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Researching features of science learning from students' view – the potential of headcam

Abstract

This article discusses the potential of small head mounted camera (headcam) to collect video data indicating student learning processes in science across time and settings (classroom and field). Empirical examples from two Norwegian research projects; one on integrating science inquiry and literacy in elementary school and the other on learning geoscience through fieldwork in upper secondary school; are used to demonstrate the potential contribution of headcam to science education research. We propose that headcam videos provide opportunities for observing features of science teaching and learning from new angles: following students during movement, connecting students' verbal interactions and interaction with physical objects, students' written products in the making, and students' development of understanding over time. However, we also experienced that headcam videos exposed some unwanted observations. The discussion of implications addresses the advantages and limitations of using headcams, including concerns arising from unwanted observations.

Introduction

You often see it: people wearing a small video camera fastened with a strap or band to their heads or helmets while performing extreme sports such as downhill skiing and biking. This type of head-mounted video camera (headcam) has been used in research on sports and medicine for a while (Miller, 2004), but it has not been widely discussed in the context of science education research. Therefore, in the present article, we describe how *headcam* can enrich video-based research in science education. Doing so, we investigate headcam video data collected during two research projects in Norway; one on the integration of science inquiry and literacy in primary school (the Budding science and literacy project), and one on learning geoscience through classroom and fieldwork activities in upper secondary school (the Geo program).

Using video technology in educational research is not new, and its advantages are widely discussed in the literature (Derry et al., 2010; Erickson, 2011; Klette, 2009). One advantage is that video observation provides researchers with important insights into the complexity and details of classroom practice – what teachers and students say and do – that is difficult to observe in situ. Furthermore, videos can be revisited for continued learning and analysis at different times, with different viewpoints, and by different researchers (Derry et al., 2010). To date, most video studies in science education appears to be based on hand-held video cameras or stationary video cameras on tripods in classrooms. More recently, some science education researchers have discovered the opportunities of headcams, particularly in outdoor settings such as nature and science centers. Therefore, the present article aims to discuss how headcams help researchers to observe student learning processes during science activities across time and settings (classroom and fieldwork).

Before presenting our research questions and examples derived from the aforementioned research projects, we review some of the video studies conducted in science education, particularly in a Scandinavian context, before narrowing down the review to studies based on headcams. In order to discuss the potential of headcam in research on science learning, our theoretical perspectives on student learning processes is also provided.

Video studies in Scandinavian science education

In the last decades, video technology has become commonplace in classroom studies in general (Derry et al., 2010), and in science education in particular (Tiberghien & Sensevy, 2012). Examples from Scandinavian video studies include Norwegian researchers' investigation of interactions between teachers and students, and types of learning activities offered (Ødegaard & Klette, 2012), classroom communication in Sweden and Denmark (Löfgren, Schoultz, Johnsson, & Østergaard, 2014), whereas Danish researchers employed video to investigate student motivation in science (Andersen & Nielsen, 2013). The video technology employed in the aforementioned classroom studies was typically cameras set up in the back of the classroom to record the whole class, or cameras on tripods set up behind, beside or in front of small groups of students. However, this video design seems difficult to replicate in research on outdoor science activities which often require teachers and students to move around in an environment without natural boundaries. Therefore, as we show next, recent studies have begun using headcams to collect video data.

Studies using headcams in science education

In science education research, headcam appears as a tool for collecting data about teaching in outdoor settings (Stolpe & Bjørklund, 2012), and as an exploration of the headcam itself and its possibilities (Maltese, Balliet & Riggs, 2013). In the following, we review the aim of the studies, how headcams are used, and the challenges of using them.

A study in social science conducted by Brown, Dilley and Marshall (2008) appears to be one of relatively few educational studies using headcam as the main data collection tool. This study aimed at gaining a deeper understanding of the experiences of mountain bikers and walkers during outdoor activities. The participants carried the headcams sometimes alone, other times with a researcher present as a participant observer. The headcam videos were further used as prompts during post-interviews with participants. According to Brown and colleagues, the headcam's ability to record real-time, continuous audio and visual data from the participants' visual angle generated new insights into social practices (moments, rhythms, and the nature of human experiences) that are difficult to verbalize. Regarding challenges, Brown et al. (ibid.) mention disconnection of cables, failure during recording, risk of rain and damage. Also, ethical challenges were noted, particularly with respect to ensuring anonymity of fellow participants not wearing the headcam. Therefore, the researchers allowed participants to turn on and off the camera, ensuring participants' control of the video recording.

In science education, Beddall-Hill (2010) applied headcams to explore how university students used mobile devices (e.g., GPS) in collaborative learning during case-based activities on fieldtrips in geoscience. The headcam circulated among participants simultaneously as the mobile device switched from one student group to another. Using headcam data together with multiple data sources enabled the researchers to demonstrate how the mobile devices fostered learning, especially regarding students' decision-making and group roles (Beddall-Hill & Raper, 2010). The challenges of using the headcams occurred during transport and set up for data collection.

Other types of headcams, such as mobile eye goggles, have also been explored and piloted in science education research. The mobile eye goggles are made of safety glasses outfitted with two cameras: one captures eye movement, the other faces forward to capture the wearers' outward view. Maltese and colleagues (2013), for instance, piloted whether mobile eye-tracking cameras were sufficient tools for investigating US undergraduate students' performances during fieldwork in geology. The researchers advocated that the camera recording from the students' angle provided more information about their learning during fieldwork than the camera recording eye movements. However, the eye-tracking camera imposed technical challenges for the researchers, as well as discomfort for the participants (e.g., the opening in the lens made sweat or wind come into the eye, which disturbed their vision).

A similar type of headcam; goggles with a built in video recorder; has been used in studies of students' learning during visits to science centers. For instance, Danish students carried video goggles capturing what the wearer was looking at and the dialogue with other students in the group (Gjedde, Horn & Sørensen, 2012). This produced video data which enabled the researchers to explore students' learning experiences regarding energy in a science center setting. Video analyses showed that the students forgot that they were being video recorded, indicating that the headcam provided a realistic insight into the actual activities as well as eliminating usual observer bias found in other museum studies where researchers are physically present during observation of learners.

While the headcam was carried by students in the studies cited above, the Swedish researchers Stolpe and Björklund (2012) equipped a university teacher with a headcam to investigate particular teaching episodes during an excursion in ecology. The headcam data was further used to facilitate stimulated recall interview with the teacher.

The authors of the two aforementioned studies did not report on particular challenges of using headcams.

In Norway, our research projects were the first using headcam to study teaching and learning in school science – in both classroom and outdoor settings (Remmen & Frøyland, 2013, 2014; 2015a; 2015b) and in classrooms (Ødegaard, Haug, Mork & Sørvik, 2014). Further details from our studies are provided in the *Methods* and *Results* sections. Later, there has been a growing interest in using headcams among Norwegian researchers, for instance in studies of literacy education (Blikstad-Balas & Sørvik, 2014).

To summarize the review of headcam studies, the aim of using headcams was primarily to study teaching and learning from the participants' view, particularly during outdoor activities requiring participants to move in settings without natural boundaries. However, learning activities requiring movements are not exclusive to outdoor settings. Practical activities in science classrooms may also require students to leave their desk, for example to collect equipment or observe objects placed around the classroom. In this article, we assume that headcam is a sufficient tool for collecting observations of teaching and learning science in classrooms as well as in an outdoor environment. Hence, "perspectives" of learning are outlined later.

Furthermore, the review uncovered two challenges of using headcams: (1) technical limitations of the equipment, and (2) ensuring anonymity of participants. However, given the fact that video research require attention to research ethics (Derry et al., 2010), it might be surprising that ethical issues following the use of headcams is not recognized as a challenge. We consider this as a shortcoming because headcam videos expose the intimate zone of the wearer, which might require researchers to take a particular ethical responsibility.

Perspectives of learning

Our research is based on the idea that student learning of science is enhanced through inquiry-based activities Inquiry learning involves making sense of data created from first-hand experiences - such as practical work (Crawford, 2014). This requires students to connect objects and observations to scientific ideas and models by interpretation and explanation. An inquiry trajectory (process) is underpinned by socio-constructivist and sociocultural perspectives of learning, meaning that learning processes involves an interaction between social activity and individual construction of knowledge. Hence, student science learning is fostered by interactions with other students and the teacher, and/or with cultural products such as books or physical objects (Leach & Scott, 2003). In doing so, students use language in various ways – in doing, writing, reading and talking science (Wellington & Osborne, 2001). Developing scientific knowledge through inquiry activities takes time, evolving from no understanding via superficial to deeper levels of understanding (Wiske, 1998). To reach deeper levels of understanding, students need to apply what they learn in new situations that involve explaining, solving problems, and constructing arguments (Wiske, 1998). In our two projects, situations for knowledge application are supported in various ways. In the Budding scientist and literacy project, students' understanding of scientific concepts is supported through integrating inquiry and literacy activities (Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012). In the Geo program, fieldwork aims to support students to apply knowledge from classroom preparation in a field environment, as well as building on what they experienced during the field activity in later classroom activities (Orion, 1993).

Of course, learning as a mental activity cannot be observed directly through a headcam. But what students do and talk about – for instance, whether they connect what they are doing with scientific knowledge – are features that can be interpreted as learning.

Research questions

Our literature review and perspective of learning provide a context for further exploration of using headcams in science education research. More specifically, we explore the potential of headcams in recording features of students' learning processes across time and settings (classroom and outdoor), in addition to possible ethical consequences of using it. Hence, two research questions (RQ's) are addressed:

1. What features of learning processes in science can be observed in the classroom and in the field, from headcam videos?
2. What observations causing ethical concerns can be exposed by headcams?

Methods

Our review shows that there are several types of headcams available on the market. Nonetheless, choosing a headcam should be based on the purpose of the research. Therefore, we outline the research projects in focus of this article before describing the process of selecting a headcam sufficient for our purposes.

The context for headcam observations: two research projects

1. The Budding Science and Literacy project (2010–2013) focused on how the interplay of inquiry-based science activities and literacy activities can improve teachers' competence and students' learning processes in elementary school. In this project, headcams were used together with a moveable camera facing the teacher and a fixed camera focusing on the whole class for collecting video data from classroom practice (Ødegaard, Haug, Mork, & Sørvik, 2014).
2. The Geo program (2008–2013) investigated how inquiry-based classroom and fieldwork activities in geoscience can support student learning processes in upper secondary school. Here, the headcams were used as the prime data collection tool: both teachers and students wore headcams simultaneously in the classroom and during fieldwork (i.e., before, during and after fieldwork). This way, the headcam recorded the activities from three visual angles: from the teachers' view and from the views of students (e.g., Frøyland & Remmen, 2013).

For both projects, the Norwegian Social Science Data Services (NSD) approved the use of headcam as an observation tool. All participants signed an informed consent stating that they could withdraw from the research project at any time, that their anonymity would be ensured, and that headcam videos would be stored securely.

Selecting a headcam to record students talk and actions

Selecting a headcam involved a consideration of our research needs. Studying learning processes during fieldwork (the "Geo program") required a headcam that endured bad weather conditions, like rain and wind. We did not want to distract the participants during the activities. Therefore, it was important that the headcam was small, easy to fasten on participants' heads and had no buttons to distract the students. It was also desired that the headcam had a high picture quality for recording in outdoor settings or settings with difficult lighting.

Based on the aforementioned considerations, we chose the headcam GoPro® Hero HD. As shown in Figure 1, GoPro® has a head mounting strap for placement on the front head. It is capsuled in a waterproof housing. The size is 60 x 41 x 30 mm and it weighs 98 grams. It covers a wide angle (up to 170 degrees), records up to 1080 p (1920 x 1080 in 16:9 format), have internal microphones for audio recording, battery capacity of app. 2,5 hours, and easy accessible SD cards for recording videos. Furthermore, there is no wire connecting the camera and the recorder, it was lighter than other cameras, easy to handle with only two buttons, and had several possible add-ons.

Note that newer versions than the one described above are lighter, have higher resolutions and more add-ons – for instance, wireless connection to mobile tablets and phones.

Analysis – selecting observations demonstrating the potential of headcam

To answer our research questions, we analyzed the headcam video data (totaling 66 hours from the Budding science and literacy project and 130 hours from the Geo program) and our published articles with one question in mind, could the features of learning processes in this video been captured by an ordinary, hand-held video camera?, If not, the incident was chosen, and in this way we were able to identify indications of student learning processes unique to headcam videos, as well as other examples evoking ethical concerns in our research group.

Figure 1. Headcam (GoPro® Hero HD) used in our research projects. 1 = video camera with head band, 2 = cable for downloading video files, 3 = extra battery.

Findings and discussion

In addition to the general benefits of video observation (capturing communication and actions between teachers and students), the headcam in Figure 1 produced video allowing us to observe from the student's visual angle. Headcam help us to see what she sees, including what her hands do with materials and gestures, and listening to how and what she talks about while working with physical objects, and how she interacts with her peers and the teacher. As a result, our analysis of the headcam videos identified four types of observations related to RQ1 that provided closer insight into student learning processes compared to other video camera solutions:

- Following students social and physical actions while moving
- Connections between students' verbal interactions and interaction with materials
- Students' written products in the making
- Signs of students' development of understanding over time

For RQ2, we identified observations of participants' actions that evoked ethical concerns in our research group.

In the forthcoming sections, the four types of observations related to students learning processes are exemplified by headcam data from the two research projects. For each observation listed above, we present one example from the classroom study of the science inquiry and literacy approach in elementary school, and one example from geoscientific fieldwork in upper secondary school.

RQ1: Features of learning processes in science that can be observed in the classroom and in the field from headcam videos.

Following students social and physical actions while moving

The headcam made it possible to observe social and physical actions when the students moved around in the classroom. This was particularly evident during practical activities in the classroom and in the field. Therefore, example 1a follows student movement in the classroom, whereas episode 1b shows student movement in a field environment.

Example 1a: Students moving in the classroom during practical, hands-on activities
The third graders in this example were asked to observe stuffed animals provided by their teacher. On the video obtained from the whole class camera, the activity seemed chaotic and noisy because the students moved around in the classroom and talked with high voices. However, the headcam video exposed another reality of the same situation: the noise and movements were caused by the students' engagement in observing the stuffed animals and writing down their observations in a Venn diagram (Figure 2).

Figure 2. Molly starts recording her observations of the animals in a Venn diagram.

The headcam video allows us to observe how Molly interacts with her peers, and how she physically moves between her writing process at her desk and observing the stuffed hedgehog and squirrel placed up front in the classroom, as shown in the following excerpt:

> Peer: *It has oval eyes.*
> Molly: *Does it?*
> Molly left her desk to observe the hedgehog.
> Molly [to some other girls]: *Is it real spikes?*
> Girl 1: *I think so.*
> Molly [touches the spikes]: *Auu!*
> Girl 2: *Maybe the eyes are real too? Touch them!*
> Girl 1 [touches the hedgehog's eyes]: *They are not real. Look at the disgusting teeth! Have you seen them?*
> Molly [touches the tail of the squirrel]: *Touch the tail! This is a fake tail.*
> Molly returns to her desk, writing down her observations.

This is an example of how a headcam mounted on a student can provide another reality of a classroom activity than both a whole class camera and a camera following the teacher. While the whole class camera videos revealed a chaotic and noisy situation, the excerpt from the headcam video showed that Molly and her peer were engaged in the task of observing and comparing the stuffed animals. They moved back and forth between their desk and the stuffed animals: observing with several senses, discussing observations with their peers and writing observations in their Venn diagram. Thus, this example demonstrates how a headcam on a student enabled us to observe features of the ongoing individual and social learning processes during movements in the classroom, which could not have been replaced by a stationary video camera.

Example 1b: Students' talk and actions while moving in a field area
The upper secondary students in this example spent one full day in the nature park to learn geoscience. The students were organized in small groups, moving freely between locations and working independently on a worksheet provided by the teacher. The worksheet tasks provided information about geoscientific concepts, and were designed to support the students' autonomy in the field as well as their ability to observe geological phenomena in practice (see also Remmen & Frøyland, 2013; 2014). The headcam provided a continuous record of their talk and actions during the fieldwork, including their physical movements between locations. Such observations would have been difficult to acquire with a hand held camera without disturbing the students.

The headcam videos provided rich information about the students' abilities to apply theoretical knowledge in the field. One common observation was that the students searched in wrong places to answer worksheet tasks. For instance, the headcam videos revealed that the students were not able to find a particular location they needed to solve a field task requesting observation of yellow color on a rock. This made the students frustrated and they gave up completing their task. When a worksheet task required identification of fossils in the rocks at a particular location, the same students spent a long time searching without finding it. The headcam video revealed that the students were uncertain about what a fossil looked like in its natural environment. Observations like facilitated our discussion of why the students were unable to solve their worksheet tasks, which in turn influenced their learning during the follow-up work in the classroom (Remmen & Frøyland, 2015a). Furthermore, the headcam videos also uncovered that the student wearing the headcam withdrew from his peers – he often wandered on his own taking pictures. This way, he did not participate in the team's interactions about the phenomena, which would delimit his learning (Leach & Scott, 2003).

To summarize, the observed features of student learning processes in examples 1a and 1b can be attributed to the headcam. In example 1a, the stationary whole class camera depicted a chaotic classroom situation, but the headcam video exposed another reality of eager students on task, commuting between their desks and the stuffed animals. In example 1b, the headcam videos recorded the students' social and physical interactions while moving around in the field, searching for locations to apply theoretical knowledge in practice. This would have been impossible to record with a stationary video camera. The headcam made these features of student learning processes available to us without needing to be physically present.

Connections between students' verbal interactions and interaction with physical objects
Although the headcam is carried by one student, it records the student's talk and actions with others nearby the camera – such as peers and the teacher. Examples 2a and 2b illustrate how headcam enables us to observe the connection between students' verbal interactions and the physical objects they focus on during practical activities in small groups.

Example 2a: Students' use of the force concept during practical activities
The fifth grade students in this example were introduced to the concept of forces by observing whether a force was a pull or a push, and to understanding that forces work between two objects. The students worked in groups, using two wooden blocks, extension and compression springs and rubber bands, to explore the force concept. The students used the materials to perform push and pull (Figure 3). Trying to make a pull by using the extension spring hooked on to the block, they called out:

> *Wow, we have to pull hard!!!!*

The interaction showed that the three students felt the strength required to pull the blocks apart. However, the students focused on how *they* made the pull, without showing an ability to transfer the idea and express how the extension spring pulled the block. This indicated that the students had difficulties with connecting their own actions of push and pull to push and pull between the wooden blocks. Another difficulty that was exposed involving the intersection of language and action seemed to be the idea that there was a concrete solution to the task they are given. The students were more engaged in solving the physical task than actually trying to use and understand the science concepts involved (Haug & Ødegaard, 2014). The headcam video enabled us to observe the relationship between how the students interacted with the objects and how they used scientific concepts in relation to that object.

Figure 3. Students practicing push and pull to learn scientific concepts.

Example 2b: Students' use of geological concepts in the field

The worksheet described in Example 1b required the upper secondary students to apply geoscientific concepts to phenomena in the field. Example 2b demonstrates how the headcam videos enabled us to study this in more detail. A team of students worked on a worksheet task asking them to identify the type of rock, describe how it looked like and connect it to theories of rock formation (Figure 4).

The following conversation ensued:

Peter: *This is gneiss.*
Eric (wearing headcam): *Yes, its band gneiss when it has such banding.*
Peter: *Banding – then its' deposited.*
Eric: *It's a magmatic rock yes.*

Despite the fact that students, in line with Orion's (1993) recommendation, had been preparing for rock identification prior to the fieldwork, the excerpt shows that the students were able to identify the name of the rock, but also revealed misapplications of geoscientific concepts, which is unlikely to build a sufficient understanding (Wiske, 1998). This was confirmed on a post-test one year later, when the students demonstrated insufficient understanding of rocks (Remmen & Frøyland, 2013). Students' misapplication of scientific concepts to natural phenomena would have been difficult to record without a headcam since the students were allowed to move freely in a larger area.

From examples, 2a and 2b, we propose that headcam videos enable researchers to view how it might look like from students' visual angle when they try to connect scientific concepts to the objects they interact with – which is decisive for succeeding with science learning (Cervetti et al., 2012).

Figure 4. Students solving a worksheet task identifying rocks.

Students' written products in the making

Science learning is supported as well as performed when students write reports, notes, tables, mental maps and so forth (Osborne & Wellington, 2001). Examples 3a and 3b show that headcam videos provide detailed observations of how students draw and write to complete a task assigned by their teacher.

Example 3a: Student diagram in the making

A grade four science class explored the concepts of system, form and function. In the present example, the students were asked to apply what they had learned about systems by drawing a diagram of a ball sorting system. Through the headcam, we were able to follow how Nick's diagram developed throughout the lesson (Figure 5).

As seen in Figure 5, Nick wrote the name of each part in his system. Then, the teacher approached the students. She says that since Even, one of the peers had been at the dentist yesterday, it is important that the other group members help him with the diagram. Although the teacher did not comment on Nick's diagram, we could see on the headcam video that when she left, Nick erased the word "pipe" and replaced it with "pipe for leading air through", i.e. he included the function of the pipe. After a few minutes, Nick said he did not know what more he could do. He got no response from his peers and switched between on and off task for a while. Then, he showed his diagram to the teacher:

> Nick: *I have drawn and written.*
> Teacher: *Great! And now you must describe the form and function of the different parts.*

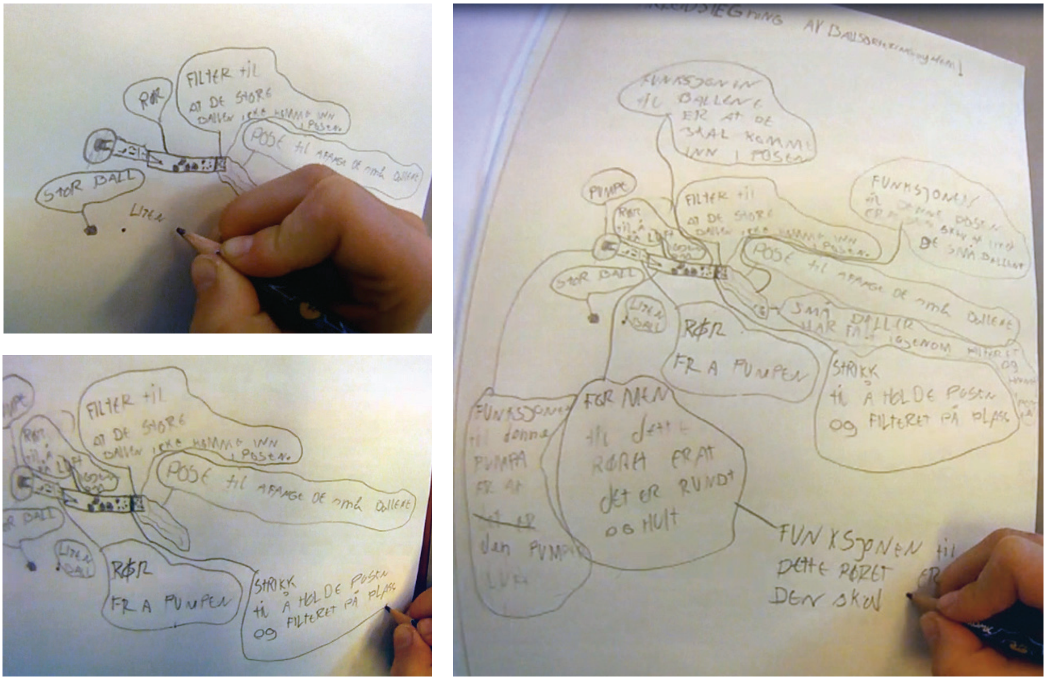

Figure 5. The development of Nick's diagram on his ball sorting system.

The teacher's comment helped Nick to continue his work by describing the function and form of each part in the system. During the following group discussion and whole class summary, Nick added even more information to his diagram. The last picture in Figure 5 depicts the final version of the diagram containing several details.

In this example, the headcam made it possible to observe Nick's diagram in the making. We gained insight into how Nick responded to the comment from the teacher and how listening to, and discussing with peers helped him improve his diagram. Furthermore, we got accurate information on whether and how long he worked on his diagram. The other cameras; one fixed whole class camera, and one following the teacher from the back of the classroom; were not able to capture such details of what was going on at the individual and group level (Ødegaard et al., 2014), as that angle was hidden by the persons back or is too distant from the cameras.

Example 3b: Field notes in the making

During the fieldwork introduced in Example 1b, the upper secondary students were expected to take notes, draw sketches of rocks, and write down things they wondered about or did not know. The headcam recorded how and when the students wearing the camera worked on their field notes and revealed that the students did not take field notes as they were required to by their teacher. Instead of writing independent observations and drawing sketches of geological phenomena, they copied text from the information boards in the nature park (Figure 6) or wrote down what the teacher said (Aarre, 2013).

These observations showed that the students in this example used field notes to learn facts – and not applying their skills involved in geoscientific fieldwork (Kastens & Manduca, 2012).

Figure 6. Field notes in the making (Aarre, 2013).

Usually, researchers collect and evaluate student field notes after the fieldwork. However, this gives little information about the process of making the field notes – including whether the students collaborated or not. In this example, the headcam document field notes in the making in a novel way.

Viewing examples 3a and 3b together, the headcam enabled us to observe the students' written products in the making from their visual angle. For comparison, a stationary video camera recording students from the side or upfront would capture their interaction – but not how they draw and write.

Features of students' development of understanding over time

Our theoretical assumption – that students demonstrate and develop understanding by applying knowledge in different situations (Wiske, 1998) – required us to track students' use of knowledge over time. Examples 4a and 4b demonstrate how the headcams can enable researchers to explore how students use knowledge in different situations.

Example 4a: Students reconsidering their understanding of the concept of force

The fifth graders described in example 2a continued working on the concept of forces. Example 4a depicts the situation some lessons later, when the class read and discussed pictures in the book entitled "Forces" in a plenary session. Before reading, the students filled in a "Getting ready to read" form, where they marked whether they agreed or disagreed with various claims about forces (Figure 7).

Filling in the form, Tommy was correct about most claims in the form, except the claim: "When someone kicks a ball, the force is in the ball". This indicated that he had not developed a complete and active understanding of the concept of force, although he was correct about the other statements in the form (Haug & Ødegaard, 2014). Recall that, in example 2a, we saw that the same students demonstrated unclear understanding of how forces work.

During the plenary discussion in example 4a, the teacher prompted the students to use evidence to support their claims. Afterwards, the students were asked to reconsider the claims in the Ready to Read form. Tommy discussed with his peer and eventually changed his opinion about the second statement about the force being inside the ball (Figure 8).

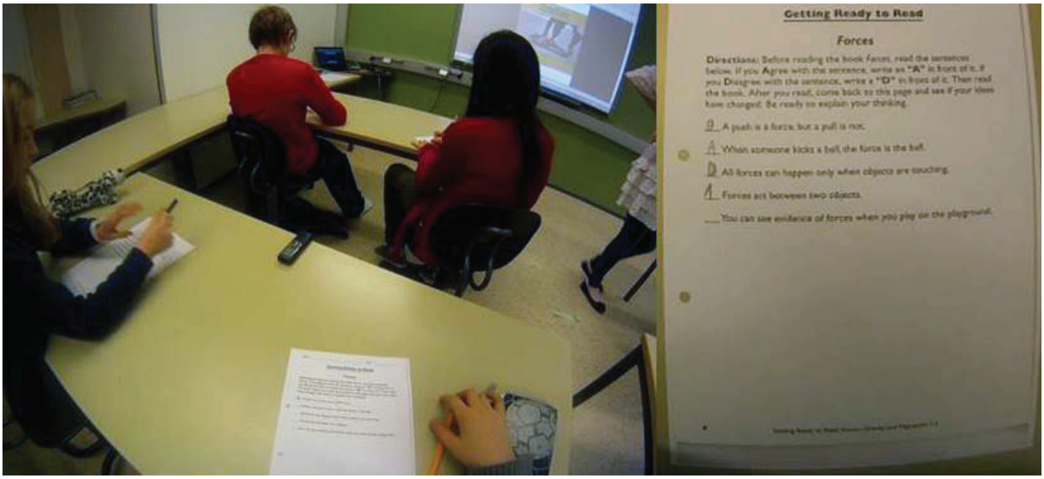

Figure 7. Tommy filled in the Getting ready to read form before reading the book "Forces".

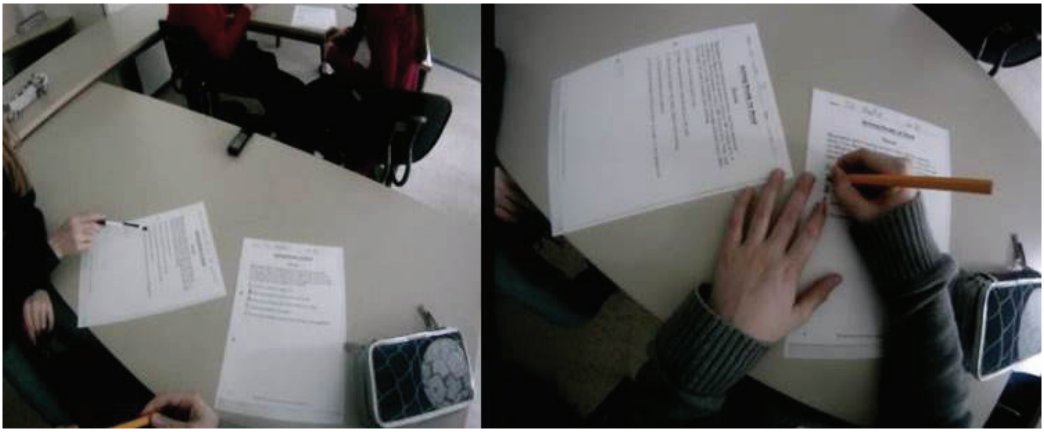

Figure 8. Student reconsiders his statements about forces after a reading inquiry.

The headcam angle made it possible for the researchers to follow the student's development of understanding about the concept of forces, through several teaching sequences (Haug & Ødegaard, 2014).

Example 4b: Students' learning of geological concepts across classroom and fieldwork activities

In upper secondary school, features of student learning processes were recorded by headcams across classroom preparation, fieldwork activity, and follow-up work, which align with theoretical assumptions of field-based learning (Orion, 1993). Example 4b presents how the students applied geological concepts from classroom preparation to phenomena in the field. During classroom preparation, the students learned to reason about the relative age of rocks by conducting a task in the textbook (Figure 9) and to identify rocks through practical activities. The headcam video revealed that in the classroom the students were deeper engaged in the relative dating task than the rock identification task.

Afterwards, the students applied rock identification and relative dating to the phenomena in the field (Figure 10). On the headcam videos, it appeared that the students struggled with rock identification. By contrast, the same students succeeded with relative dating; they had longer conversations applying geological principles introduced in the classroom when reasoning about the relative age of rocks

Figure 9. Student learning of relative dating during classroom preparation.

in the field. The fact that the same students were able to apply classroom learning of relative dating to phenomena in the field; but not to rock identification; enabled us to discuss ways of supporting student learning processes during fieldwork (Remmen & Frøyland, 2013).

In sum, example 4a and 4b supplement examples 1–3 by indicating how the use of headcam over time allows researchers to connect students' talk and interactions about phenomena they are observing, and written products they are developing, to interpret whether students develop understanding (or not) of scientific concepts.

RQ2: Headcam observations causing ethical concerns

The headcam captures talk and actions from all participants nearby. Sometimes teachers and students can do things that the researcher analyzing the videos find unwanted or problematic to witness. During our research, we observed the following events in the headcam videos evoking ethical concerns for us as researchers.

- Private conversations, for instance students gossiping about social events outside school.
- Students describing what they think about their teachers.
- Teachers and students typing passwords into private accounts (e.g., e-mail).

It is worth noting that these actions occurred when participating teachers and students had been recorded by the headcam over several lessons, which indicates that they became accustomed to the headcam and perhaps forgot that they were being video filmed.

Figure 10. Students' application of relative dating of rocks in the field.

In a few other instances, the participants chose to turn off the headcam because they did not want their actions to be recorded. Two examples are:

- When the teacher had conversations with students about semester grades.
- When students went to the toilet during the lessons.

Some of these observations, particularly typing of passwords, could have been avoided if we had used hand-held or stationary video cameras. In contrast, recording private conversations is not exclusive to headcams. The difference is that the headcam videos provide researchers with a closer and more intimate observation of the participants' privacy than video data obtained from other camera solutions.

Discussion of implications

Examples 1–4 in this article indicate that positioning headcams on students enable researchers to view features of learning processes more closely. Specifically, researchers can observe how students write, how they interact with each other and with physical objects, how they behave while moving from one spot to another, and how they develop understanding (or not) of scientific concepts by participating in activities across time. We consider these as unique observations that would easily be missed by stationary video cameras placed on the side or upfront of students, and video cameras carried by a researching observer. Put differently, using headcams as tools for recording observations provides a new angle for researching the individual and social processes students go through during science activities. In the following, we discuss advantages and limitations of using headcams as a data collection tool.

Headcams are easy to use and transport

In our research projects, we wanted to visit several schools over several weeks, and record teaching and learning in classroom and outdoor settings – as shown in examples 4a and 4b. This was possible because the headcam was light to transport and easy to set up. In contrast to other researchers (e.g., Bedall-Hill, 2010; Maltese et al., 2013), we did not experience any technical difficulties with using the headcam. Hence, we believe that headcam, at least the type we used, can lower the threshold for researchers to follow teaching and learning over time. This is important if we consider learning as a time-consuming constructive process (Wiske, 1998).

Headcam data complement traditional video studies

Video cameras placed on tripods on the side of students capture both physical and spoken interactions during writing tasks. But the headcam enables researchers to get a closer, more intimate view of the wearers' actions combined with their use of language (as shown in examples 3a and 3b). However, we can only observe her talk and what she does with her hands. As noted by (Brown et al., 2010), we cannot observe facial expressions of the person wearing the headcam – which is a shortcoming of headcams in general.

Although the GoPro® headcam records a wide angle and captures much of the classroom activity, it has some limitations. Therefore, in some instances, we propose that headcams can complement rather than replace traditional video technology (i.e., cameras placed alongside students or in the back of classrooms) described by previous video studies in science education (e.g., Ødegaard & Klette, 2012). Nonetheless, the research questions determine the video camera solutions.

Headcam enables an investigation of student learning processes

Unlike the studies reviewed earlier, we applied headcams to record activities across time (Example 4a) and also settings – classroom work and fieldwork – (Example 4b). This allowed us to track how students applied learning from one situation to another – which is important for developing understanding (Wiske, 1998). For instance, we found that the same students were able to apply one concept (relative dating) learned in the classroom to phenomena in a field setting, but not another concept (rock identification). We also observed how students' conceptual understanding of forces developed during inquiry-based activities; the student made changes in his reading form after being presented to new information about forces. Furthermore, the examples 1a and 3a also show that headcam can reveal what individual students can do on their own, and what they are able to do together with peers. This way, the headcam enhances opportunities for studying features of learning as both an individual and a social process (Leach & Scott, 2003).

Dealing with unwanted observations evoking ethical concerns

Although the headcam has a great potential for exploring student learning processes, we realized that it also captures surplus information about participants generating ethical concerns. For instance, we did not anticipate before the video recording that we would witness participants typing of passwords. This is in line with Brown et al. (2008) who noted that headcams require researchers to take ethical responsibility beyond informed consent. To us, the unwanted observations became a reminder that ethical concerns must be taken into account throughout the whole research process (Tangen, 2014). Therefore, in this section, we reflect on our experiences to discuss how researchers may deal with unwanted headcam observations in order to take a greater ethical responsibility.

Typing passwords and gossiping are observations indicating that the participants got used to or did not bother about wearing a headcam or being filmed, which has also been recognized by others (e.g., Brown et al., 2008; Gjedde et al., 2012). Reasons for this, we believe, is that the headcam is so small making it less intimidating than being observed by a researcher or a large stationary video camera, and that today's youths are used to electronic gadgets in their surroundings. From a research perspective, it can be an advantage that participants forget they are being recorded by a headcam because it would be more likely that they behave naturally. However, our findings expose the negative side as well: participants may expose private matters – which researchers do not really want to know and participants may regret. In our research, we focused on science teaching and learning – hence, participants' private matters were irrelevant in our video analyses. However, this might be unsatisfactorily because the unwanted observations cannot be deleted from the raw headcam videos. Therefore, the headcam videos are stored on a secured server. Another opportunity other researchers may want to consider is to edit headcam videos by only selecting and storing video clips relevant for the research project. A counter argument is that editing videos might make analyses even more time consuming, and less verifiable.

As recognized earlier, recording private conversations is not unique to headcams – it is a general problem of video observation. It is therefore interesting to find that the participants in our research projects utilized the opportunity to turn off the headcam to protect their privacy (e.g., discussing semester grades, visits to toilets). This shows that when the video camera is placed on the participant's head they have a direct influence on the recording. This way, the headcam strengthens the participants' self-determination – which is an argument for using headcams instead of stationary or hand-held cameras. On the other hand, important and interesting data could be lost if participants turn off the headcam frequently (and perhaps forget to turn it on). In our case, we told the participants about the positive and negative sides of stopping the video recording. Nonetheless, to prevent unwanted observations in the future, we will try to inform teachers and students that they should try not to reveal secrets or private issues, including passwords.

To summarize our experiences with the headcam videos, we advise other researchers considering using headcams as a data collection tool to:

- Inform the wearer about how to turn off the headcam.
- Inform the wearer to try not to reveal private matters and sensitive information that he/she does not want to share with others.

Our suggestions for dealing with unwanted observations generated from headcam videos are not exhaustive. Hence, we encourage other scholars to elaborate on ethical guidelines for using headcams in educational studies.

Conclusion

The examples presented in this article demonstrate that headcam data has a great potential to expose new or different observations of student learning processes in science. This can provide opportunities for researching teaching and learning in new ways. That said, our headcam data also revealed participant actions that required ethical responsibility. When used carefully, unwanted observations should not hinder researchers from utilizing the potential of headcams in science education research.

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