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Investigating Situational Interest in Primary Science Lessons

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Pupils' interest has been one of the major concerns in science education research because it can be seen as a gateway to more personalised forms of interest and motivation. However, methods to investigate situational interest in science teaching and learning are not broadly examined. This study compares the pupils' observed situational interest and their expressed situational interest. One class of Finnish fourth-graders ($N = 22$, age 9–10 years) participated in a heat transfer lesson. The lesson encompassed an interactive demonstration with a thermal camera, teacher-led discussions and the conduct and presentation of a collaborative inquiry task. Pupils expressed their interest levels (scale: 1 = very boring, 5 = very interesting) by using an electronic response system called a 'clicker'. The measurement took place 15 times during the lesson, with 1 measurement being just a rehearsal. The lesson was video recorded, and visible aspects of interest at the measurement time points were analysed. Reported and observational data were compared. In most cases, the observations did not yield data compatible with the pupils' own evaluations, indicating that most pupils' expressed interest is not easily interpreted through observation of their facial expressions and behaviour. In general, the interest of the group as a whole seems to diminish during the lesson. We argue that in order to maintain and increase pupils' interest, their evaluations should be taken into account in lesson planning. Video-based research might also be further enriched and validated by employing the participants' own expressions. The clicker is a suitable means of collecting primary pupils' experiences concerning their interest levels.

Keywords: *Observed situational interest; Expressed situational interest; Science education; Electronic response system; Experience sampling method*

1. Introduction

This research took its inspiration from the literature on student interest, motivation and attitudes towards science (Bennett, Hogarth, & Lubben, 2003; Osborne,

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Simon, & Collins, 2003; Sjøberg, 2000). Research on student interest and motivation has revealed that, outside the school context, science in general is of interest to students but that most students, especially girls, are less interested in school science and technology or in careers and occupations in those fields. Interest in science diminishes among older students (Tytler, Osborne, Williams, Tytler, & Cripps, 2008; Woolnough, 1996); for example, a recent survey in Finland revealed that ninth-grade students' physics- and chemistry-related attitudes were quite negative. There was also a large gender difference in attitudes towards physics (Kärnä, 2012).

Interest is a manifold concept and a distinction is commonly drawn between situational and personal interest (Hidi, 2006). Situational interest can transform into personal interest (Hidi, 2006), which, in turn, is related to higher motivations (Deci, 1992). In other words, situational interest can be seen as a possible gateway to more personalised and internalised forms of motivation and interest, and in the school science context, it is expected that situational interest will in part be under the control of the teacher with respect to what kind of activities are included in her lessons.

In order to design teaching sequences that will potentially engage interest, it is essential to obtain accurate information about what the students actually find interesting. The challenge of obtaining accurate information about situational interest is central to this study. However, before examining how to gather information about situational interest and about those aspects of the lesson that appeal to students' interest, it is important to consider how student interest is understood and to consider the basis upon which something can be considered interesting. Very often, a teacher can infer whether or not students are interested in something by observing them during lessons and by interacting with them both during and after the lesson; the teacher can also use questionnaires and other means of evaluation, usually after a specific activity. However, it is worth considering whether it is really situational interest that is evaluated by employing such methods, and whether observation or the participants' own experiences offer more accurate information about the level of situational interest.

2. Situational Interest

Interest has been identified as a way to motivate people to learn (Silvia, 2008) and to develop higher quality motivation orientations towards a certain topic (Deci, 1992). Hidi (2006) describes interest as 'a unique motivational variable, as well as a psychological state that occurs during interactions between persons and their objects of interest, and [it] is characterised by increased attention, concentration and affect' (p. 70). Interest has usually been divided into two different categories: situational and personal interest. While situational interest is awakened by something in the environment that spontaneously captures the attention, personal interest has a permanent connection with a person's values and knowledge structure (Schiefele, 1991). Several researchers (Krapp, 2002) have made a distinction between *catching* and *holding* situational interest. Hidi and Renninger (2006) have proposed a four-phase model of interest development, in which the aroused (caught) and maintained (held) situational interest first develops into emerging personal interest and then into a well-developed personal interest—that is, a relatively stable, predisposition-like interest with high personal relevance to 'the whole spectrum of contents and actions that make up the curriculum of an entire educational program' (Krapp, 2005, p. 382). Linnenbrink-Garcia, Patall, and Messersmith (2013) have further developed this model, proposing that maintained situational interest may be divided into maintained feeling-related situational interest and maintained value-related situational interest.

In a classroom setting, triggered situational interest is externally supported by the teacher primarily through the choice of activities and contents, and it may cause positive changes at both the cognitive and emotional levels. Linnenbrink-Garcia et al. (2010) see situational interest as a significant predictor of individual interest. Silvia (2008) has conceptualised interest as an emotion that arises as a result of subjective cognitive appraisals of the novelty and complexity of an event, as well as its comprehensibility, referring to individuals' considerations about whether they have the knowledge, skills and resources needed for coping with the new situation. He emphasises that 'if people appraise an event as new and as comprehensible, then they will find it interesting'. The arguments of Linnenbrink-Garcia et al. (2013) further support the view that practices implemented by the teacher may relate to the development of students' immediate interest. Tapola, Veermans, and Niemivirta (2013) suggest that, for primary school pupils with relatively low prior knowledge of the topic, the concreteness of simulations seems to be a key factor in maintaining and enhancing students' situational interest during the task.

A curriculum guides pupils' actions—not their free will—and it is therefore valuable to know how the development of interest might be supported. The shift from catching to holding situational interest may be achieved by choosing appropriate learning activities that make the topic personally relevant (Schraw, Flowerday, & Lehman, 2001). As already mentioned, interest is a motivational variable, and supporting motivation may support interest in a certain task. More specifically, according to the self-determination theory (SDT) of motivation (Ryan & Deci, 2002), lesson tasks should be chosen to support the fulfilment of pupils' basic psychological needs. As proposed in the SDT, these needs encompass the need for autonomy (the desire to be self-initiating and to have a sense of acting in accordance with one's own sense of self), competence (the desire to feel efficacious, to have an effect on one's environment, and to attain valued outcomes) and relatedness (the desire to feel connected with and to be accepted by significant others). Motivation can be seen as a result of interactions between an individual's need system and environmental factors that interfere with or support the need fulfilment process (Ryan & Deci, 2002).

Teaching is interaction between teacher and pupils; the teacher experiences pupils' level of interest as she proceeds with her lesson, and she probably considers making some changes if the interest level of the pupils seems low. The teacher may see the direction and maintenance of pupils' attention and physical activity. She may also get a sense of the emotional aspect of interest, based on the pupils' outward appearance, but the validity of this appraisal may vary, depending on pupils' temperament and regulation of emotional expression as well as on the atmosphere and norms of the group. Pupils may have reasons for hiding their real state of interest from the teacher.

3. Methods of Assessing Situational Interest

We are interested in studying pupils' experiences of situational interest in the naturally occurring classroom context at certain moments of the lesson. When defining experience, we follow Hektner, Schmidt, and Csikszentmihalyi (2007), who define it as any contents of consciousness, thoughts, feelings and sensations. As the events in a certain context follow each other and constitute a continuously changing stream of experiences, tracking those experiences in a reliable way is challenging.

A person's interest level can be investigated during the activity or afterwards. It should be considered that there is a difference between measuring interest at a certain moment in time and retrospectively trying to remember that moment and then to figure out how interesting it was. In what follows, we consider the benefits and problems of both approaches. If pupils are asked about their interest levels after an activity, the activity itself is not interfered with by the process of measurement. However, it may be difficult for children to recapture their emotional state, and they may even have difficulties in remembering what was actually happening during the activity. The recall of the situation may be facilitated by the use of stimulated recall—for example, by watching photos or video-clips of the situation. However, it may still be difficult to trace the nuances of the emotional state retrospectively.

Memory bias is diminished if experiences are collected during the activity. Hektner et al. (2007) argue that the experience sampling method (ESM) is a reliable means of tracking an individual's experience at certain moments in time. Traditionally, ESM means repeatedly collecting written responses to questions tailored to fit the particular situation (Hektner et al., 2007). This reporting would take place multiple times a day, usually over a period of several days (Katz-Buonincontro & Hektner, 2014). Participants would usually hear a signal at random moments in time and would then answer questions related to their feelings and experiences at that particular moment (Csikszentmihalyi & Hunter, 2003). Besides using traditional paper and pencil questions that students complete during the lesson after specific activities (which, in the context of science lessons, have been used, for example, by Palmer 2009), ESM studies have also used tools designed for mobile phones or iPods as a means of collecting experiences (Katz-Buonincontro & Hektner, 2014; Litmanen, Lonka, Inkinen, Lipponen, & Hakkarainen, 2012). Asking about experiences at the very moment they take place diminishes the bias that might occur if asked retrospectively about those experiences. ESM makes it possible to separate the immediate context of a certain feeling from longer term conditions (Csikszentmihalyi & Hunter, 2003).

However, measuring an interest experience interferes with the situation because a student has to interrupt the learning activity in order to indicate her interest level. Depending on the time and concentration required for the evaluation itself, students' attention may be more or less shifted away from the actual activity that should be evaluated, and they may instead be evaluating the interestingness of the evaluation situation. Reading the instruction and writing the answer are activities that completely capture one's attention, making it unclear what is actually evaluated. Especially when the research participants are children, it must be taken into account that reading and writing skills are not fully developed, and owing to the limited capacity of attention and working memory (Gazzaniga, Ivry, & Mangun, 2009), the measuring situation may interfere unduly with the activity itself. For example, in the research of Katz-Buonincontro and Hektner (2014), the three to four minutes that it took the students to answer is subjectively a very long time for primary pupils. And if the context of the study is a double 45-minute science lesson, answering a 4-minute questionnaire several times leaves little time for other activities. In the present research, this interference effect of measuring was considered. Previous ESM research has also been conducted with smartphones in the context of an upper secondary (high) school or university context (Litmanen et al., 2012). In our study, the students are primary school pupils (age 10–11), and the use of smartphones was considered too complex for them in the middle of a learning situation.

In order to complete the picture about the pupils' interest level, two observers evaluated that the interest level from the video data, based on agreed criteria. The use of video enables richer and more reliable data about complex social interaction than is possible with traditional alternatives such as field notes, participant recollections or transcripts of audio recordings (Pea, 2006). Video technologies provide ways of collecting, sharing, studying, presenting and archiving detailed cases of practice to support teaching, learning and intensive study of those practices, and for that reason many science learning research projects now incorporate a video component (Derry et al., 2010). In their article, Derry et al. (2010) argue that video technologies provide researchers with 'microscopes' that increase the level of detail of the data and enable reanalysis by multiple investigators. Furthermore, Goldman (2014) emphasises the power of the video to reveal nuance and subtlety.

Granted the benefits of using video in research, Derry et al. (2010) address four sets of challenges arising from the wider use of video technologies in research. The first of these relates to selection: how to decide which elements should be recorded, or which aspects should be selected for further examination. In the present research, selection was based on measurement time points. Second, Derry et al. (2010) point out the challenges for analysis. Video analysis can range from approaches hoping to revealing unanticipated phenomena (inductive) to top-down (deductive) approaches that code events mostly conceptualised prior to data collection. In the present case, the analytical framework followed from the theoretical background of the study and the behavioural aspects of interest, and the analysis was guided by the research questions. We followed the suggestions of Derry et al. (2010) in analysing the observations twice in order to strengthen the likelihood of generating findings that would be both reliable and valid. The third concern related to video research is the technology used. Pea (2006) introduces a variety of technological solutions that are most appropriate for data collection. The fourth concern relates to the ethics of video studies, and especially to how participants' privacy can be protected in sharing the videos. This aspect was not particularly relevant in the present case because the data were not shared other than among the three authors.

4. Research Desideratum and Research Question

As outlined in Section 1, situational interest is regarded as a channel to more personalised and internalised forms of motivation and interest and, further, to student learning. Accurate information about what pupils find interesting is useful for teachers when planning their teaching. For the present research, a rich instructional context was designed, and two methods were used to measure pupils' situational interest: electronic student response devices (clickers) and video-based observations. Our aims were as follows: (1) to test an electronic student response system (clicker) in order to obtain real-time information about primary school pupils' in-the-moment level of interest while minimising the impact of measurement on the lesson; (2) to compare the data gathered (by use of clickers) with observed behavioural indicators of interest; and (3) to gather information about interest development among pupils during the lesson.

The aim of investigating what pupils find interesting in the lesson was placed last on the list of aims because this was a pilot study, concentrating on the methodology of evaluating the interest level. After analysis of the results, it is hoped that further interest level evaluations can be collected from a greater number of pupils, and that teachers may use this tool in order to plan lessons and teaching sequences that better support the pupils' interest.

After reviewing the literature concerning interest and its external signs (Gross, 2005; Silvia, 2008), we hypothesised that the interest level expressed by pupils would be compatible with the observed one. The specific research question is How do the clicker data compare with the observational data?

5. Methods of Data Collection and Analysis

The electronic student response system (www.mimio.com) was chosen as the least intrusive means of measuring pupils' experienced s of situational interest in a science class as compared with paper and pencil questionnaires. Instead of a written response, this type of ESM tackles the experience of interest in a certain situation by compressing it into one numeric value. For present purposes, the electronic student response system handset will be referred to as a 'clicker'. Besides the data yielded by the clickers, the picture was consolidated by the observations of two researchers.

The study was conducted in one class of fourth-graders ($N = 25$, age 9–10 years, 12 female and 13 male). One boy and one girl were absent on the day of the study, so they did not participate. One girl did not have permission from her parents to participate; she participated in the lesson but did not in data collection. All the other pupils' parents had given permission for their children's participation. The first author was the class teacher and so knew the pupils very well. The second author was not acquainted with the pupils beforehand.

The topic of the lesson was heat transfer, set in the context of appropriate clothing for different weather conditions. To ensure some variation in pupils' interest, the lesson had three main elements: an interactive demonstration with a thermal camera, teacher-led discussions and the conduct and presentation of an inquiry task in small groups. The lesson is described in detail in the next section.

As a means of gathering data about pupils' subjective experience of their level of situational interest, each pupil was given a handset or 'clicker', with which they had familiarised themselves beforehand. On hearing a tinkle of a bell and noticing the lights of the clicker go on, the pupils were instructed to reflect on how interesting their experience of learning was at that particular moment in time and then to push the appropriate button on their clicker (1 = very boring to 5 = very interesting). A chart was then generated from the data gathered by the clickers, with the columns of the table representing the different measuring time points.

The lesson was video recorded with two cameras that showed the whole classroom and most moments of measurement. These cameras showed all the pupils accept the one who did not participate in the research. This pupil was placed in the classroom at a blind spot for the video recorder, and her responses were removed immediately after the lesson. Still photos were taken from the videos, showing the classroom and the pupils just before the sound of the bell. We selected the frame where the bell had started to sound but pupils had not yet reacted. Both researchers independently analysed the pictures by evaluating the level of pupils' interest just before the clicker data were collected.

Before the evaluation, the researchers had agreed on evaluation principles for assessing pupils' interest, based on the visible emotional components of interest. Gross (2005) describes emotions as consisting of subjective experiences, physiological reactions and associated behaviours. More specifically, Silvia (2008) suggests that the behavioural aspects of interest as indicators of emotion include, for example, facial expressions, concentration and approach-oriented actions. The adopted scoring system was as follows.

(1) Pupil's attention is directed elsewhere than towards the activity, and posture is withdrawing or away from the activity.
(2) Pupil's attention is directed towards the activity, but posture is withdrawing, or the pupil seems tired or bored.
(3) Pupil's attention is directed towards the activity, and posture and facial expression are neutral.
(4) Pupil's attention is directed towards the activity, posture is approaching and facial expression is positive. The pupil may express a wish to say something by raising her hand.
(5) Pupil's appearance is enthusiastic, facial expression seems glad and the pupil may be smiling.

The interest levels of all participants were evaluated from video playback by the first and second authors; in total, there were 259 evaluations. Based on these, Cohen's kappa was calculated using SPSS. The value was relatively low (.48, $N = 259$, $p < .001$). In 92 situations, there was a discrepancy between the two observers' evaluations. In approximately two-thirds of these differing evaluations, the magnitude of the difference was one unit. In approximately one-third of these differing evaluations, the difference was two units (which was the maximum difference). Typically, the author who was the class teacher interpreted the criteria in a more stringent way, requiring external interest features to be more strongly visible. Subsequently, the researchers compared their results, discussed discrepancies and reached agreement about the appearance of pupils' interest levels at a certain moment at every measurement point. The criteria for interest levels guided the process of searching for agreement. Each of the situations including any discrepancy was analysed again, and compromises were made in both directions, so that neither researcher's opinion was more dominant. Ultimately, there were two sets of data per pupil—one based on the clickers and one based on the observations.

The clicker data were collected in a spreadsheet. Averages and standard deviations of clicker and observational data were calculateD for the whole group ($N = 22$) at every measurement point. These averages are presented in Figure 1 and Table 2. For the 15 participants with whole data sets, sequence averages and standard deviations were calculated. These sequence averages are presented in Table 3 and in Figures 2–5. Finally, sequence averages and standard deviations were calculated for the groups of boys ($N = 8$) and girls ($N = 7$) who had complete data sets; these are presented in Table 4 and Figure 6.

Finally, the time taken to express the interest level was measured from the video recordings. For each vote per pupil, the interest level was defined as the time elapsing from the bell sound to the point at which the pupil continued the activity she or he was doing before the voting request. The average time taken for measurement was 15.8 seconds, and the standard deviation was approximately 6.5 seconds. It can be argued that, in general, such measurement interferes very little with lesson activity.

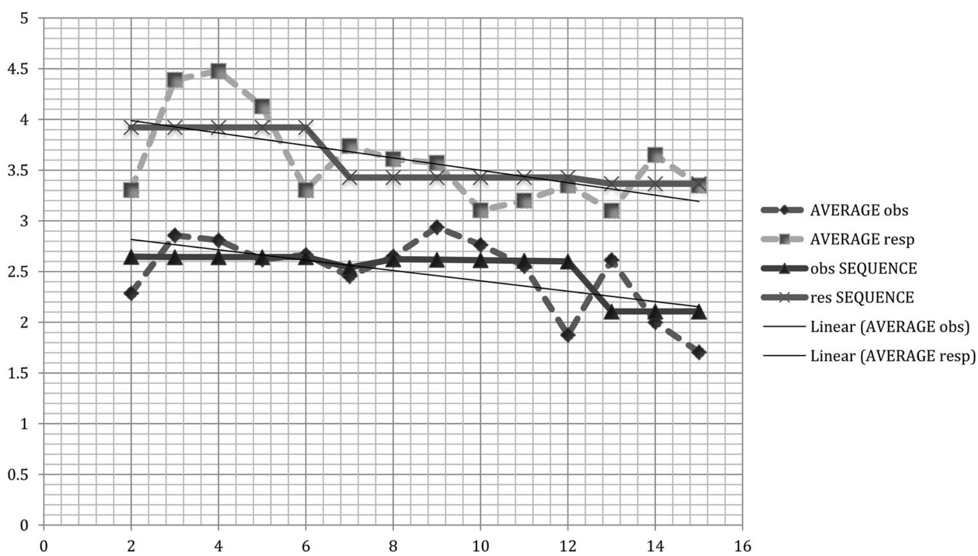

Figure 1. Averages based on single measurements and sequences, based on observations and respondents' evaluations

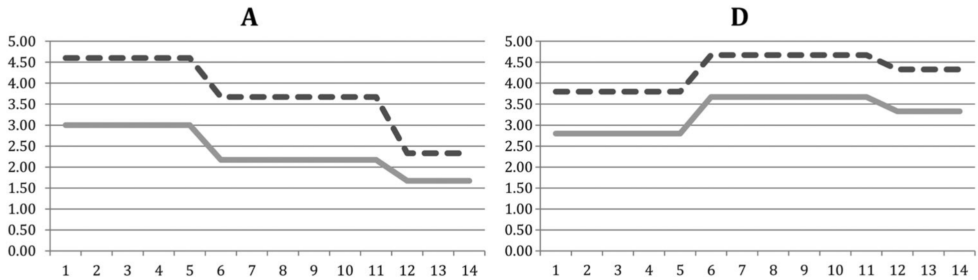

Figure 2. Sequence averages of expressed (dashed line) and observed (solid line) interest values of pupils A and D

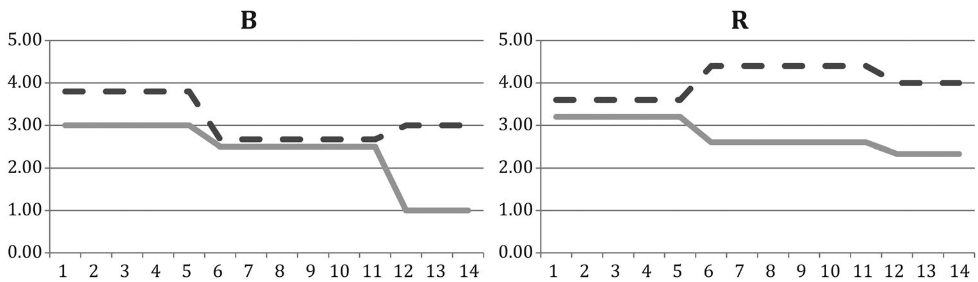

Figure 3. Sequence averages of expressed (dashed line) and observed (solid line) interest values of pupils B and R

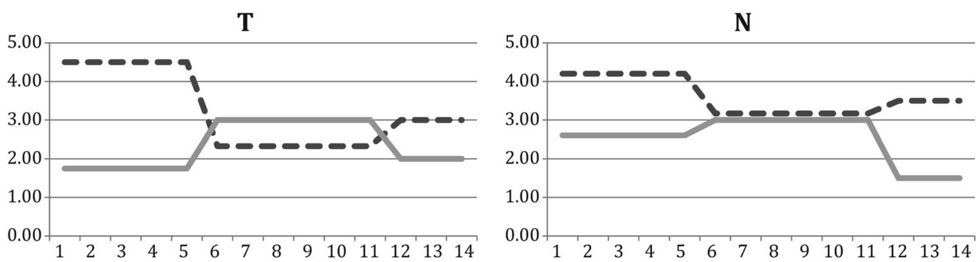

Figure 4. Sequence averages of expressed (dashed line) and observed (solid line) interest values of pupils T and N

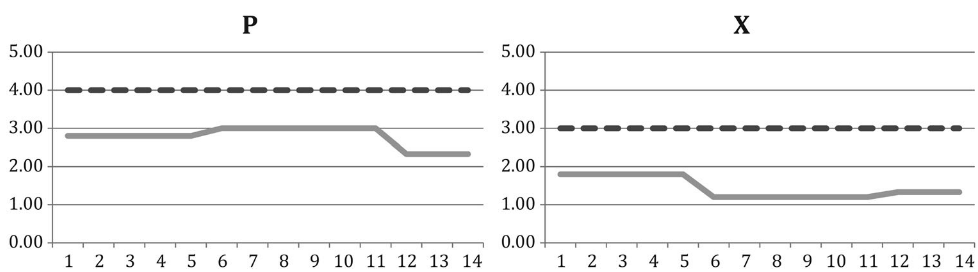

Figure 5. Sequence averages of expressed (dashed line) and observed (solid line) interest values of pupils P and X

5.1. *The Structure of the Lesson*

The topic of the lesson constituting the context of this research was heat transfer and what kinds of demands it makes on clothing in winter conditions. The lesson was designed with particular regard to three aspects. First, the content of the lesson was chosen to be compatible with the aims of the curriculum, and to be interesting and relevant from the pupils' point of view in order to catch situational interest. Second, in relation to the demand of relevance, the lesson topics were designed to have some connection with pupils' lives outside the classroom. Finally, the instructional methods and activities were designed to be versatile in order to meet the basic psychological needs of different pupils and so to hold situational interest. According to the SDT of motivation proposed by Ryan and Deci (2002), fulfilling basic needs is beneficial for the development of high-quality motivation. (These needs are described in more detail before.) In what follows, the structure of the lesson is elaborated from the point of view of possible ways of supporting the fulfilment of basic psychological needs according to SDT, along with possible ways of influencing situational interest.

In his research, Palmer (2009) found that in the context of a science inquiry lesson, students found novelty, choice, physical activity and social involvement to be important sources of interest. Each of the three main parts of this lesson included two aspects: interactive demonstration to awaken curiosity, and group work and presentations of the results of group work to promote physical activity and social involvement. The four-phase interest development model of Hidi (2006) was also kept in mind, the aim being first to trigger pupils' interest with a demo and then to awaken pupils' own experiences related to the topic, maintaining their situational interest by activating those experiences.

Table 1 shows the lesson activities and occasions of measurement. In detail, the course of the lesson was as follows. The lesson took place at the beginning of

Table 1. Structure of the lesson

Measurement number and time	Sequence	Activity in the classroom
1 ( )		Trial measurement
2 (10.10)	1	Introduction to the topic
3 (10.15)		Demonstration and teacher-led conversation
4 (10.20)		Demonstration and teacher-led conversation
5 (10.24)		Demonstration and teacher-led conversation
6 (10.29)		Background information for group activities
7 (10.38)	2	Instruction for group activities
8 (10.42)		Group activities
9 (10.50)		Group work continues
10 (10.55)		Group work continues
11 (11.00)		Group work continues
12 (11.04)		Return to original seats
13 (11.11)	3	Presentations by the pupils
14 (11.18)		Presentations by the pupils
15 (11.25)		Concluding discussion and end of lesson

December 2012 as the first and second lessons of the school day. In primary education in Finland, a 45-minute lesson is typically followed by a 15-minute break. In this case also, there was a 15-minute break between the two lessons, during which the pupils went into the schoolyard. At the beginning of the lesson, the clicker was introduced as a data collection device. The video cameras were located in the corners of the classroom.

Before the video recording started, the use of the clickers was rehearsed once. This was the first measurement, and it is not included in the data analysis. The actual lesson and the video recording started at the same moment. As mentioned, the topic of the lesson related to heat transfer. The teacher started the lesson by introducing the pupils to the programme of the day and writing it on the blackboard, a routine that took place every day. The teacher then continued by asking about the weather on that particular day. The pupils answered the question, and the answer (temperature) was written on the blackboard. This was also an introduction to the demonstration and so belonged to sequence 1.

After the starting routines of the day, a demonstration was introduced. The aim of this demonstration was to show pupils the amount of heat loss from the skin in winter weather conditions without proper equipment, and to concretise the importance of proper clothing during wintertime. In Finland, it is often quite cold in December, and it is essential that pupils are dressed properly during their outdoor breaks. For the demonstration, one pupil had filled two big plastic containers with snow from the schoolyard. Both containers were placed on the document camera so that they were visible on the screen to all pupils. One volunteer pupil put on one of his gloves and came in front of the classroom. He then put the gloved hand into one of the containers and the bare hand into the other. After a while, the hands were withdrawn, the glove was removed and the temperatures of both hands were examined with a thermal camera. Both the demonstration and aspects related to the temperature of the skin were discussed. Picking a volunteer supported the pupils' feeling of autonomy (they could choose whether to volunteer or not), as well as the chosen pupil's feeling of competence.

After the demonstration, another phenomenon related to weather (other than temperature), was explored, wind. The units of measurement for wind speed and the effects of wind blowing at a certain speed were discussed. Then, a table combining the effects of wind speed and temperature was introduced to the pupils, and the teacher gave instructions for the group task. Each group of pupils was given a table of wind speeds and temperatures, along with their combined effects on a human being. A certain wind speed and temperature was allocated to each group, and the pupils then had to examine their combined effects and design a suitable set of clothes for a person going out in those weather conditions. Finally, the pupils were to draw their designs on a template. The broader aim of the group task was to combine information from the demonstration (that heat transfers from higher to lower temperature, and that insulation prevents heat loss) with information about the effect of wind on the experienced temperature, and to apply this information to design a solution for an everyday problem: what kinds of clothes are most suitable for certain weather conditions. The aims of the task also related to working together with peers. The task was structured in such a way that the teacher gave the pupils the temperature and the wind speed, but the rest of the designing was done autonomously by the task group. The pupils were helped by the teacher in collaborating if their views were conflicting.

After introduction of the task, pupils moved into their groups. The teacher gave a final summary of the instructions, and then the pupils went on a break. After the 15-minute break, pupils started working in small groups. When they finished working, they went back to their own seats, and their working groups started to present their results to the rest of the class. During presentation of the group work, the teacher asked questions of the groups, and other pupils commented as well. After the final voting session, the teacher concluded the lesson, and the groups left the classroom to have lunch. The group work phase supported the pupils' feelings of autonomy as a group and their feeling of relatedness. In the presentation phase, the pupils' feeling of competence was supported, as they received constructive comments about their work from the teacher and from their peers.

In Table 1, the exact times of measurement are mentioned. The lesson is divided into three different sequences: demonstration, group work and presenting the results of the work.

6. Results

Figure 1 presents the results of this study with respect to the whole group, and Table 2 presents the exact numeric values (averages and standard deviations). In Figure 1, there are four lines. The lines labelled 'average_respondent' and 'average_observer' are constructed by counting the average of responses or observations of all participants at a certain moment of measurement. Lines that are labelled 'respondent_sequence' and 'observer_sequence' reflect the average of all responses or observations during a certain sequence of the lesson. As mentioned above, the sequences involved teacher demonstration, small group activities and pupils' presentations. Along with these four lines, the linear averages of participants' responses and observations are presented. The horizontal axis in the figure represents the moment of interest measurement, and the vertical axis represents the level of interest.

Besides combining the data from the whole group of pupils, the pupils' interest levels were separately considered. Table 3 represents the sequence averages and standard deviations of all pupils who had complete sets of data, based on clickers and observations as well as on average response time. The overall average time taken to respond to interest level requests was 16.5 seconds. Some pupils were excluded either because they were absent from the second part of the lesson or because they participated in small group activities in other groups, according to their personalised learning programmes.

In analysing the results, emphasis was placed on the shapes of the lines because different pupils may have set the starting level differently in evaluating their interest. In other words, although the researchers agreed about certain criteria for interest levels 1–5, the pupils may have had different conceptions of their own evaluation criteria—how it feels to be interested at level three, for example. Additionally, a pupil's

Table 2. Averages and standard deviations based on single measurements and sequences, based on observations and respondents' evaluations

	Sequence 1					Sequence 2						Sequence 3		
Measurement	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AVE_obs	2.286	2.857	2.810	2.619	2.667	2.455	2.650	2.938	2.765	2.556	1.875	2.615	2.000	1.706
(SD)	(0.825)	(0.990)	(0.587)	(0.844)	(0.836)	(0.940)	(0.654)	(1.144)	(0.941)	(1.212)	(0.857)	(1.273)	(1.604)	(0.749)
AVE_resp	3.304	4.391	4.478	4.130	3.304	3.739	3.609	3.571	3.105	3.200	3.350	3.100	3.650	3.350
(SD)	(1.040)	(0.642)	(0.827)	(0.947)	(0.997)	(1.031)	(1.093)	(1.178)	(1.293)	(1.122)	(0.853)	(1.136)	(0.963)	(1.062)
obs_SEQ	2.643	2.643	2.643	2.643	2.643	2.540	2.540	2.540	2.540	2.540	2.540	2.107	2.107	2.107
(SD)	(0.201)	(0.201)	(0.201)	(0.201)	(0.201)	(0.334)	(0.334)	(0.334)	(0.334)	(0.334)	(0.334)	(0.379)	(0.379)	(0.379)
res_SEQ	3.922	3.922	3.922	3.922	3.922	3.430	3.430	3.430	3.430	3.430	3.430	3.367	3.367	3.367
(SD)	(0.517)	(0.517)	(0.517)	(0.517)	(0.517)	(0.228)	(0.228)	(0.228)	(0.228)	(0.228)	(0.228)	(0.225)	(0.225)	(0.225)

Table 3. Sequence averages and standard deviations of pupils' expressed and observed interest values and average time taken for measurements

Pupil	Data source	Sequence 1	Sequence 2	Sequence 3	Time used
		M (SD)	*M* (SD)	*M* (SD)	
A	Clicker	4.60 (0.49)	3.67 (0.94)	2.33 (0.47)	
	Video	3.00 (0.00)	2.17 (1.07)	1.67 (0.94)	9.2
B	Clicker	3.80 (0.75)	2.67 (0.47)	3.00 (0.82)	
	Video	3.00 (0.00)	2.50 (0.96)	1.00 (0.00)	20.6
D	Clicker	3.80 (1.47)	4.67 (0.47)	4.33 (0.94)	
	Video	2.80 (0.40)	3.67 (1.37)	3.33 (1.70)	16.8
E	Clicker	4.00 (0.89)	3.50 (0.50)	3.00 (0.00)	
	Video	2.40 (0.49)	3.17 (1.21)	3.67 (1.25)	15.5
F	Clicker	3.80 (1.47)	3.00 (1.00)	2.50 (0.50)	
	Video	1.80 (0.98)	1.67 (0.47)	3.50 (0.50)	18.9
G	Clicker	3.60 (0.49)	3.67 (1.37)	4.50 (0.50)	
	Video	3.40 (0.49)	2.67 (0.75)	3.00 (1.00)	20.0
H	Clicker	5.00 (0.00)	5.00 (0.00)	3.00 (2.00)	
	Video	3.80 (0.75)	2.67 (0.75)	2.50 (1.50)	16.8
L	Clicker	4.20 (1.17)	2.00 (1.15)	2.00 (1.00)	
	Video	2.80 (0.98)	2.50 (0.96)	2.00 (1.00)	35.1
M	Clicker	3.60 (1.02)	2.17 (1.46)	4.00 (1.00)	
	Video	2.60 (0.49)	2.50 (0.96)	1.50 (0.50)	21.1
N	Clicker	4.20 (0.75)	3.17 (1.07)	3.50 (0.50)	
	Video	2.60 (0.49)	3.00 (0.58)	1.50 (0.50)	9.1
P	Clicker	4.00 (0.00)	4.00 (0.00)	4.00 (0.00)	
	Video	2.80 (0.75)	3.00 (0.58)	2.33 (1.25)	7.3
R	Clicker	3.60 (0.80)	4.40 (0.80)	4.00 (0.00)	
	Video	3.20 (0.98)	2.60 (0.80)	2.33 (0.94)	13.4
S	Clicker	4.00 (0.89)	3.17 (1.07)	4.67 (0.47)	
	Video	2.80 (0.40)	2.67 (0.47)	1.67 (0.47)	6.9
T	Clicker	4.50 (0.87)	2.33 (0.47)	3.00 (0.00)	
	Video	1.75 (0.43)	3.00 (0.58)	2.00 (1.41)	21.1
X	Clicker	3.00 (0.63)	3.00 (0.00)	3.00 (0.00)	
	Video	1.80 (0.75)	1.20 (0.40)	1.33 (0.47)	15.5

decision at the first time point of measurement (measurement 2) established a level against which that pupil compared his or her increased or decreased interest.

When comparing the lines representing averages of all participants' responses with those representing the averages of researchers' observations of all participants at certain measurement moments, it can be argued that, at the beginning of the lesson in the sequence during which the demonstration took place, the interest seems first to increase and then to decrease as the demonstration goes on. So, during the demonstration, the pupils' expressions seem easy to interpret. The averages of participants' responses are higher than the averages based on observations, which can be interpreted to suggest that pupils do not express as much interest through their gestures and facial expressions at the beginning of the lesson as they may in fact experience. However, based on both sets of data, it seems that the pupils' interest levels dropped towards the end of the demonstration.

The interest levels of pupils during the next sequence of the lesson—the group work phase—proved more difficult to interpret. The lines representing the averages of observations and of participants' responses at certain measurement moments reflect changes in differing directions, except in the interval between measurements 9 and 10, during which interest seems to have decreased. This might be explained by the organisation of the classroom, in which the pupils moved from their original places to sit with their group. Some pupils sat in a position that made their expressions difficult to interpret, and because the task required physical activity (e.g. drawing), the interpretation of the direction of some pupils' attention may have been ambiguous. In the group work situation, the pupils were allowed to allocate group tasks individually to group members, without the strict supervision of the teacher. This may have caused an uneven distribution of tasks, with some pupils concentrating on something other than the task itself. These students may have looked interested but may actually have been interested in something other than the task, which would explain why they might have evaluated their interest level as lower with respect to the actual task.

The interpretation of the last sequence of the lesson—presentation of the group work—also proved quite ambiguous to observe. In this sequence, the pupils were in different positions with respect to each other as compared to the previous sequence of the lesson. While some were presenting their work at the moment of measurement, others were watching other pupils present their work. The presenters (three pupils at a time) were located outside the picture.

When concentrating on individual pupils' sequence averages, only those pupils for whom data collection was complete or those with only one missing measurement were included in the analysis. Altogether, 15 pupils were included. Of those included in the analysis, seven were female and eight were male. The sequence averages of pupils' evaluations varied between 3.00 and 5.00 in the first sequence, between 2.00 and 5.00 in the second sequence and between 2.00 and 4.67 in the third sequence.

We were especially interested in the direction of change in the level of interest at those points of the lesson where one sequence ended and another began. The data based on individual pupils can be classified into four different groups, based on the shape of the graph.

(1) *Combinations of clicker and observation data that seem to fit very well to each other (two pupils)*. The shapes of the graph based on the clicker data and on observations are compatible. In fact, if corrected with a suitable coefficient, the graphs of these two pupils are almost convergent. This can be taken to mean that these pupils are easy for the teacher to interpret; in other words, their appearance seems to offer accurate information about their interest level. Pupils A and D are the only examples of this category (Figure 2).

(2) *Pupils whose interest change direction is the same for both clicker and observation data in one of the transfer phases of the lesson but not in the other.* Eight out of 15 pupils belong to this category. Five of these eight reported a change that is compatible with observations at the first transfer point of the lesson, while three reported a parallel change at the

second transfer point of the lesson. These results indicate that only at certain points of the lesson was the observer able to make almost correct evaluations of the level of pupils' interest. Pupils B and R have been chosen as representatives of this category (Figure 3).

(3) *Pupils whose expressions of interest and appearance have been interpreted in an inaccurate way compared to their own announcements (three pupils)*. The direction of change in the observed interest level is the opposite of the pupils' own evaluation at both transfer points of the lesson. This indicates that the observers have made a wrong interpretation about the pupils' interest levels. Pupils T and N are representatives of this category (Figure 4).

(4) It may also be that not all pupils were engaged in the task of evaluating interest by using clickers. This assumption is based on data that show that the two pupils in this fourth category expressed their interest level to be the same for the whole double 45-minute lesson. However, an alternative explanation is that these pupils really did not experience their level of interest changing. Pupils X and P are representatives of this category (Figure 5).

Another comparison was conducted by comparing the sequence averages of expressed and observed interest values of boys and girls (Table 4 and Figure 6). Based on this comparison, it seems that, on average, boys of this group were easier to interpret with respect to their interest expressions. The shapes of the graphs based on clicker and observational data are compatible, although the difference in the averages of observed interest between sequences 2 and 3 is very small (from 2.25 to 2.23). Boys as a group belong to category 1; girls as a group belong to category 3, as the direction of change in observed interest level is the opposite of the pupils' own evaluation at both transfer points of the lesson. Boys' and girls' expressed average interest is almost the same in the first sequence of the lesson (3.93 and 4.04, respectively) and exactly the same in the second sequence of the lesson (3.36). In the third sequence of the lesson, girls on average reported their interest as having increased while the boys' reported interest level decreased. It may have been that the presentation phase at the end of the lesson appealed to the girls more than to the boys, but the girls hid their increased interest from the observers, who evaluated the girls' interest as having decreased.

In summary, a graph was constructed based on both observational and clicker data for the whole group of pupils and then for 15 pupils separately. Taking the group as a

Table 4. Sequence averages and standard deviations of boys' and girls' expressed and observed interest values

	Sequence 1	Sequence 2	Sequence 3
	M (SD)	*M* (SD)	*M* (SD)
Boys_ave_resp	3.93 (0.60)	3.36 (0.97)	3.17 (0.85)
Boys_ave_obs	2.80 (0.67)	2.25 (0.51)	2.23 (0.71)
Girls_ave_resp	4.04 (0.23)	3.36 (0.73)	3.64 (0.65)
Girls_ave_obs	2.59 (0.39)	3.00 (0.35)	2.21 (0.90)

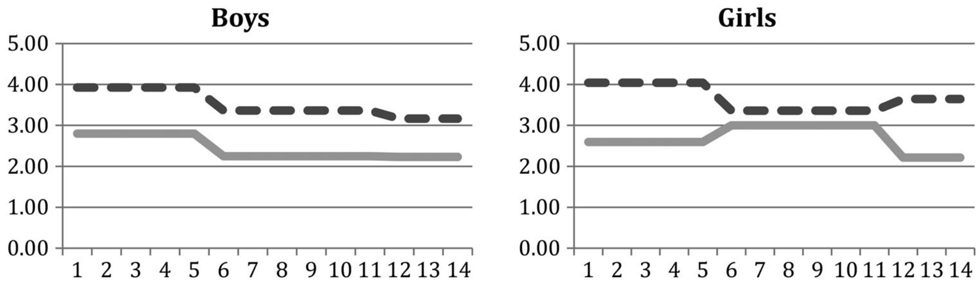

Figure 6. Sequence averages of expressed (dashed line) and observed (solid line) interest values of boys and girls

whole, the shapes of the lines representing measurements at certain moments are somewhat compatible during the demonstration sequence at the beginning of the lesson. Subsequently, the changes do not occur in parallel or even in the same direction, other than between measurements 9 and 10. The sequence averages of the observations and the participants' self-evaluations for the whole group show better compatibility with each other, except that the pupils seem to experience more interest at the beginning of the lesson during the demonstration sequence than they express. The drop in the interest level between sequences 2 and 3 and between the group work and pupils' presentations is obvious from both observations and participants' self-evaluations. This drop is steeper in respect of pupils' facial expressions as interpreted by the observers.

When considered one pupil at a time, it appears that the pupils distribute into four categories. In the first of these categories, change in the interest level is interpreted correctly by the observers as compared with the pupils' own reports. In the second category, interest change has been interpreted correctly at one of the transfer points of the lesson but not at another. In the third category, the changes have not been interpreted correctly for any of the transfer points. In the fourth category, the two pupils do not report any change in their experienced interest levels. We argue that most pupils' expressed interest is not easy to interpret. On average, boys seem easier to interpret than girls. Difference between students' response and video observation evaluation was analysed using paired samples *t*-test. The analysis was conducted separately for boys and girls. Cohen's $d = (M1–M2)/\text{SD.pooled}$, where $\text{SD.pooled} = \text{sqrt}((\text{SD1}^2 + \text{SD2}^2)/2)$ (Table 5).

Table 5. Sequence statistics of paired samples tests (responsed–observed) for boys and girls.

Sequence	*Gender*	*t*	*df*	*Sig.*	*d*
1	Boy	5.35	7	0.01	−2.19
2	Boy	3.09	7	0.18	−1.55
3	Boy	2.37	7	0.49	−1.43
1	Girl	5.96	6	0.01	−3.69
2	Girl	1.65	6	1.50	−0.55
3	Girl	3.28	6	0.17	−2.87

7. Discussion

In this study, pupils' situational interest during a science lesson was examined by combining an electronic student response system (clickers) and observations from video recordings. The research question was *How do the clicker data compare with the observational data?* Answers to this question were arrived at by counting the averages of observations and participants' self-evaluations at certain measurement moments, the averages of observations and participants' self-evaluations per sequence and the linear averages of observations and participants' self-evaluations during the course of the lesson, as well as the sequence averages of individual pupils and boys and girls separately, and then constructing graphs based on the averages of observations and participants' self-evaluations during certain sequences of the lesson.

Situational interest has traditionally been examined using paper and pencil tests (Palmer, 2009). However, we considered that this kind of test interrupts the activity, especially among younger children, as it may take them some time to pick up their pencils and write down the answer; in terms of cognitive processes, this shifts their attention away from the activity to another focus. On the other hand, surveys conducted to examine students' interest retrospectively (e.g. Kärnä, 2012; Lavonen, Byman, Uitto, Juuti, & Meisalo, 2008)—that is, at some other time than during the activity—usually convey a more general picture of interest and are more closely related to personal forms of interest. We wanted to gather information about an authentic situation by means of a method that was easy to use and that minimised disturbance of the activity itself. According to our experience, and based on the data for time spent in voting during the lesson, the clicker seemed to meet these requirements well. Time taken to measure the interest level was very small when compared to other methods, such as in Katz-Buonincontro and Hektner (2014), which take several minutes. Using the system often would probably make it still less intrusive, as the pupils would come to use it automatically and routinely, with less need to shift their attention away from the activity itself.

The lesson under investigation related to heat transfer and encompassed three different sequences. The first of these was a demonstration that aimed to arouse situational interest; the second involved small group activities; and the third involved the presentation of results of the group activities. Data collection using these two methods yielded two different pictures of pupils' interest levels during science lessons—and here, we emphasise the word *different*. Clicker and observational data from 15 pupils were compared, and in only two cases did the shapes of the curves based on observation and on clicker data resemble one another. In fact, by using an appropriate coefficient, the curves in these two cases may have been almost convergent. However, in the remaining 13 cases, the observers' evaluations did not reflect the pupils' own expressions of their level of situational interest. This difference can be interpreted from different perspectives.

The first interpretation is that it is the observer who has an incorrect view of the situation and has failed to grasp the pupil's state of mind at a certain moment in time, so misunderstanding the external expressions and gestures. A number of factors may have caused these biases. The lesson encompassed three sequences, between which the pupils physically changed places. These changes in the classroom setting, when pupils changed places during group work, caused difficulties for the observation. When conducting such observations in future projects, pupils' seats and intended activities must be organised more carefully, and video recording needs to be more extensive. That said, the method of data gathering was designed to interfere with the normal lesson as little as possible.

The second interpretation of the differences between the two data sets is that the observer has taken the correct view, but the pupil has for some reason not expressed his or her true state of mind. However, this research assumes that emotional regulation among primary school pupils is so developed that they are able to recognise whether or not they feel themselves interested in something (Saarni, 1999; Schaffer, 2006). Nevertheless, there may be reasons to explain why a pupil's evaluation would not reflect their actual level of interest. For example, the pupil may have accidently pushed a wrong button, although it seems unlikely that this would have happened multiple times for any one pupil, and the counting of averages diminishes the bias caused by any such inaccurate choices. Another possible explanation is that, for some reason, the pupil is so lacking in motivation to participate in the activity that he or she pushes random buttons on purpose. However, in the present case at least, the pupils' behaviour during the lessons does not support this interpretation; pupils did not complain about the measurement process, and they willingly carried the clickers when changing places.

Our conclusion, based on this evidence, is that it is possible to use the clickers as a means of collecting information about primary pupils' interest levels to minimise any disturbance of the learning situation. We would also argue that, in respect of this particular group, it was difficult for an observer (even one who is familiar with the pupils) to grasp the pupils' actual state of mind in relation to situational interest. Usually, teachers' evaluations of how pupils feel about certain activities are based on their observations during lessons, but for a variety of reasons, pupils may hide their actual feelings from the teacher. Interest is a subjective experience, and despite external signs of interest, it was in this case difficult to externally evaluate a pupil's degree of interest in a dynamic classroom situation with plenty of things competing for the pupils' attention and interest. For this reason, it is very important to ask pupils whether or not they feel that the activities during a lesson are interesting.

During the lesson, the clicker seemed to disturb the activity less and less as pupils got used to it, and the measurements took less time. In future research, it should be possible to use the clickers to track interest-supporting features in real time, so diminishing memory biases that might occur if those features were asked about retrospectively. In so doing, it should in turn be possible to design lesson structures that allow situational interest to emerge and, further, to develop into personal interest (Hidi & Renninger, 2006). Mapping out interest levels in an activity by non-intrusive means may also provide the teacher with more useable tools for her reflection-in-action. However, because this was a pilot study, the sample size was very small, and to strengthen this conclusion, a replication study should be conducted, with a larger sample size and a control group. The control group should have fewer interesting activities in their lesson to enable investigation of whether pupils' interest levels differ between the groups. As we have emphasised, the present research was mainly concerned with testing the method; in the future, the method could be used to investigate the most effective ways of promoting situational interest. The research should be replicated in more than one school, and it would also be worth considering whether pupils' interest should be evaluated by the teacher or by external observers alone. Outcomes could be used to plan lessons and teaching sequences that better support pupils' interest.

As well as facilitating the planning of interesting activities for pupils, taking account of pupils' views about the interestingness of activities may also benefit pupils' autonomous motivation on a larger scale. According to Reeve and Halusic (2009), it will support pupils' autonomous motivation if the teacher allows pupils to express their feelings—even the negative ones—and the clicker also offers a means of doing that. In an ideal situation, pupils' voices would be heard and they could be involved in planning science teaching; according to research, this should increase pupils' participation, and this has been considered important, for example, in developing the Finnish core curriculum for basic education (Finnish National Board of Education, 2014).

To enhance the validity of the data collected from pupils, the criteria for evaluation of situational interest should be discussed thoroughly with them—for instance, it should be explored with the pupils how it feels to be interested in such a way that one would choose level 5, and so on through all levels. It is worth considering whether the scale would be more appropriate for pupils if the numeric values were to be replaced with face icons, as in the study by Tapola et al. (2013). However, a smiling face would emphasise the emotional aspect of interest rather than cognitive arousal, making it unclear whether pupils were evaluating interest or some other emotion. If teacher and pupils were to discuss the criteria thoroughly and then work to ensure that interest evaluations really directed lesson planning in the future, the pupils might be more engaged with the evaluation situation rather than choosing numbers randomly. Reeve and Halusic (2009) emphasise that accepting students' negative feelings enhances autonomous motivation. In that light, an open discussion about pupils' interest and stated acceptance that they may not always find the topic interesting may help them to express their interest more openly.

To enhance validity even further in the future research concerning this topic, while also enhancing pupils' participation, the lesson videos could be watched with the pupils, allowing them to explain how they felt in certain situations and why they chose to push a given button on the clicker. In order to strengthen the interpretations made based on the data, some more triangulation should take place. Interviews, for example, could be used to gather the pupils' views in a more accurate way. Dohn (2013) has introduced two different types of interviews that he has used in order to get a complete picture about how the students experienced the teaching sequence from the point of view of its potential to awaken situational interest. In more detail, Dohn (2013) has used informal interviews that took place during the activity, and semi-structured interviews that took place after the activities. By combining the two kinds of interview data, Dohn generated a view about students' interest levels. This kind of procedure could be used with the clickers and videos as well. From the quantitative analysis point of view, the times that the pupils are engaged in intended activities could be counted but in order to do that, more intensive and sophisticated video recording would be required that would allow detailed investigation.

The averages of the whole group of pupils indicate that the graphs seem to become more compatible as the level at which the data have been analysed becomes more general. Based on the linear average graph, the interest level of the group in general seems to decrease as the lesson proceeds. The drop in participants' own evaluations is a little steeper; in other words, the slopes of the lines are not equal. However, both graphs presenting the linear average show that the level of situational interest inevitably drops as the lesson goes on. The break between the lessons does not seem to help. When this is considered in light of the four-phase interest development model of Hidi (2006), it seems that situational interest is relatively easy to trigger—in this case, with an interesting demonstration that has a close relation to the pupils' own lives—but that maintaining the triggered interest is more difficult. One objective for future research in this area would be to examine whether this effect is typical of traditionally organised science lessons, and then to consider how the structure of the lessons should be modified. Science courses can be seen as a series of occasions that are somehow related to each other, just like episodes in a TV series. These series are typically written to follow a structure whereby, at the end of an episode, something happens that gets the audience hooked on the story and makes them come back the following week.

Finally, one aspect worth considering relates to what is understood by the 'situation'. From a pupil's point of view, a situation in a typical science class may encompass other aspects beyond what the teacher has planned. From the point of view of the teacher and of teaching, the situation consists of activities that are usually implementations of the teacher's lesson plan. However, from the pupil's point of view, the situation is experienced in a subjective way; in our case, what the pupils were probably evaluating at the measurement points consisted of the planned activity in which they were participating. But they might also have been evaluating their own feelings and sensations at a certain moment of time, including thoughts that may have taken them very far from the actual physical situation, in line with the definition of Hektner et al. (2007). In concluding that a situation is experienced in a subjective way by all the different participants, it becomes obvious that the term 'situational' in 'situational interest' may have a variety of meanings, making it very difficult to explicate what exactly induced a certain pupil to push a certain button. Was it an intentional choice, or was it done without conscious reasoning, or even by accident? By counting the averages over a set of measurements, we have tried to reduce the influence of chance.

On the whole, we argue that a teacher's observations about pupils' situational interest do not always or alone provide sufficient evidence for reflection-in-action and future lesson planning; student voices also need to be heard. An electronic student response system may complete the picture and can be used even with younger children. If employed in such a way that pupils' opinions genuinely direct future activities, this kind of information gathering may even have positive effects on pupils' motivation to learn and may increase their participation.

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References

Bennett, J., Hogarth, S., & Lubben, F. (2003). A systematic review of the effects of context-based and science-technology-society (STS) approaches in the teaching of secondary science. Version 1.1. *Research evidence in education library*. London: EPPI-Centre, Social Science Research Unit, Institute of Education.

Csikszentmihalyi, M., & Hunter, J. (2003). Happiness in everyday life: The uses of experience sampling. *Journal of Happiness Studies*, *4*(2), 185–199.

Deci, E. L. (1992). The relation of interest to the motivation of behaviour: A self-determination theory perspective. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 43–69). Mahwah, NJ: Lawrence Erlbaum Associates.

Derry, S. J., Pea, R. D., Barron, B., Engle, R. A., Erickson, F., Goldman, R., … Sherin, B. L. (2010). Conducting video research in the learning sciences: Guidance on selection, analysis, technology, and ethics. *Journal of the Learning Sciences*, *19*(1), 3–53.

Dohn, N. B. (2013). Upper secondary students' situational interest: A case study of the role of a zoo visit in a biology class. *International Journal of Science Education*, *35*(16), 2732–2751.

Finnish National Board of Education. (2014). *Draft version of the new national core curriculum for basic education.* Retrieved from http://www.oph.fi/ops2016/perusteluonnokset

Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2009). *Cognitive neuroscience: The biology of the mind* (3rd ed.). New York, NY: W. W. Norton.

Goldman, R. (2014). Video representations and the perspectivity framework: Epistemology, ethnography, evaluation and ethics. In R. Goldman, R. Pea, B. Barron, & S. Derry (Eds.), *Video research in the learning sciences* (pp. 3–38). Mahwah, NJ: Lawrence Erlbaum Associates.

Gross, R. (2005). *Psychology: The science of mind and behaviour* (5th ed.). London: Hodder Arnold.

Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). *Experience sampling method: Measuring the quality of everyday life*. Thousand Oaks, CA: Sage.

Hidi, S. (2006). Interest: A unique motivational variable. *Educational Research Review*, *1*(2), 69–82.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41*(2), 111–127.

Kärnä, P. (2012). Peruskoululaisten asenteet fysiikan opintoja kohtaan – mitä tehdä, kun fysiikasta ei pidetä [Comprehensive school students' attitudes towards physics studies—what to do when students do not like physics]. In P. Kärnä, L. Houtsonen, & T. Tähkä (Eds.), *Luonnontieteiden opetuksen kehittämishaasteita* [Challenges of the development of science teaching]. Koulutuksen seurantaraportit 10, (pp. 121–142). Tampere: Suomen yliopistopaino.

Katz-Buonincontro, J., & Hektner, J. M. (2014). Using experience sampling methodology to understand how educational leadership students solve problems on the fly. *Journal of Educational Administration*, *52*(3), 379–403.

Krapp, A. (2002). An educational-psychological theory of interest and its relation to SDT. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 405–427). Rochester, NY: The University of Rochester Press.

Krapp, A. (2005). Basic needs and the development of interest and intrinsic motivational orientations. *Learning and Instruction*, *15*(5), 381–395.

Lavonen, J., Byman, R., Uitto, A., Juuti, K., & Meisalo, V. (2008). Students' interest and experiences in physics and chemistry related themes: Reflections based on a ROSE-survey in Finland. *Themes in Science and Technology Education*, *1*(1), 7–36.

Linnenbrink-Garcia, L., Durik, A. M., Conley, A. M., Barron, K. E., Tauer, J. M., Karabenik, S. A., & Harackiewicz, J. M. (2010). Measuring situational interest in academic domains. *Educational and Psychological Measurement*, *70*(4), 647–671.

Linnenbrink-Garcia, L., Patall, E. A., & Messersmith, E. E. (2013). Antecedents and consequences of situational interest. *British Journal of Educational Psychology*, *83*(4), 591–614.

Litmanen, T., Lonka, K., Inkinen, M., Lipponen, L., & Hakkarainen, K. (2012). Capturing teacher students' emotional experiences in context: Does inquiry-based learning make a difference? *Instructional Science*, *40*(6), 1083–1101.

Osborne, J., Simon, S., & Collins, S. (2003). Attitude towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049–1079.

Palmer, D. (2009). Student interest generated during an inquiry skills lesson. *Journal of Research in Science Teaching*, *46*(2), 147–165.

Pea, R. D. (2006). Video-as-data and digital video manipulation techniques for transforming learning sciences research, education, and other cultural practices. In J. Weiss, J. Nolan, J. Hunsinger, & P. Trifonas (Eds.), *The international handbook of virtual learning environments* (Vol. 14, pp. 1321–1393). Dordrecht, The Netherlands: Springer.

Reeve, J., & Halusic, M. (2009). How K-12 teachers can put self-determination theory principles into practice. *Theory and Research in Education*, *7*(2), 145–154.

Ryan, R. M., & Deci, E. L. (2002). An overview of self-determination theory: An organismic-dialectical perspective. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 3–33). Rochester, NY: University of Rochester Press.

Saarni, C. (1999). *The development of emotional competence*. New York, NY: Guilford Press.

Schaffer, H. R. (2006). *Key concepts in developmental psychology*. London: Sage.

Schiefele, U. (1991). Interest, learning and motivation. *Educational Psychologist*, *26*(3–4), 299–323.

Schraw, G., Flowerday, T., & Lehman, S. (2001). Increasing situational interest in the classroom. *Educational Psychology Review*, *13*(3), 211–224.

Silvia, P. J. (2008). Interest—The curious emotion. *Current Directions in Psychological Science*, *17*(1), 57–60.

Sjøberg, S. (2000). Interesting all children in 'science for all'. In R. Millar, J. Leach, & J. Osborne (Eds.), *Improving science education: The contribution of research* (pp. 165–186). Buckingham: Open University Press.

Tapola, A., Veermans, M., & Niemivirta, M. (2013). Predictors and outcomes of situational interest during a science learning task. *Instructional Science*, *41*(6), 1047–1064.

Tytler, R., Osborne, J., Williams, G., Tytler, K., & Cripps, C. J. (2008). *Opening up pathways: Engagement in STEM across the primary-secondary school transition*. Canberra: Australian Department of Education, Employment and Workplace Relations.

Woolnough, B. E. (1996). Changing pupils' attitudes to careers in science. *Physics Education*, *31*(5), 301–308.