Framing a topic: Mobile video tasks in museum learning

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Abstract

This study explores the conceptual framing work of a group of upper secondary students as they first collaborate to understand a particular science museum exhibit, and then relate aspects of the exhibit to a larger scientific principle. The task involved producing a video of the groups' explanation to a problem using a mobile device. Applying methods from interaction analysis we examine how the group accomplishes and performs conceptual understanding. The analysis shows the indexical affordances of video as medium in the setting, allowing students to use the exhibit as a visual and physical prop in the film to explain scientific concepts. Moreover, we found that the students' conceptual work was conducted in advance of making the video, and that making the video entailed collaboratively actualizing understandings previously accomplished in the group. Based on our findings, we propose that video tasks may be a productive way to 'frame topics' and orient students to disciplinary aspects of museum exhibits.

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1. Introduction

As museum visitors increasingly produce and share media content using mobile devices, educators and researchers are studying how new media practices are intertwined with visitors' learning and engagement with museum exhibits, narratives and artifacts. From the perspective of digital literacy (Buckingham, 2006; Group, 1996; Jewitt, 2006), studies in museums show how taking and editing pictures, making videos, and writing text for cultural-specific social media platforms involves cultural competence, creativity and dialogical skills. New forms of engagement also emerge when visitors use InstaGram to 're-curate' exhibit themes for an intended audience of friends (Weilenmann, Hillman, & Jungselius, 2013), or use Twitter to create an interconnected opinion space that requires joint attention to physical and ambient aspects of communication (Charitonos, 2011; McCullough, 2013).

In the learning sciences, there is interest in how the performative and interactional aspects of producing different kinds of media content may be translated into pedagogical designs for specific formal and informal learning settings (Charitonos, 2011; Pierroux, 2009; Pierroux, Krange, & Sem, 2010). Numerous mobile learning projects have been developed for school field trips to museums and science centers (Frohberg, Göth, & Schwabe, 2009), many of which include functionality for students to record videos. The activity of producing digital videos has been found to have many positive features, promoting students' creative and active learning (Loveless, 2002), and increasing disciplinary talk and social interactions among students (Goldfarb, 2002). Studies report that students gain an increased feeling of responsibility for the final outcome and that the learning experience is seen as rich, authentic and memorable (Kearney & Schuck, 2006). A number of studies in museums have analyzed final videos, and how students use these in post-visit learning activities in classrooms (Hsi, 2002; Moland, 2014; Pierroux et al., 2010; Vavoula, Sharples, Rudman, Meek, & Lonsdale, 2009). However, less attention has been paid to the actual process of producing videos in the museum space, and how “task and tool” may be matched to support interactions with exhibits in ways that are productive for students' learning (Lund & Rasmussen, 2008;...
Worksheets and video tasks

Extensive research has been conducted on school field trips to museums (DeWitt & Storksdieck, 2008), an educational practice that contains both formal and informal aspects of learning (Bonderup Dohn, 2011). Findings from the field trip literature tell us that choice is essential for engaging students' interest and motivation (Bamberger & Tal, 2007), and that students learn best when guided by a clear agenda and scaffolding that supports knowledge integration across contexts and over time (Falk, Moussouri, & Coulson, 1998; Steier & Pierroux, 2011). Paper-based worksheets are one 'mobile' means of orienting students to a disciplinary domain in a museum setting, and this widely used approach has been shown to produce modest learning effects (Mortensen & Smart, 2007). Worksheets are shown to be most effective when the tasks provide a moderate amount of structure, intermediate levels of support (Bamberger & Tal, 2007), and are combined with opportunities for students to freely explore an exhibition (DeWitt & Storksdieck, 2008). In an analysis of 12 worksheet types, Kisiel (2003) identified eight characteristics that have implications for students' learning: task density, orientation, level of choice, level of development, site specificity, information source and response formats that may be written/non-written and verbal/non-verbal. Mortensen and Smart (2007) used these characteristics to develop 'worksheet design criteria' that reflected a free-choice learning perspective (Falk & Dierking, 2000). They recommended open-ended tasks that allow students choice in where and how to solve them, and which foster group discussions and shared object observations. Also, worksheets should offer a variety of response formats, and focus on conceptual thinking rather than gathering facts. The structure of the activities in this study was designed based on these and other findings in field trip research, characterized as a guided exploratory learning approach (Hauan & Kolstø, 2014).

In recent years, there have been numerous studies of ways to integrate museum learning research, effective worksheet designs, and mobile applications for field trip use, often modeled on inquiry learning perspectives that prompt students to develop scientific questions and hypotheses, make observations, collect evidence and communicate findings (Frohberg et al., 2009; Marty et al., 2013). The option of making videos using cameras in mobile devices is often included in the educational design of such 'multimodal worksheets.' In the MyArtSpace project (Vavoula et al., 2009), students were encouraged to take pictures, write notes, and record short video clips that were accessed and annotated on a website in post-visit learning activities. In the Gidder project, a mobile blogging function was integrated in a wiki-based learning environment that contained interpretive tasks and curated information for art museum field trips (Pierroux et al., 2010). Both studies found that producing videos deeply engaged students in interpreting art in the museum, and that these interpretations fostered further disciplinary engagement in post-visit classroom activities (Moland, 2014).

Video-making tasks require literacy skills related to documenting, organizing and presenting information about an event. Weißenmann, Säljö, and Engström (2013) applied interaction analysis methods in a study of young people learning to produce videos in a science center. They found that while the participants struggled with both the technology and what to display in the videos, the problems they encountered prompted discussions and solutions that fostered learning. In a different setting, a study looked at how nurses at a Swedish hospital videotaped the use of technical equipment for knowledge sharing. The study showed that the process of producing video material for other nurses shaped and strengthened participants' arguments of how to do a particular procedure (Brandt, Hillgren, & Björvgvinsson, 2004). These studies suggest that producing videos in situ can support what Engle and Conant (2002) termed productive disciplinary engagement across learning contexts, that is, actions and talk that include terms and concepts from a discipline or subject matter. Interestingly, a recent study found that video is the least used media type for user-generated content in such location-based learning applications (FitzGerald, 2012). Moreover, there have been relatively few studies of how tasks involving the making of videos in museums and science centers may frame and support students' learning. Our study thus contributes to research on students' learning when making in situ video productions, and on how conceptual understanding develops through embodied interactions in a science center exhibit.

3. Perspectives on conceptual understanding

Our investigation of how students co-construct conceptual understanding in a science center is grounded in sociocultural perspectives, which entail the study of human interactions as situated in and mediated by tools and language in particular cultural, historical, and institutional settings (Vygotsky, 1978; Wertsch, 1991). In science museums, students' interactions are thus understood as mediated by a range of semiotic resources that may include worksheet tasks but also language, gestures, gaze, exhibits and digital technologies. The potential to combine resources with diverse properties expands the repertoire of possible actions for participants to engage in, for example, solving learning tasks (Streeck, Goodwin, & LeBaron, 2011). Goodwin (2000a) describes this realm of possible actions...
as embodied participation frameworks, which implies that a group of people develops a mutual orientation toward particular events or objects. They "create local environments where participants can treat each other as attending to, and working together within, a shared world of perception and action" (Streeck et al., 2011). Within this shared world, participants use and elaborate multiple resources to foster intersubjectivity and shared orientation, e.g., supplementing talk with pointing gestures to visible structures in the environment (Goodwin, 2000b). Note that these kinds of frameworks are not communicative in themselves. Rather they form an environment from which actions emerge and are situated within. They are built and sustained by the visible actions of participants that occur within the framework, making them open to challenge, negotiation, and modification.

In the learning sciences, interactional perspectives are applied to study how students learn about scientific concepts, and to gain insight into the dynamics of how groups achieve convergence in conceptual understanding (Roschelle, 1992; van de Sande & Greeno, 2012). In their study of participants’ cognitive processes in a non-digital environment, van de Sande and Greeno (2012) explored how convergence in conceptual understanding is accomplished. Building on the work of Goffman (1986), they suggest the notion of framing as integrating interactional and information aspects of activity. Van de Sande and Greeno distinguish between positional framing, which attends to how participants assume the role of source or listener in problem-solving discourse, and conceptual framing, which describes the unfolding alignment work of participants to achieve conceptual understanding in a subject matter domain. As shown in related studies (Arnseth & Silseth, 2013), an important aspect of achieving conceptual alignment work is participants’ previous knowledge and initial conceptual understanding as they engage in conversation to formulate questions, hypotheses and explanations in a new setting. The importance of students’ previous understandings and experiences when challenged in new settings is highlighted by Greeno (2006). Previous knowledge is apparent in the authoritative and accountable positioning by students who have “developed a participatory identity with strong conceptual agency while learning concepts and methods in a subject-matter domain” (Greeno, 2006, p. 539). In this perspective, persons with conceptual agency are thus expected to be able to “move about the environment freely, with access to resources throughout the environment and with the authority to use, adapt, and combine those resources in unconventional ways” (Greeno, 2006, p. 539).

In our approach, we acknowledge the institutional framing when classes of students visit museums on field trips, while focusing on the embodied and situated character of the students’ interactions. An attention to the embodied character of interaction allows us to address ways in which the students’ talk and orientations are intertwined with the material environment, while “conceptual framing” (van de Sande & Greeno, 2012) allows us to analyze how students understanding of science develops during interaction. This theoretical framework directs analytical attention to what the students see as relevant information in the museum situation, and how they frame and reframe a problem based on new information. While van de Sande and Greeno (2012) present conceptual framing as part of a larger theoretical proposal, we apply this concept in an analysis of how students orient to particular aspects of a problem, and how they organize and make sense of various sources of information to construct a scientific explanation that will be performed in a video.

4. Research design

The research questions are explored through a case study of a class of upper secondary students visiting the museum as part of a 3-week course in science dealing with both scientific and socio-political aspects of energy. This section describes the visit, the design of the video application, and the museum context. We also provide an overview of the data material collected and outline our approach to transcribing and analyzing the data.

Energy Transfer (heading)

Solve the problems by making a short video (maximum 3 minutes). In addition, you may take pictures and make notes.

Use the solar exhibit and other resources in the energy exhibition to explain why energy cannot disappear or come into existence, but only change form.

When you are ready, push the button to start the recording.
4.1. The mobile video application

The mobile video application was designed for pre-visit and post-visit classroom activities as well as for the museum setting. The overall aim was to foster students’ (16-18 years old) disciplinary engagement with science, with energy as the main topic. The mobile application was designed for iPod use in the museum setting with three tasks to choose from, all of which involved making short videos that presented solutions to a problem. Upon completion, the videos were uploaded to SciWork, a web-based platform for sharing and reflecting on different kinds of digital content. When students were back in the classroom, the teacher chose videos to play for the whole class and discussed issues that were relevant to the curriculum. The videos could also be revisited and included during other activities. However, focus in this study is on the museum context.

The task that the students are working on deals with energy transfer. The topic was part of the class’ curriculum and was discussed in lessons prior to the museum visit. A screen-shot of the task description and a translation is shown in Fig. 1.

There are three features of the problem formulation that are worth pointing out. First, the problem requires students to illustrate a scientific principle by applying it to an exhibit dealing with solar panel technology. This is not a trivial assignment, in that the museum exhibit illustrates a specific process of energy transfer—how a solar panel works—using a carnival game analogy, where participants model electrons bouncing off a Silicon atom by ball-throwing and point-scoring. A second noteworthy feature of the problem is the partial solution written into the formulation, which serves as a prompt for generalization, i.e., the statement “energy does not disappear or come into existence but only changes form.” Finally, since the task requires groups of students to produce a verbal explanation, there is an implicit aim to develop students’ ways of talking and thinking about relations between exhibit components and the subject matter domain (Greeno, Collins, & Resnick, 1996).

The iPod application is used in the following way: First, the students choose one of three tasks, bringing them to the next screen with the task description. Having read the task, and when ready, they start the recording by pushing the button which automatically starts the video recorder. When done with the recording, the students may watch the video, and then decide whether to upload it to SciWork or discard it. There is no functionality for editing the videos, so if the students are not pleased with the result they need to make another one. It is, however, possible to upload several videos to the SciWork workspace and then delete some of them when back in the classroom.

The science museum visited by the class is one of the largest museums in Norway. One part of the museum is a science center that contains more than 20 interactive exhibits, all dealing with various themes in science and technology. At the time of this study, the solar energy exhibit was a prototype located in the science center. As mentioned, the solar energy exhibit is a game where participants throw yellow balls at a representation of a Silicon atom. Every time one of the electrons in the outermost shell is hit, the electrons take off to the right and the game score increases by one. The goal of the game is to get as many hits as possible during a period of 30 s. At the end of the period, the total score is displayed, as well as a text presenting the highest score of the day. Before the game starts, a short introduction explains the basics principles of solar panel technology. A more thorough description of the exhibit can be found in Fig. 2a–d.

Fig. 2. Solar panel exhibit.
4.2. The museum visit

The museum visit lasted for 3 h and involved different activities. The first was an introduction to the topic of energy given by the museum staff. The students were then divided into groups of seven to eight students in which they explored three different exhibits, followed by a short session where museum staff asked questions regarding the exhibits. During the 3 h spent at the museum, the last 50 min were devoted to the activity of solving the three tasks using the mobile video application, with students divided into groups of four. Researchers documented all activities in the museum using video cameras. Other data collected were field notes and photos, and videos and photos produced by the students during their visit. The data collection resulted in a total of 12 h of video recordings, with a total of 3 h and 20 min of video in which students are using the video application.

4.3. Analytical approach

In line with previous research on situated interactions, this study acknowledges the emergent properties of action, meaning that its “not predetermined, but neither is it random” (Suchman, 2007, p. 177). A basic research goal is thus “to explicate the relationship between structures of action, and the resources and constraints afforded by material and social circumstances” (Suchman, 2007, p. 177). From our sociocultural learning perspective, this entails paying close analytical attention to participants’ discourse and interactions with various material artifacts, focusing on how these become relevant as resources for the students. This implies focusing on what is being said, but also on participants’ orientations in space, their gestures, and interactions with various artifacts. The notion of conceptual framing is used to study how students orient towards different parts of their environments, and to analyze how their learning develops in this process.

4.4. Transcriptions

The data are presented as five episodes. The episodes are transcribed using notation building on Jeffersonian conventions (Jefferson, 2004) (see Appendix A). The non-verbal interactions seen as relevant for the students’ interactions are included. To communicate the embodied character of the students’ video-making activity, the last episode is presented using an illustrated transcription, with frames captured and rendered from the video. This transcription approach is used to graphically illustrate how talk, gestures and the physical setting become resources in the students’ video production (Lymer, 2009; Steier, 2014). Students’ names have been changed by the researchers.

5. Analysis: Making a video about energy transfer

The following excerpts will show how a group of four students solve the video task dealing with energy transfer (Fig. 3). The group of students has already worked together on a similar task in school, where they used iPods for documenting and explaining small experiments. The energy transfer problem is the first of three tasks they are required to solve. When the first episode begins, the students had already visited the solar energy exhibit together with another group.

![Fig. 3. The group in front of the solar panel exhibit. From left to right: Clara, Jenny, Andrew and John.](image-url)
The data material presented consists of five consecutive episodes of interaction. The first four episodes show how the students discuss the workings of the exhibit and relate it to the problem posed in the task. The last episode, which occurred at the very end of the activity, shows the students’ interactions while making the final video product (Fig. 4).

5.1. Episode 1: We get heat energy from the sun, right?

The first episode starts a few seconds after the group has arrived at the solar panel exhibit. John (with his back against the camera) is holding the iPod in his hands (Fig. 3). Before arriving at the exhibit, Jenny was reading the task out loud to the rest of the group.

1. **John:** (holding the iPod) we are supposed to explain why energy is not disappearing
2. **Jenny:** ok
3. **John:** or (gazing at the iPod) why energy can disappear or come into being, but only change form
4. **Andrew:** what did you say. let me see. I also need to have a look (takes the iPod out of John’s hands, then gazes down at it)
5. **Jenny:** (4.0) okay (.) anyone starting
6. **John:** yeah (.) first (takes a step toward the exhibit and picks up a ball) we get heat energy from the sun (.) right (facing and looking at Andrew)
7. **Andrew:** (moving his gaze from the iPod to John) yeah right
8. **John:** or no (.) heat energy (turning his head toward the exhibit immediately followed by Andrew doing the same thing)
9. **Jenny:** yes
10. **John:** and

In this excerpt, the students start their work by John reading the task out loud (turns 1–3). Jenny initiates further action by saying “okay” and then “anyone starting” (turn 5). John responds to Jenny’s request by picking up one of the yellow balls and saying “we get heat energy from the sun (.) right” (turn 6). Holding the yellow ball in his hand, he articulates a general fact about the sun and then orientates himself toward Andrew for confirmation. Andrew concurs but John immediately hesitates by uttering “or no”, and then “heat energy” before he turns around toward the exhibit and utters a prolonged “and” while gazing at the screen (turns 8–10). Immediately after John turns toward the exhibit, Andrew does the same thing.

The excerpt shows how the students initiate their work by reading the task description and the problem formulation on the mobile device. Without any further planning of their activities, John takes a first step toward explaining what the exhibit is about. His initial focus is on the yellow ball in his hand, and he conceptually frames the exhibit to be about heat energy. While this framing is understandable, heat energy is not a scientific principle that can explain solar panel technology. Nevertheless, it is clear that the students at this point start engaging with the exhibit and the subject matter using the kind of disciplinary talk that characterizes productive disciplinary engagement (Engle & Conant, 2002; Kumpulainen, 2014; Mercer & Wegerif, 1999). Toward the end of the excerpt, the exhibit once more becomes the center of the students’ attention, as John says “or no” (turn 10) and then turns toward the screen.

5.2. Episode 2: Energy is created

This second episode is a direct continuation of the previous one. All students are now oriented toward the exhibit.

1. **Andrew:** (looking at John) particles from the sun
2. **John:** yes
3. **Andrew:** are sent to earth
4. **John:** when we hit (pointing his index finger toward the exhibit that displays the representation of a silicon atom) e::hh (.) (making circular gestures toward the exhibit) [those electrons]
5. **Andrew:** [the electrons]
6. **John:** then we transfer [the energy from here] (pointing to the ball in his hand)
7. **Andrew:** [then we set it in motion]
8. **John:** then energy is transferred from here (pointing to the ball in his hand)
9. **John:** [to the electrons] (pointing to the exhibit)
10. **Andrew:** [to the electrons]
11. **Andrew:** and sets the electrons in motion
12. **John:** yes which then creates-
13. **Andrew:** and in that way =
14. **John:** one creates
15. **Jenny:** [because it creates energy]
16. **Andrew:** [we create energy] (.) electrical energy

In this episode, the students’ focus is on collaboratively articulating an explanation for the workings of the solar panel exhibit. Andrew first states that particles from the sun are sent to earth (turns 1–3), and John continues by pointing to the representation of the Silicon atom while explaining how “we” hit “those electrons” (turn 4). The two students then, partly overlapping and building on each other’s utterances, collectively construct an account of how energy is transferred from the balls to the electrons, which then sets the electrons in motion (turns 5–11). Finally, in turns 12–16, John, Andrew and Jenny all state that the act of hitting the electrons results in energy being created.
The excerpt shows how parts of the exhibit become resources for the students when they talk about solar panel technology. In turn 4 John points to, and then gestures toward the exhibit. He uses indexical references when talking about transferring energy from “here” while pointing to the ball in his hand (turns 6, 8), and then pointing to the exhibit while saying “electrons” (turn 9). The students’ orientation to the exhibit creates a shared world of perception and action for the participants (Goodwin, 2000b; Streeck et al., 2011). Their interactions with the material, semiotic affordances of the exhibit create an environment within which talk and gestures can flourish (Streeck et al., 2011). A second theme is how the participants converge on a mutual conceptual framing of the exhibit. Andrew and John explore relations between components in the exhibit to co-construct alignment in what may be seen as a coherent conceptual framing (Greeno et al., 1996), converging on the understanding that “energy is created.” This can be seen in the last four turns that start when John says “which then creates” (turn 12) and ends up with Andrew concluding that “we create energy (.). electrical energy” (turn 16). Toward the end of the excerpt, it becomes apparent that Jenny is also listening in, and that all three students converge on the mutual understanding of how “energy is created.”

In summary, the excerpt shows three things: the dialogical and collaborative aspects of achieving a common understanding of the science communicated by the solar panel exhibit, how the physical components of the exhibit become resources for talking about solar panel technology, and finally, how the three students converge on an explanation of how “energy is created.”

5.3. Episode 3: Energy is transferred

The third excerpt is a direct continuation of the previous episodes. It starts when Clara, who up to this point has not said anything, objects to the group’s conclusions that energy is created.

1. **Clara:** no (raising herself up on her toes) energy cannot be created
2. **John:** (looking at Jenny) yes one creates electrical current
3. **Jenny:** kidding (pointing her pen at John)
4. **Andrew:** (looking at Clara) no but we transfer energy
5. **John:** yeah that is-
6. **Jenny:** we transfer yes we do not create (turning toward John) we transfer
7. **John:** we transfer energy and then we create electrical current
8. **Andrew:** right

The last utterance in the previous excerpt was Andrew stating that: “we create energy (.). electrical energy” (turn 16, episode 2). When Andrew is about to end this statement, Clara stands up on her toes and says “no energy cannot be created” (turn 1). This intervention first spurs an initial respond from John, Jenny and Andrew (turns 2–4). An alternative explanation is then developed and summed up by John in turn 7. Andrew acknowledges this with a “right” (turn 8).

In this episode, a shift in the students’ conceptual framing takes place. While the previous episode shows how Andrew and John collaboratively produced an explanation for how energy is transferred from the sun to the electrons, resulting in the creation of energy, Clara in this excerpt disagrees with this conclusion by referring to a scientific principle, namely that “energy cannot be created” (turn 1). In doing so, she reframes the students’ initial understanding of the exhibit to become more aligned with the scientific concept of energy transfer. The group’s shift in understanding becomes apparent as John, Andrew, and Jenny adjust their previous explanations to align with Clara’s more precise conceptual framing. This can be seen in turns 5 to 8. First, John shows agreement with Andrew’s statement that “we transfer energy” by saying “yeah” (turn 5). Then, Jenny not only acknowledges, but reformulates what Andrew and John said, focusing on the distinction between creating and transferring: “we transfer yes we do not create we transfer” (turn 6). John then builds on Jenny’s statement by linking it to his clarification in turn 2 by saying that “we transfer energy and then we create electrical current” (turn 7). Here John makes a distinction between the terms energy and electricity, and transferring and creating, thus clarifying their meaning in relation to the exhibit. Moreover, he sets them in a causal relationship: “[First] we transfer energy and then we create electrical current.” Finally, Andrew shows agreement with John’s statement by saying “right” (turn 8). That John, Andrew and Jenny were able to quickly align their understanding with Clara’s more precise explanation indicates that their conceptual framings were nonetheless sufficiently aligned to make the difference meaningful to all of them (Greeno et al., 1996).

5.4. Episode 4: Why energy cannot disappear or come into existence

The fourth episode starts about 10 s after the previous one. It shows how the students return to the mobile application and the problem they are asked to solve. As we enter the excerpt, Andrew is staring at the iPod he is holding in his hand.

1. **Andrew:** (has been looking at the iPod in his hand, now moving his gaze from the screen to John)) but (.). but but but but
2. **Jenny:** but
3. **Andrew:** (looking down on the iPod in his hand) why energy cannot disappear (looking up onto John)
4. **John:** because it’s transferred to- (pointing to the exhibit)
5. **Andrew:** because it’s constantly transferred isn’t it (.). right
6. **Jenny:** yeah ok
7. **John:** and why it cannot come into existence (.). well that’s because (.)
8. **Jenny:** transferred maybe
9. **John:** no isn’t it because the sun is (.) everywhere (.) and the sun is the main source (.) to: energy
10. **Jenny:** ye:ah
11. **Andrew:** we have three main sources
   ((8 turns not included))
12. **Andrew:** earth’s interior (.) wind (.) and the sun
13. **John:** we’re also in a way a type of energy (.) we are heat energy
14. **Andrew:** yeah but you get the energy by eating food right (.) you are not (.) you are not like-
15. **John:** yes (.) I am energy
16. **Andrew:** haha ((laughing)) but we have to make a film

In this episode, there is a shift in attentional focus, as the students return to the problem they are asked to solve: “Use the solar energy exhibit and other resources in the energy exhibition to show why energy cannot disappear or come into existence, but only change form.” The excerpt starts when Andrew orients the group’s attention to the problem formulation. In turns 1–6, the students answer the question “why energy cannot disappear.” John points to the exhibit and says “because it’s transferred to” (turn 4), which prompts Andrew to say that it’s “constantly transferred” (turn 5). In turns 7–15, they discuss the second part of problem formulation that deals with why energy cannot come into existence. John first suggests that this is because the sun is the main source of energy (turns 7–9). Then, in the exploratory talk that follows, Andrew lists three main sources of energy (turn 12), to which John adds a fourth (turn 13). Finally, Andrew laughs and says that they have to make a film (turn 16).

This excerpt shows the structuring role of the task description and how the problem formulation becomes a resource for thinking about solar panel technology in terms of general scientific principles. The structuring role of the task takes two forms: one relates to the scientific topic, the other to the activity. On the level of the topic, the formulation of the question becomes a resource for orienting the students’ attention to how a general scientific principle, energy transfer, relates to the particular exhibit at hand, thus providing a link between the general and the particular. This can be seen in turn 5, when the problem formulation helps Andrew to make this kind of link. In response to John’s reference to how energy transfer happens in the exhibit (turn 4), Andrew says that energy cannot disappear “because it’s constantly transferred isn’t it” (turn 5). While John talks about the particular case of the solar panel exhibit, Andrew is not referring to the exhibit, but to energy transfer in general. On the level of the activity, Andrew brings the group’s attention to the task of producing a short video, when he ends the discussions regarding types of energy by saying “but we have to make a film” (turn 16). While the previous episode displayed how the students aligned their conceptual framing of the solar panel exhibit, this episode shows how the video task now becomes a resource for discussing this understanding in relation to a general scientific principle.

5.5. Episode 5: Making the video

The last excerpt shows how the students make the final video product. At this point, the students have already attempted one video, but due to technical problems they need to make another one. As we enter the excerpt, the students are about to start the shoot. Clara is in charge of the iPod while the rest of the students are in front of the camera. Andrew and Jenny have picked up a number of balls that they are now holding in their hands. A graphical rendering of the students’ video-making activity is presented below (Fig. 4).

In this excerpt, the students fulfill their assignment by producing a short video. Clara has positioned herself with the camera and initiates the activity when saying that she is ready (panel 1). Then, John, Andrew, and Jenny collaboratively describe how the exhibit works and explain what the different parts of the exhibit represent (panels 1–2). After a short sequence of ball-throwing, Jenny prompts John, who then relates the science of the exhibit to the question of why energy does not come into existence (panels 4–6). Finally, Jenny adds that what happens in the end is that electric current is produced and then signals that the shoot is over by saying “done” (panel 6).

The excerpt shows the group’s conceptual alignment, how making the video is a collaborative accomplishment through a coordinated division of labor, and how different parts of the solar panel exhibit become resources for the students’ live performance in front of the camera. Throughout the excerpt, John is the ‘lead actor,’ while Andrew and Jenny contribute with additional information that gives direction to what is being said. The students’ actions are highly coordinated as can be seen in panel 1, where John refers to the balls which are then lifted up by his fellow students. Jenny’s contributions are important, keeping the performance on track and steering utterances to align with the key understandings they have reached during their previous interactions. Serving as interviewer, she prompts John to expand on his explanation by asking a question about what the exhibit demonstrates (panel 4). She confirms the link that John makes to a general scientific principle (panel 5), and then makes the important link back to the particular when saying that what happens in the end is that electric current is produced (panel 6). The interactions in this episode are quite different from what can be seen in the other excerpts, in that the students’ activities are not geared toward furthering their understanding of the exhibit. Rather, the students engage in performing a shared, coherent conceptual understanding. At this point, the exhibit and the problem formulation are no longer phenomena to be explored and understood; rather they become useful props in the story told by the students. So the shooting of the video represent a change in the students’ activity, which in turn changes the role of the artifacts, as they are now mediating another activity (Wertsch, 1991).
5.6. Summing up

Together, the five episodes show how the group of students structure, coordinate and enact responses to the video task and how their conceptual framing of solar panel technology and energy transfer develops during the activity. In episode 1, John’s first framing of the exhibit was in terms of heat energy. However, he soon abandoned this tentative explanation and turned to the exhibit where he and Andrew collaboratively articulated and converged on the understanding that energy is transferred from the sun, setting electrons...
in motion, which then create energy. Clara then challenged the group by arguing that energy cannot be created (episode 3). As a result of this intervention, the students' previous understanding was re-evaluated and revised to be more precise; energy is transferred, while electricity is created. When the students had converged on this understanding, they returned to the problem formulation, which then became a resource for discussing the exhibit in relation to two more questions: why energy cannot disappear, and why energy cannot come into existence. In the analysis of the last episode, we show how the activity of shooting the video did not challenge the students' conceptual framing but rather became an opportunity to summarize and collaboratively "perform" the findings of their previous discussions. Tracing how the group of students frame and reframe the solar panel exhibit and energy transfer, the five episodes display how their understanding developed over time, becoming actualized and increasingly more specific and precise through their interactions in the museum setting (Mortimer et al., 2012). In the following discussions, we highlight three aspects from the analysis that we view as particularly relevant for the students' development of conceptual understanding: the material features of the exhibit, the problem formulation in the video task, and the role of the video making activity.

6. Discussion

A first point is how interactions with the material features of the exhibit supported gestures and bodily orientations, and became a means for organizing the students' learning and video making. When the students focused on understanding the exhibit and how it related to the problem they aimed to solve, they created a learning arrangement that allowed them to talk about representations and objects without necessarily knowing or using correct scientific terms. The different parts of the exhibit became shared resources available for all participants to refer to, interact with, and talk about, and their conceptual understandings were made available to be challenged, negotiated, and eventually revised (Goodwin, 2000a). When one student made a circular hand gesture toward the representation of a silicon atom, another student translated it into "electrons," sharing this knowledge with the group as a whole (episode 2). Inaccurate use of a term such as "energy" prompted fellow students to propose an alternative explanation (episode 3). Engle and Conant (2002) describe this dynamic as part of productive disciplinary engagement; when students problematize and display their understanding in the open, they make themselves accountable to each other and to the wider scientific discourse. Support for students' authority, agency and accountability is seen as an important feature of productive learning environments. In this study, we found that when students reframed their understanding of one part of a problem, it prompted new associations and led to more precise descriptions of the scientific phenomena on display; the clarification that energy cannot be created led the students to talk about electricity, a concept that had not previously been mentioned.

A second point is the role of the problem formulation and how it guided the students to explore a general scientific principle in relation to the particular exhibit. A common challenge for students in science is relating an understanding of particular phenomena to general scientific principles (Krange, 2007). In this case, the problem definition becomes an opportunity for the students to articulate what a general scientific principle implies for the particular exhibit at hand. While the previous section discussed how the students' orientation toward the solar panel exhibit created a shared orientation (Goodwin, 2000b), this environment does not in itself provide any resources for students to talk about the workings of the solar panel technology in a more generalizable way. The problem formulation and the video task did the work of guiding the students toward discussing principles of energy transfer in relation to the exhibit.

A third and final point is about the activity of making a video and the explicit types of work the video task did in supporting the students' learning. Making videos in museums can be seen as a task that requires other literary skills than those previously needed in pen-and-paper based approaches. In his analysis of worksheets, Kisiel (2003) distinguishes between different response formats, including written/non-written and verbal/non-verbal. In this classification scheme, the medium of video as a response format spans several categories: non-written, verbal and non-verbal. Our analysis of the students' video production shows how this medium allowed students to embed indexical gestures through interactions with the exhibit in their narrative. The video medium allowed the exhibit to serve as a visual and physical prop in the students' scientific account, enabling them to effectively link the museum exhibit to a general scientific principle. We propose that video is a particularly valuable mediational tool in learning tasks designed for rich semiotic settings like museums. Moreover, we see that the video-making task effectively supported group collaboration in developing, discussing and enacting a succinct scientific explanation. Video making is an activity with a distinctly performative response format, with a temporal dimension that invites 'acting out' scientific understandings. In this case, the video application had no means for editing the videos, heightening this real time performative aspect. This may be seen as an incentive for students to find a common understanding. At least, the group of students converged on a coherent scientific understanding of the exhibit and the problem in advance of making the video, and then collaboratively gave a condensed 'knowledge performance.'

7. Conclusions

In this study, we have shown how a group of students collaboratively developed a shared conceptual understanding of the workings of a solar panel exhibit and then related this understanding to the general scientific principle of energy transfer. Drawing on the notion of conceptual framing, we identified how students iteratively framed and reframed their understanding based on information emerging from their interactions with the museum exhibit, the video application, and each other. Throughout the analysis we have focused on the mediational means and how these become relevant learning resources for the students. Three main points have been highlighted and discussed separately: the role of the exhibit, the role of the problem formulation, and finally, the significance of the video-making activity. The notion of conceptual framing refers to the interactional work of achieving a shared understanding in a
specific scientific domain. Our study shows how this framing work is structured by the video application. The problem formulation orients the students toward viewing the exhibit in terms of general scientific principles, and the activity of making a short video becomes an engaging way for students to use the exhibit in their collaboratively developed response. Video tasks take advantage of the media rich and performative qualities of the medium, offering a tool for students to frame and capture their interactions with exhibits. Based on the findings in our study, we propose that video tasks may be a productive way to ‘frame topics’ and orient students to disciplinary aspects of museum exhibits. As mobile video applications are increasingly integrated in learning environments, this study contributes a better understanding of how they may be designed to support museum learning.

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References


Charitonos, K. (2011). Museum learning via social media: (How) can interactions on Twitter ENHANCE THE MUSEUM LEARNING EXPERIENCE?


Appendix A. Transcription notation

[text] Brackets indicates the start and end points of overlapping speech.

text Underlined text indicates that the speaker is emphasizing or stressing the speech.

= Equal sign indicates the break and subsequent continuation of a single interrupted utterance.

- Hyphen indicates an abrupt halt or interruption in utterance.

( . ) A brief or unmeasured pause.

(number) A number in parentheses indicates the time, in seconds, of a pause in speech.

:: Colon or colons indicate prolonging of an utterance.

(italic text) Italic text in parentheses is the author’s own descriptive comments and observations.