
06	Mike	|Especially because it is Sir David Attenborough|
07	Robbie	Yeah the David Attenborough
08	John	We should get back on the topic because we're just talking about David Attenborough ((low pitched voice))
09	Author 2	So why did you like the David Attenborough ones what is good about them
10	Robbie	Because they're David Attenborough () because they are interesting and stuff and it's stuff I would actually watch after science as well
11	Tim	He's an effective presenter
12	Robbie	I don't really want to watch um yeah the one
13	Kelly	The ones that were n:o:w g:o now sit th:ere and think about wh:at we just said rather than the teacher just saying it, looking at the screen and there was a guy
14	Mike	|I do like to () and what part did you enjoy I like that t:o:o|
15	Kelly	|Yeah|
16	Ann	|I'm pretty sure they do like Dora the Explorer that will help us learn Dora is amazing|
17	John	I like it more when you choose stuff that's more relevant like documentaries and stuff rather than just () ((looking at the teacher))
18	Mike	Plus most of those are like from 1991 they are like all retro they are more common in English
19	Author 2	The thing is though in science okay Mike one little question in science do you get to view that type of video I haven't noticed that personally
20	Mike	Notice what
21	Author 2	Noticed the kind of video you're talking about
22	Tim	Occasionally in science but it is much more common in other subjects
23	Kelly	You have to get it so that it is compulsory for the curriculum you have to watch this one because it covers these topics

The shared mood evident in this episode is reflective of the emergent and contingent nature of generating critique of the videos watched in class. What emerges in this episode is a continuation of the passion for David Attenborough contingent on what unfolds in the conversational thread. The focus here is on the authenticity and status of the presenter in a documentary style video, compared to some actors in a video in a different genre. Again the adoption of voices is reproduced as a semiotic resource to critique the video presentation styles. This time the focus is on a different form of video, with Mike leading off with his critique of the Australian actors who had appeared in more than one video, but were unconvincing to him with their facial hair, spectacles and hats (turn 1). Terming them "actors" seems to be suggesting that for him they did not gain the authenticity and respect of a documentary presenter such as David Attenborough.

Using a strident and slightly sarcastic tone of voice to express a concern that the conversation got off topic, it is interesting to note John's observation that perhaps David Attenborough was becoming a group obsession (turn 8). This idea of topic may have come from Ann, who talked about "the topic changing" (turn 3). The other participants did not

appear to see the focus on David Attenborough as an issue and so, following the mutually agreed cogen participation protocols, Author 2 made an "in the moment" decision to go with the group rather than with the one individual, John. While obviously being able to draw on symbolic capital as an authoritative other, debatably any of the cogen participants could also have countered John's suggested redirection to a more general discussion of what helped them learn and why. This rupture in the sequence was fuelled by strong collective emotions that constrained a potential discussion of ideas of and about science and underscores the importance of videos for teaching needing to be perceived as sophisticated by students.

In this episode there were three notable instances that demonstrate the fluidity of fields representing students' multiple diverse life-worlds that constantly impinge on learning experiences. For instance, as with Kelly in the first cogen, Robbie in this cogen talked about watching these science videos out of school (turn 10). Ann also appeared to be drawing from her home world when she mentioned *Dora the Explorer* (turn 16), an American animated series. Later in their conversation the students drew from fields other than the classroom in their critique of the retro videos used in their English class (turn 18).

Robbie's statement (turn 12) went as far as saying that he did not want to watch videos other than documentaries. We might surmise that such a stance would constrain the learning of science from other sources that a teacher might select. Kelly, employing a voice (turn 13) saying "n:o:w g:o now sit th:ere," illustrated and supported Robbie's point and Mike's use of a voice (turn 14) "in what part did you enjoy I like that t:o:o". Underlying both Kelly's and Mike's ritualised voices replicating the tone and pitch of a teacher's voice was the use of mockery to convey their resistance to positioning the viewer as "student". Ann's suggestion (turn 16) that *Dora the Explorer* would help them learn was not picked up by anyone else in the cogen, maybe because Kelly and Mike were using voices as a "tool to hand," enabling their conversation to maintain fluency. However, this fluency appears to be disrupted at the point at which Ann made her suggestion. As in the previous episode the interaction ritual chain shows the fluency between utterances. We suggest that the use of different voices indicated a growing tension in the students' critique of David Attenborough videos compared to any others. It is not our intention to suggest that just because the students felt passionately towards David Attenborough videos this will necessarily afford their learning; rather, we suggest that this is an example of the messiness of using digital tools in the science classroom; in other words the use of video is contradictory and nuanced.

Kelly appeared to have an understanding about why specific videos are selected by teachers, along with John (turn 17), who applauded the relevance of Mr. G's choice of video for their science learning. Their comments about the videos used in English classes being "retro" (turn 18) appears to contradict some of their reasons for being passionate about David Attenborough, who by this stage in the thread has assumed a seemingly elevated status. Looking beyond his appearance and focusing on his status as a preeminent science commentator and documentary maker shows that for these students, contrary to their critique of video actors as "retro" based on their appearance, were very much focused on what helped them to learn science. It is perhaps not the year of production, but rather the sophistication of the video production – or lack of it – that matters to students.

Episode 3: "They get outdated"

A further 2 weeks on, the conversation about what matters to the students about different forms of video continued. The thread here focuses on how video clips can become dated and why and what to do about it.

01	Tim	The problem with these old ones is that they get out-dated almost instantly you know the clothes soon become unfashionable I think is just best if they were to just show ones that were on TV
02	John	And if the older ones people just make remarks but oh look at that what are they wearing look how they're talking this is |dull|
03	Tim	|You don't concentrate|
04	John	|Yeh, they| don't focus on the thing we just want information and just like sort |of|
05	Mr G.	|That detracts from the actual content|
06	Ann	Because everyone is laughing at |people|
07	Kelly	|They can't of|
08	Tim	And they also make jokes
09	Robbie	That aren't funny
10	Author 2	Okay let's talk about the ones you've been watching here the David Attenborough ones what is |good about them|
11	Ann	|It's David Attenborough| so they're amazingly interesting
12	Tim	He he doesn't cut any crap he doesn't um he doesn't make any bad jokes about anything like
13	Mike	He doesn't make jokes which is awesome
14	John	And Mr. G he has found the parts that are relevant to us
15	Kelly	It goes to the screen shots he'll be talking like the one with the spores and the raindrops and he'll explain ex:actly what's happening as you see it happening rather than saying this is what happens and then you just kind of okay I don't really understand I didn't see it happening
16	Mike	He talks about interesting things instead of saying look at this average garden flo:w:er look at how it poll:in:ates ((sounds out the syllables)) it's kind of like look at this random African one |that like opens when it gets caught on fire| it's f… ing awesome
17	Ann	|He always finds exotic flowers and stuff|
18	John	Language ((low pitch))
19	Tim	Arh and also he manages to display things effectively like um they had this bit where they were displaying the different types of like seeds that can be flown and they had a black background that just had them shown to be spinning and that kind of showed them popping up and then he'd explain each one as it and you could see the different way they moved and stuff

This third episode continues the cogeneration of dialogue about different video genre used in class and begins with a discussion of video designed to quickly gain the viewer's attention through humor; this video genre contrasts with the more serious authoritative style of David Attenborough documentaries. Similar to the previous episode about actors, the conversational thread is about how out-dated the clothes are, how people from a different era might talk, and how distracting jokes interrupt viewers' concentration (turns 1 through 9). This interaction ritual chain of overlapping talk, signals intensifying emotional energy that is not supportive of such videos. Mr. G. also contributed that any of these features of video "distracts from the actual content" (turn 5). The aspect that was added to their critique of video was about the use of jokes (turns 8, 9, 12, and 13), with consensus from Tim, Robbie and Mike that from their perspectives humour is an unnecessary feature of a documentary video. There is an important contradiction when John (turn 4) said, "we just want information." However, it would seem that it is more about how "the information" is presented.

At this point Author 2, redirected the conversation back to an exploration of how David Attenborough helped them learn (turn 10) overlapping with Ann's comment about David Attenborough being "amazingly interesting" (turn 11). The intent of the redirection was to draw on David Attenborough as an authoritative and knowledgeable communicator in contrast to the other videos discussed. Ann in this cogen appeared more aligned to the other participants than she was in the episode from the previous cogen. Again there was affirmation and trust in Mr. G. selecting "the parts that are relevant" (turn 14).

As for the previous episodes, we see the generation of structures for collective use, such as in the voices employed towards the end of this episode. Again, Kelly (turn 15) and Mike (turn 16), mimicked David Attenborough to convey their passion for the time-lapse images and the accompanying commentary. It is important to note that in their extended dialogue they began to engage with science ideas such as wind pollination as well as the use of time-lapse photography, illustrating that communicating in science is an important curriculum goal of science education.

Concluding comments

Our authentic inquiry of video as a mediating artefact of science learning drew on what was happening, and why, in three episodes from cogen that occurred across a two-month timeframe. Using a range of analytical tools, we investigated why students viewed different characteristics of video as affording and constraining their science learning. We were not looking for a consensus on these aspects, but rather our analysis was oriented to difference and contradiction as a means of exploring Hennessy's (2006) suggestion of the messiness of learning science, in this case from watching a video. In choosing episodes where students talked about videos they had seen, we also encountered video watching in their other life-worlds, such as home and other school curricula.

What became apparent through the cogen were the complexities associated with video selection for the purpose of learning science. Perhaps the most important criteria teachers could use to identify and select video to mediate science learning is to be purposeful in their selection and to assess whether the video designers' purposes conflicts with their own as teachers; that is an imperative is being clear about reasons for showing a particular video and knowing how it connects to curriculum goals. In the case discussed in this paper the teacher chose a documentary style video, drawing on David Attenborough as an authoritative and knowledgeable communicator of scientific ideas, to promote the curriculum goal of scientific communication. However, as we have shown the constraints of such videos, through liberties taken in the telling of the stories about biological processes, possibly limited student learning of thinking, participating and contributing to discussion about the tentative nature of science ideas.

Cogen can be a useful tool for teachers to check the extent to which curriculum goals are realised, particularly that of developing critical, informed, and responsible citizenry (Ministry of Education, 2007). While video can potentially generate discussion of and about science, we found that these harder to achieve epistemic goals of science were not observed nor achieved in these cogen sessions. A number of factors may enhance or prevent teachers from being able to use cogen effectively to learn about their students and to select appropriate videos for teaching science. These include the challenge of maintaining the mutually agreed participation protocols described earlier, as

well as teachers' own understandings about the nature of scientific knowledge. The predominantly European Pākehā ethnicity of NZ teachers has implications for teacher educators and researchers in addressing growing diversity of the student population. Shady (2014) from his study about negotiating cultural differences promoted cogen as part of both teacher preparation and ongoing professional development. He argued that that the insights gained from cogen will "become even more critical as the challenges of globalization create a growing tension between local and global cultures" (p. 50).

These episodes have shown contradictory views of design features common to different genre of video arising from the complexity of the features employed including real life examples, explanatory formats, and commentary. In particular, the genre of video generated a lively emotionally charged discussion among the cogen participants, with students holding strong views about their preference for videos with an educational framing that was relevant to the purpose of the lesson. The episodes show that there are multiple ways in which video artefacts are inscribed with emotions that structure students' learning, both affording and limiting opportunities. Perhaps more importantly, these students provided insights into how their collective emotional responses to videographic techniques, such as humor and authoritative commentary, generated social resonance within the group. This has implications for the importance of acknowledging emotional engagement as mediating student learning. Further, the cogen provided educative insights into learning in this science classroom as well as prompting the teacher to modify his practice of using video, evidence of catalytic authenticity. It was evident that the teacher implemented the students' suggestions, and that the students could see that their views on, and ways of, learning were valued. This built solidarity around the focus on learning and brought ontological shifts for all participants in the study through a better tactical understanding of the process of learning from watching video.

The New Zealand Curriculum (Ministry of Education, 2007) sets the Nature of Science strand of the curriculum as an overarching strand and prioritises the learning about the Nature of Science alongside the learning of science content. Part of becoming scientifically literate is developing a critical stance around the concept of evidence (Bennett et al., 2010). Here was an opportunity to critique the content of the video and not just accept the narrative presented to them by David Attenborough as facts. While videographic features used in clips, on the one hand can engage students in scientific ideas through images and commentary, on the other hand in the telling of a story scientific details important to fully understanding a concept can be compromised and can misrepresent a concept such as evolution.

In constructing a tight storyline without unpacking the details the video took liberties with specific aspects of evolution creating a misconception around the evolution of the process of seed dispersal. Specifically, in the telling of the story the evolutionary sequence of birds developing color sight to enable them to play their role in seed dispersal by selecting berries that are ripe was glossed over. Attenborough's commentary suggesting that this happened quickly was not picked up and could have provided opportunities for students to engage with evidence of evolutionary processes. The commentary was accepted as fact yet could have led to a discussion about not accepting facts without critique.

Not taking the discussion beyond the obvious is a missed opportunity to discuss the tentative nature of science, encourage the evaluation of the evidence upon which the

claims are being made, and talk about the value of critique and how scientific theories change as new evidence is found. It provides an opening for teachers to encourage a critical stance to explore the ongoing social construction of scientific ideas. This aspect was missing from the teaching focus and did not arise during the cogens in the case reported in this paper. Design features and the use of environmental "celebrities" and the construction of scientific authority, such as assigned to David Attenborough, was raised by Nanson (2015), Pearce (2015), and Brockington (2017) and has important implications for teaching and learning about the nature of science. Further, David Attenborough largely interprets and talks about his observations of the natural world from a Western science perspective while indigenous science education researchers such as (McKinley, 2005) argue for valuing other ways of knowing. There is extensive international literature that investigates the relationship between indigenous knowledge and Western science (McKinley, 2005). Perhaps documentaries like the ones used in this research can be used to encourage students to view and discuss them from a range of perspectives. It is important for researchers to raise these issues in forums with different readerships such as those in the Asia-Pacific region so as to "engage in the kind of dialogue needed to raise awareness about how international and multi-discipline research can expand our individual and collective understanding about how science is being understood and experienced in local and global contexts." (Martin & Chu, 2015, p. 6).

Thinking about the use of video also helped the teacher and the researchers to examine what helps students to learn science. From a teacher's perspective, the use of video to present scientific ideas is an alternative to other forms of instruction, such as explanations in textbooks, or didactic teaching, with the combination of images of the natural phenomena alongside an expert explanation being an appealing option. The teacher's approach is in congruence with the view that if a teacher wants to stimulate their students' interest in plants and animals they could grab a handful of David Attenborough videos and use them alongside some quality texts and references for inquiry-based learning (Vise, 2016). From the students' perspective, they generated strong emotions about the relative merit of different presenters, favoring Sir David Attenborough for his authoritative, informative stance, as well as the inclusion of contextual examples and narrative and expository components in his documentaries. They contrasted this with presenters who used humour in what was perceived as an unsophisticated and insincere manner. Above all, the sense of caring about learning was conveyed in Tim's comment about this science class in contrast to some of their other classes:

> Tim: I just feel in science that we're getting a lot done compared to other subjects. It just feels like we're doing a lot more learning.

Additional files

Additional file 1: Maori abstract. (DOCX 17 kb)

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Authors' contributions

JH and AM made substantial contributions to the conception and design, acquisition of data and its analysis and interpretation; Authors JH, RE, and AM were involved in drafting the manuscript and revising it critically for important intellectual content; and all three authors have read and approved the version of the manuscript to be published.

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Competing interests

The authors declare that they have no competing interests.

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