ORIGINAL ARTICLE

Fostering Curiosity in Science Classrooms: Inquiring into Practice Using Cogenerative Dialoguing

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ABSTRACT

Developing students' scientific literacy requires teachers to use a variety of pedagogical approaches including video as a form of instruction. In addition, using video is a way of engaging students in science ideas not otherwise accessible to them. This study investigated the merit of video clips representing scientific ideas in a secondary science classroom as one component of a science program. Drawing an interpretive approach framed as authentic participant-centered inquiry, the analysis used cogenerative dialoguing to generate collective perspectives on the affordances and constraints of learning from video. We found that the structure of a video in terms of complexity of the content delivery and its length shaped students' viewing experiences and access to science ideas. We argue that structures of the learning context afford and constrain students' opportunities to learn science from video.

KEY WORDS: learning science; video to teach science; application of science ideas

INTRODUCTION

The discipline of science requires curiosity (Luce and Hsi, 2015) that is an important part of school science programs that aim to develop scientifically literate students (Millar, 2014). In order for teachers to develop students' scientific literacy through fostering curiosity, teachers need to use a variety of pedagogical approaches. It is generally accepted that teaching science is more than mere content delivery and that knowing the content, passing it on to the students does not automatically lead to students' learning what the teacher intends (Millar, 2010). Also accepted is that teaching is more than a collection of activities that are rehearsed and worked through (Berry and Milroy, 2002). Along with teaching science ideas and skills, teaching school science includes helping students to develop habits of mind that Lawson (2009) defines as "fostering science as a way of thinking" (p. 5) through generating an inquiry culture in the classroom that underscores the importance of curiosity alongside critical thinking. Such an inquiry culture in the science classroom is likely to include longing to know and understand, to question things, to search for meaning in the data, respect for evidence, critique, reasoning, and consequences (Lawson, 2009).

Expert teachers recognize that teaching is complex, interwoven, and students do not always learn what the teacher thinks they are learning (Hodson, 2014). At the heart of good teaching practice is an understanding of the relationship between teaching and learning (Loughran et al., 2012) with teaching requiring an appreciation of students' current knowledge, any alternative conceptions they may have and how well they understand the intended science ideas (Taber, 2014). Osborne (2015) argued that science is a set of ideas and the role of the teacher in his view is "to build students' understanding of the ideas and the reasoning that has led to their establishment" and that "developing an understanding of an idea requires talking about it, writing about it, reading about it and representing/drawing or visualizing it" (p. 18). Knowing the learners and how they learn, or knowledge about the learner is a key aspect of teaching and science is no different. It is the teacher's task to support students to make sense of new ideas in light of their existing ideas (Driver, 1985). Teachers are entrusted with providing opportunities for students to be both curious and critical in the quest for scientific literacy. It is important to actively provide students with opportunities to discuss their classroom learning experiences with the teacher.

The mix of pedagogical approaches that engage learners in science years 7-10 (age 11-14) of schooling is paramount (Allchin, 2014). We contend that this mix can include practical work supported with video. With a blended approach, it is also important that teachers inquire into their practice particularly given that New Zealand is one of the schooling systems that has identified the problem of disengagement of learners in years 7-10 of schooling with specific reference to the learning of science and developing scientific literacy (Allchin, 2014). One system-wide policy mechanism in response to improving teaching quality is for teachers to inquire into their practice (Ministry of Education, 2007) underpinned by the principle of adaptive teaching "since any teaching strategy works differently in different contexts for different students, effective pedagogy requires that teachers inquire into the impact of their teaching on their students" (Ministry of Education,

2007. p. 35). Reflecting on teaching is an essential element of teaching practice and when practiced leads to better teaching (Loughran, 2006).

LITERATURE REVIEW

While "science is about hands-on practical work" is an international slogan, there is little research to back the claim that doing science leads to understanding science (Millar, 2010; Osborne, 2015). Practical work has two aspects, doing and the thinking about the doing. Literature suggests that teachers have too many learning outcomes and that limiting the range of practical activities may limit learning (Millar, 2010). Abrahams and Millar (2008) recommended having few and clear learning outcomes for any practical activity and assert that this is more likely to result in student learning. Practical work is just one approach to learning science, and Hodson (2014) suggested teachers select the teaching methods that are most appropriate for the content to be learnt. Hodson (2014) argued that:

> Effective pedagogy demands that specific learning methods are chosen in relation to the characteristics of the content, the knowledge and understanding the students already possess, their previous experiences, needs and interests, the need for a variety of classroom activity, the availability of resources, specific teacher expertise... (p. 2538).

For instance, video is a useful pedagogical approach for teaching content that cannot be easily accessed in the school laboratory.

Video as a Form of Instruction

Using video as a pedagogical tool alongside practical work can be a fruitful way of engaging students in science ideas not otherwise accessible to them through practical work. It also has the potential to foster science as a way of thinking about the world (Lawson, 2009) by supporting the development of curiosity about science. However, the complexities of video watching to foster scientific literacy need to be considered. Mayer and Moreno (2003) defined multimedia instruction as "presenting words and pictures that are intended to foster learning" (p. 43). Compared to traditional forms of instruction such as text, cognitive load is an important consideration in multimedia instruction because the interaction between words and pictures are implicated in the learning process. Many of the articles entailing guides for the classroom incorporate Mayer's (2001) cognitive load theory. Berk (2009) has written perhaps one of the more comprehensive guides to using instructional video. He noted changes in four areas of instructional multimedia possibilities that include; the variety of video formats, the increasing ease of accessing and using these in a classroom context, the video techniques available to an instructor, and empirical studies and theoretical papers to inform the effective use of multimedia tools. The comprehensive discussion in the second part of his article includes types and sources for selecting video as well as generic techniques for using video in teaching are aimed at instructors. Other writers who have advocated ways of using different types of multimedia such as web-based video and YouTube clips include technical aspects to consider; for instance, Pace and Jones (2009) write about web-based video and the high cognitive load content of many of these. They remark these "often fast-paced, and information rich-science concepts can be fragmented and embedded within larger cultural issues. Although these qualities enhance the value of these resources, they may undermine their instructional value" (p. 48). Their argument is that contextual examples are a means of developing scientific literacy. Interestingly they recommend pre-viewing, segmenting, and taking account of characteristics of video such as the inclusion of a problem or question and using a range of locations that optimize student access to the ideas. Everhart (2009) specifically talks about using YouTube in the science classroom. Writing from his own experience of using web-based video, his position is that YouTube energizes students because the videos are visually stimulating. In advocating a mix of videos that align with lesson objectives and are informative as well as show practical activities, he cautioned to check content for incomplete explanations or misconceptions.

An emerging field of research is that of pedagogical approaches to using video as an instructional tool. For instance, Roodt and Peier (2013) in a South African classroom-based study of a 2nd year undergraduate university course, investigated using YouTube for the internet generation of students, defined as those born after 1982, to see if it supported student engagement of this age group. They found that while the extent that YouTube was used varied between the groups surveyed, students who considered the use of YouTube in the classroom had a positive effect on overall engagement including behavioral, emotional, and cognitive engagement. In a United Kingdom (UK) study, investigating how multimedia is used in secondary science, Hennessy et al. (2006) examined the affordances for learning from a broad range of pedagogical approaches. Otrel-Cass et al. (2011) in a New Zealand study in primary science of Information Communication Technologies (ICT) including video, called for teachers to focus on identifying specific pedagogical strategies for different digital tools and advocated matching pedagogy to how the culture of the learning context is shaped by the physical and cognitive attributes and the digital tools employed. Their remarks about the sequencing of student practical work and watching the associated time-lapse video of scientific phenomena are relevant to this paper. They noted the comparatively short length of the clip of 40 s, to argue that "showing the students the video after their own investigation allowed them to make connections with what they had experienced in real time and benefit from seeing the changes highlighted and illustrated in full through the time-lapse video" (p. 3).

We suggest that it is important to examine video as a form of instruction as aside from curriculum requirements (for instance, Ministry of Education, 2007), the use of multimedia including the use of video for instruction is increasingly cited in statements of teacher registration or licensure (Education

Council, 2016) and evaluations of teaching programs (for instance, Education Review Office, 2016) which states "The integration of current and emerging technologies plays an important enabling role in supporting innovative teaching approaches and creating new opportunities to learn" (p. 33). Furthermore, accessibility to video for classroom use has been substantially enhanced since Web 2.0 in around 2006 as technology continues to expand at a rapid pace and multimedia becomes increasingly sophisticated in form (Berk, 2009; Mayer, 2001; Pace and Jones, 2009).

We respond to Otrel-Cass et al.'s (2011) call for insights into pedagogy that exploit the opportunities of ICT/multimedia in terms of matching pedagogy to the culture of the learning context in unpacking the complexities of developing a culture of inquiry in a secondary school classroom. Our focus is on how practical work and video clips of scientific phenomenon beyond the practical work setting might be combined to form a blended pedagogy that engages students in an inquiry approach. We are also interested in how teachers might inquire into such practices. We explain next how we went about this.

METHODOLOGY

Our authentic inquiry (Tobin, 2015) of the pedagogy associated with using video clips to teach science assumes an interpretive stance that is participant-centered (Alexakos, 2015). We are seeing classroom practices as culturally mediated. Alexakos argued, "New knowledge production is therefore grounded in participants' everyday experience. By participating in interactions, individuals are not only guided by culture and prior knowledge but also shape, mediate, and transform culture, knowledge, and what is considered knowledge" (p. 14). These practices form an emergent pedagogy influenced by the cultural setting of the classroom and the use of tools, such as video clips, used in that setting. Furthermore, cultural tools are imbued with "theories of the activity they have been designed to fulfill, and of the users" (Hennessy, 2006. p. 25). The theory of activity associated with video clips contributes to nuanced claims about learning from viewing video clips in a classroom setting.

In this study, the classroom setting or learning context is regarded as a dynamic system incorporating human, material, and symbolic structures that participants have agency to access and appropriate. These structures are fluid and emerging as classroom activity unfolds as an expanded set of cultural practices "thereby disrupting cycles of reproduction" (Roth and Tobin, 2002. p. 3). The study introduced a reflective process through cogenerative dialogs (Roth and Tobin, 2002) to give the teacher, who was also a coresearcher, the other two researchers (also taking a role as coteachers in the science sessions alongside the teacher) and students, opportunities to consider classroom practices that afford and constrain engagement with scientific ideas. Tobin (2014) describes cogenerative dialogs as:

> (Cogenerative dialogs) are reflective conversations among selected participants. One of the key purposes of (cogenerative dialogs) is to identify contradictions that might be changed with the goal of improving the quality of teaching and learning - that is, (cogenerative dialogs) is part of a process of critical pedagogy. As such all participants in (cogenerative dialogs) are encouraged to speak their minds, identify specific examples to illustrate where improvements can be made, and also identify examples of exemplary practices or counter examples of those that exemplify a need to change (p. 181).

Seeing cogenerative dialog as a regular and ongoing structured conversation (Bayne and Scantlebury, 2012) about classroom activities enabled an emergent and contingent approach in making connections between practices and their interrelatedness with the learning context (Alexakos, 2015). We tracked contradictions arising from the multiple perspectives to focus specifically in this paper on the use of video clips. Our research questions are:

1. What are the key dimensions for fostering year 10 students' science learning in urban schools?
2. To what extent and in what ways does the use of a reflective process involving the teacher's and students' perspectives on practical work and by watching video clips foster student learning in science?

Participants

The participants included 24 students year 10 students (aged 14-15-year) in their second year in a large coeducational secondary school in a major city in New Zealand. The study class teacher/coresearcher was male, in his mid-thirties, with a master's degree in conservation biology and a graduate diploma in secondary teaching. At the time of the study, he was in his 7th year of teaching in the same school. He was valued for his contribution to the science department where he held a position of responsibility. He was a regular contributor to the local science teachers' network and shared his research at various subject teacher conferences. The teacher had researched his teaching from his 1st year of teaching at the school, and was interested in teaching his students "how to learn" rather than telling them "what to learn." He was interested in the science learning of all students and conducted ongoing formative assessment of the class. He provided both written and oral feedback to students for each lesson, using this process to ascertain each student's capability and to identify areas in which they needed to improve. He encouraged students to ask for help when they needed it - the cogenerative dialoguing appealed to him as another means of gaining students" perspective on science sessions.

The two core searchers who were coteachers were experienced teacher educators, one specializing in science, and the other in mathematics education. Both have been classroom teachers, one a secondary science teacher and head of department, the other a primary school teacher of all curriculum areas, including science. Both researchers have 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.

Design and Method

The data drawn on in this paper included cogenerative dialog, field notes and video records of lessons in which the researchers were participant observers. Taking a participatory approach, the researchers cotaught (with the teacher) 16 lessons over two school terms (approximately 20 weeks). The evidence drawn on for this paper includes our experiences of these lessons. While this teacher was student-focused, there were limited structures for him to find what helped the students to learn in his class and how he could best teach students like them, hence the introduction of cogenerative dialog. The cogenerative dialogs were typically held at the conclusion of a lesson with three to seven students, the researchers/coteachers, and coresearcher/teacher participating and providing an opportunity to raise lesson events salient to them. The researchers used video recordings of these reflective sessions to analyze how students and the teacher raised issues about learning scientific ideas through video to identify what these issues were, and how the students and teacher responded. Where necessary, researchers referred back to the specific events in the video record of the class session. In the first cogenerative dialog session there was three students and three teachers participating. In later cogenerative dialog sessions student numbers expanded to seven which included the initial three students. Eight cogenerative dialogs, following mutually agreed participation protocols such as active listening and being respectful, were associated with 16 lessons that formed the other component of the data set. Approval for the videoing of the class session and the reflective session 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.

FINDINGS AND DISCUSSION

Video clips as a form of instruction are an appealing option to teach science through illustrating the world of scientific endeavor, but they also have the potential to distract with sophisticated cinematographic features and with a dense stream of information that requires high levels of concentration on the part of learners. Given these factors, it is imperative that the activity of viewing video is structured to afford learners' engagement with scientific ideas. It is likely that a teacher will play a key role in ensuring this. Here, we aim to unpack these complexities of engaging with scientific ideas through watching video and show how the learning environment is restructured to embrace inquiry, curiosity, creativity, and critical thinking generated through the video clip. We argue that the structures of the classroom culture or learning context afford and constrain students' opportunities to learn science from video watching including strategies or structures for viewing a video. We present how one teacher adjusted his practice over a 2-month period in response to cogenerated conversations about aspects of the program students considered helped them to better access scientific concepts as part of their practical work, including video watching. We see the match between pedagogy and learning context as a dialectic relationship with the classroom as a dynamic system in which all participants have agency to access and appropriate human, material, and symbolic structures. What follows are questions raised in the cogenerative dialog conversations that illustrate the structures employed. We have structured the findings as responses to questions raised during cogenerative dialogs. These are set out as:

- Example
- Description of the practice
- Student perspective
- Discussion.

Example 1: What was the Science Behind the Experiment you Did?

Description of the practice

The teacher wrote the learning outcomes on the board and shared these with the students at the start of the lesson along with the success criteria that he revisited at the end of the lesson. His intention was to focus students at the conclusion of the lesson on the learning experiences he had provided. Examples of typical questions the teacher used included: "What do you think the key learning was in the last lesson?"; "What was the science behind the experiment you did? How did you know this?"; and "What part of the lesson stands out in your mind and why?"

Student perspective

The students said that they found the sharing of learning outcomes useful to link to their learning in the previous lesson and for revision for assessments. Their preference was to write these in their books even though they had the choice to just read them.

Discussion

The teacher reviewed students' prior knowledge and encouraged the linking of new learning to what was learnt in the previous lesson along with their teacher's approach to structured or unstructured practical experiments. Students also brought up revision strategies used in the lesson, group work and learning outside the classroom. The cogenerative dialog discussion was useful for illuminating both the teacher's intention as well as how useful students found the routine. Although sharing of intended learning is emphasized as good practice, Abrahams and Millar (2008) found that in their investigation into learning from practical work that science teachers commonly shared what students needed to do during the practical work but did not share what they intended students to learn. Consequently, practical work was not effective in terms of students learning what the teacher intended them to learn, level one, but not at the higher, level two of Abrahams and Millar's framework (2008). It appears that the participating teacher in this study shared what he intended the students to learn that afforded the opportunity for the students to perform at a higher level.

Example 2: What Evidence do you have to Classify the Plants and Vegetables?

Description of the practice

During practical work sessions, the teacher encouraged students to explore. He began the topic with the study of plants and incorporated different types of investigations. He began by setting up an exploration of different parts of flowers in which students were each given a flower to pull apart and identify the parts. Through a classification and pattern seeking investigation he provided an opportunity for students to explore a number of different flowers to ascertain the similarities and differences these flowers had from the common fuchsia flower they had dissected as a class. The students also looked at the flower under a microscope. One student could see a pollen grain on the stigma which was a wow moment for them. The teacher asked them if it was the pollen of the same kind of flower. "What evidence did they have?" He used a variety of teaching strategies during these investigations including the use of Venn diagrams, and tables to record, for example, seed germination and plant growth. Using a similar approach to the exploration of flowers, students were given an assortment of fruits and vegetables and had to decide in groups what made something a fruit or vegetable. The students found it interesting when their teacher, Mr G. told them that "vegetable" is a social construct. He explained, "something mum puts on the plate with meat and potatoes! So, tomatoes, chili, and cucumber are the fruits of their respective plants. Plants have vegetative parts that we have learnt to eat, for example, carrots (root), celery (stem)." This lesson concluded with agreement that a fruit in science was something that has seeds.

Student perspective

Students said they were excited about seeing a pollen grain on the stigma (under a microscope) just as the teacher had on the diagram on the whiteboard. The students, after discussion, came to the conclusion that science needs evidence and that they would have to look for the pollen of that flower to match the pollen grain they were looking at. This led to some students commenting during cogenerative dialog that the unstructured style of doing practical work helped them to construct their own learning. They preferred to have the problem presented and the opportunity to work it out for themselves with the teacher as an observer and potential helper if needed. They wanted "play or fiddle time" and to learn from either talking or working with others. For instance, one student decided to use a stack of magnifying lenses to look at a flower. He informed the teacher that he was increasing the magnification to look for detail. The students also said that the teacher should help those who are not able to work out the scientific concept for themselves.

Discussion

The teacher used the practical work to emphasize the nature of science in teaching. The Nature of Science strand of the science curriculum (Ministry of Education, 2007) is the overarching strand through which the content of science is to be learnt. We observed students not just planning investigations and gathering evidence but critiquing the plan and critiquing the evidence. Further, the teacher valued student knowledge, for example, when one girl said that her father was a beekeeper, the class learnt from her what beekeeping was all about; it was relevant and added to class discussion and learning.

Example 3: Why did I Show this Video Clip?

Description of the practice

The teacher used video clips to show examples not easily accessible for students to experience during the course of the lesson. The videos he chose covered a range of content including human childbirth and elephant birth and plant, animal, and insect pollination. The videos used for reproduction in plants included a David Attenborough video "The Sneaky Reason Why Plants Bear Fleshy Fruit." This is a full-length hour-long documentary on how plants disperse their seed. The teacher selected the YouTube clip of this video, "Introduction To Seed Dispersal" because it was short and focused on explaining the seed dispersal process compared with the full video with more detail and examples. For animal reproduction, the teacher selected a Lord Winston video, "The Human Body" and a YouTube clip "Elephant Birth."

From the teacher's perspective, the cogenerative dialog provided an opportunity to discuss his pedagogical decisions and come to a shared understanding with students about why he had selected particular videos for this topic and his purpose in showing them. For instance, across different cogenerative dialogues, the teacher, Mr. G. quizzed the students about his purposes in showing them various video clips as part of their science lesson by asking, "so why did I show it?"

Student perspective

The students could see that the teacher's purpose for showing them video was motivational -encapsulated in Tim's response to the teacher's question about why he showed the video being, "To get us interested." Similarly, in another cogenerative dialog thread, Kelly's connection to another aspect of their science program about human reproduction enabled Mr. G. to confirm that he was trying to tie it to the life cycle of plants that they have been studying across several science lessons.

Discussion

Video clips can afford access to science knowledge not possible in the classroom either due to the sophisticated equipment required or the field nature of the content being presented. They can also provide ideal opportunities for developing epistemological understanding by drawing attention to the nature of science investigation, learning the skills of critiquing evidence, evaluating the reliability of the evidence presented as well as the evidence-based logical argumentation. Given the examples in nature, it is not always practicable to conduct a field trip for reasons including that examples of different types of seed dispersal take place at different times of the year.

Specifically, we are interested in how the showing of video clips in a science classroom fosters science as a way of thinking or habit of mind that forefronts dispositions of curiosity, creativity, and critical thinking. In this example, it appears the clips were used to encourage discourse and argumentation in the class similar to McNeill and Pimentel (2010).

Example 4: What Does the Teacher Want us to Notice?

Description of the practice

In conjunction with the practical work on seed dispersal the teacher posed questions, such as in the seed dispersal unit of work, "Now that you know how birds disperse seeds if you were an orchardist, for example, a cherry grower how would you protect the ripe fruit from birds?"

Student perspective

The students said they liked it when they were given a question on the board, to think about rather than having to complete a worksheet as they watched the video; for example, Mike said, "when you are asked to think about how wind pollination is the same as or different to insect pollination, then I have to really think about what the teacher wants me to see while watching the video."

Discussion

Video clips can also be used to generate questions and as a starting point for inquiry aimed at generating curiosity about science concepts and their application to daily life. In another example, when showing the video about human childbirth that these adolescents were uneasy about, the teacher followed it with a short clip of an elephant birth video from a zoo. The question he wanted them to consider was, in what ways the two births were similar and how were they different. This led to students commenting on the fact that the human mother had the support of three adults during the birth process whereas the mother elephant did not have the support from "sister elephants" that she would have had in the wild. Students also engaged in conversations about the concrete ground on which the mother elephant delivered the baby and how she had to break the amniotic sac herself, which in these students' view was "a very stressful situation." In the lesson after the reproduction videos, the teacher referred back to the elephant birth video to set students the group task to prepare for a debate about whether it is good to have zoos. Such opportunities afforded students time to discuss, summarize, argue and debate the pros and cons of having animals in zoos, an ideal opportunity to consider socio-scientific issues and enhancing their scientific literacy while learning about the positive conservation role that modern zoos have.

Example 5: Can we Delve into This Video Clip?

Description of the practice

The teacher used a variety of genres of video clips including straight documentaries as well as humorous shorter clips sourced from the web. The developers of the video clips were not necessarily educators but rather might be described as being engaged in eco tainment (Kearns et al., 2016).

Student perspective

From the students' perspectives, while they appeared to be aware of the range of reasons that a video might have been made, they saw that information on the clip was not always aligned with an educational purpose. For instance, commenting on the YouTube clip about seed dispersal, Tim observed that he did not think that it was really made for educational purposes because of the way in which the information was presented as "quick fired" so as "to hook" the viewer in, while John suggested that it was not designed to be "delved into" in detail, but "it was like prime movies where they don't even tell you but just preview it" such as shorts of upcoming full-length movies.

In general, the students agreed that they did not want to view what they categorized as a "YouTube type of video clip." In their view, such clips were fast, loud and tried to give too much information in one clip. Students appeared critical of such delivery because it constrained their opportunities to engage with the scientific ideas being presented. For example, Kelly explained that for her there was too much information in rapid succession, a common sentiment expressed by other students during cogenerative dialog. Matt suggested that shorter formatted clips did not allow enough time to develop detailed scientific explanations such as in some YouTube clips. Further comments made by other students expanded on the problem of being bombarded with words and the impact on their concentration, as explained by Kelly who felt that the speed at which the facts were presented did not allow her to process them. In contrast, they liked short clips of "our world" type of video programs where knowledgeable scientists explained science concepts in easy to understand language.

Discussion

As researchers, we were surprised at how strongly the students felt about the quantity of information on some videos that they found overwhelming because of the density and speed at which it was presented. The cogenerative dialog conversational threads about video clips were contradictory. Here they are referring to the purpose that the developers of the video had to inform their perceptions.

Example 6: What do you Need to Remember from the Video?

Description of the practice

In unpacking his purposes beyond the motivational, the teacher asked whether students thought it was information that they needed to remember.

Student perspective

The students concluded that it was not information to be remembered, but suggested that it was "just facts," "just to recap," and "relevant but not really necessary." They could recognize the relevance to what they had been learning and the teacher's purpose in showing them the clip.

Discussion

This example illustrates the idea of the connectedness of scientific knowledge.

Azra Moeed continued this thread by wondering why "there was a need to try and do that." Kelly's explanation, "we just did the life cycle of plants so we can think about it in the same sort of way so we can go "oh that's what's happening with plants that are happening with humans" ah I get it" proved to be a key moment in students' making connections.

Considering the content, students saw that these videos offered a better option than textbook explanations. What is interesting about this example is that the childbirth episode from "The Human Body" was followed without any pause by the YouTube clip on elephants with no opportunity for discussion in between the two clips. Rather than just using them to illustrate reproduction, in the discussion following the viewing of the video clips the students were challenged to think about the similarities and differences between the two clips. In this instance, the cogenerative dialog had been a useful way to unpack the teacher's pedagogical purpose in showing the video clip and provided an opportunity for students to realize the connectedness of the scientific knowledge of life cycles as well as appreciate the purpose in showing a specific video.

These examples illustrate the complexities between the developers' and end-users' varying purposes for a video as a cultural artifact. Cowie The context also incorporates macrostructures of this era of Web 2.0 multimedia that mediates teachers' and students' engagement with video clips in a classroom setting. We suggest that video clips have the potential to foster science as a habit of mind by affording broader access to scientific ideas and current debates, as well as generating an understanding of the empirical nature of science knowledge. In addition, they afford access to episodes in nature not easily represented in textbooks or through practical work.

Example 7: Is this Viewing Session too Long?

Description of the practice

The teacher was curious to know the students' views on the optimal length of a video in response to the question, "is this viewing session too long?"

Student perspective

When asked, students had different impressions of how long the video that they had just viewed was, suggesting between 10 and 20 min. There appeared to be a consensus that students preferred to watch shorter video clips, regarding a 20-min video as too long for them to hold on to the ideas introduced, as well as hold their questions until the video finished.

Students' perception of the length of a video appeared to be unrelated to the actual length. For example, students were unsure of how long the short video was and guessed anywhere from 45 s to 3 min. What mattered for them was that it felt like it was rushed. On another occasion, Azra Moeed asked how long they thought another video clip was to which Kelly responded 10 min. After no one else offered a guess she commented, "Arghhhh that's interesting, anyone else how long do you think it was." Azra's probing spiked overlapping guesses among Mike, Tim and Robbie of 5 min or as Mike commented "5 or 3 it was really short." John interestingly commented, "There was this introduction" implying that the introduction was long.

Discussion

Contradictions arose in discussions about how long the viewing sessions actually were. Perceptions of length perhaps overshadow the actual length of the viewing and suggest that the density of the content and the form of the production complicates students' judgments. It is worth noting here that none of the clips the students were commenting on during cogenerative dialog were longer than 10 min, with most between 2 and 5 min.

Example 8: How do you Prefer to Watch it?

Description of the practice

During one cogenerative dialog the teacher and the researchers explored the strategy of how to sequence the viewing session, so there were opportunities to review sections before moving to another aspect. The teacher, Mr G., probed students for more specifics by asking: Someone mentioned about the length of a video so let's say I had a 30-min video that I think is going to be quite good for you umm how would you prefer to watch it? Sensing perhaps that Kelly's position was slightly different to the other students the teacher asks if anyone agrees with her.

Student perspective

The cogenerative dialog discussion highlighted that the length of the video clip was relevant in terms of how it might be sequenced. All students participating in the cogenerative dialog agreed that recapping the content of the video was an important strategy and wanted the teacher to stop the video more often and allow time for discussion that some found useful for picking up ideas that perhaps they had missed in the original viewing. Students wanted to stop after each example of animal pollination, for instance, insect pollination and pollination by monkeys. John suggested watching a video with one break part way through to recap key points. He commented that pausing a video more often might be distracting. Later, Kelly suggested pausing after viewing the video to note what they had picked up. Robbie suggested viewing all at once; with Ann adding that viewing a video in sections can be problematic for concentration and retention of their interest. Kelly pointed out that watching in one go is better if it is a really short video providing lots of information because if it was longer, she could not concentrate, had trouble remembering all aspects, and did not have time to process it.

Discussion

A key issue that emerged from the cogenerative dialog discussion was how a video viewing session is structured best in terms of promoting the learning of science. Here, we are thinking of structure in terms of content, length, and videographic techniques employed. We acknowledge that there will be differencing thoughts among different groups of students. This brings our attention to the teacher's role in structuring viewing sessions to enact the students' ideas about chunking the viewing of clips to enable them to ask questions as they arose. This question about sequencing the viewing is particularly interesting as the teacher's practice was to stop after showing the various forms of, for example, animal pollination, before stopping for discussion at the end.

In navigating distracting videographic features that have the potential to subsume scientific knowledge it was important to the learners how the teacher broke up the viewing of the video so as to emphasize key parts or highlight scientific concepts and to manage the amount of information and videographic distractions to optimize their capacity to concentrate on the science. Through organizing and focusing on particular aspects of the video before the viewing, the teacher explored ways to direct the students' attention to more scientifically useful parts of the video. The role of the teacher in generating structures enabled viewers (the students) to navigate between the interconnected purposes of entertainment and information sharing as well as making connections between aspects of science presented through other modes of the program. This is particularly important where clips are dense with information and light on scientific explanation.

Over the duration of the study in response to the cogenerative dialogue conversations, the teacher adjusted his practice by cutting the longer videos into shorter chunks and by checking his use of YouTube formatted video clips. The example of the two reproductive video clips shown together, however, highlights that depending on the pedagogical purpose for the session, formatting viewing sessions need to be responsive to the context.

CONCLUDING COMMENTS

Mediating collective viewing sessions and associated discussion in the classroom is an important part of a teacher's role (Otrel-Cass et al., 2011). Central to this role is the structuring and restructuring of the learning environment to embrace inquiry, curiosity and critical thinking (Lawson, 2009; Luce and Hsi, 2015) to mitigate the features of the clip associated with embedded and perhaps contradictory educational purposes of the developers of the video (Pace and Jones, 2009). Here, we have shown the complexities of using video as an instructional approach to teaching secondary school science. We have taken the stance that pedagogy is embedded in the learning context to explore our research focus; what are the key dimensions of fostering science learning from video clips? We have also used cogenerative dialog to gather multiple perspectives from students, their teacher and the researchers (Bayne and Scantlebury, 2012). There was considerable influence on teacher practice due to participation in cogenerative dialog. The teacher listened carefully, considered what the students were communicating about their learning and changed his practice to implement students' suggestions. At times he presented his reasons for teaching in a particular way and was comfortable in taking onboard student responses. The outcome was a change in teacher practice and enhanced teacher-student relationships. It seemed evident that students were interested in their learning and in engaging in activities that the teacher presented once they knew the teacher's reasoning behind the activities. For the teacher, there were pedagogical opportunities to engage students to think in creative ways about the material presented to them. Students became more independent as learners than they were at the start of the topic. There appeared to be a change in the classroom culture showing a change from student expectations of the teacher providing information to students being more engaged, informed and in control of their learning.

The study has a number of potential benefits:
1. For teachers: Understanding and informing practice about the use of a reflective process that incorporates student perspectives that enhance student engagement in science learning;
2. For researchers: Understanding and informing practice within teacher education;
3. For the wider education community: Describing and understanding factors that impact on student engagement in science learning.

The study raises implications for teacher education, namely, what expertise do teachers need to use video as instruction? The purpose and form of the video were shown to potentially undermine video as an instructional approach by obscuring the scientific ideas. Cogenerative dialog can provide a means for teachers and students to consider and generate local knowledge of what such teacher expertise might look like for their setting.

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