

# Is There (Any)Body in Science Education?

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**Abstract** In this article we develop and use a comparative approach for studies of the role of the body in meaning making processes in science education (SE). In debates about learning, the discussion often centres on how to explore the relation between body and mind. For example, many studies either focus on changes of bodily behaviour or on changes of people's conceptions and ideas. In a pragmatic perspective on learning it is not possible to envision an ontological distinction between body and mind. By comparing video recordings of physical education lessons, we have studied the role of the body in meaning making processes in SE. The results show that the body is used and constituted in different ways in the analysed situations and how the participants use artefacts in order to do things in a way that would not otherwise be possible. Furthermore, we argue that the comparative approach developed in the article, together with the results of the study, can be used by teachers in their discussions about teaching in relation to different educational objectives and content.

**Keywords** Comparative didactics · Body · Science education · Physical education · Artefact

## Introduction

In recent years considerable attention has been paid to what students in school know and learn. This has been fuelled by the international debate on the results of PISA, TIMSS and similar evaluations of student knowledge, which often revolves around

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knowledge as a cognitive entity. But learning is not just a matter of intellect and cognitive knowledge measured in different tests. It is also embodied in practical, emotional and physical aspects. Indeed, learning in school is complex, and entails both cognitive and practical knowledge. In educational practices, teachers and students continuously use their bodies, for example by talking, making gestures, smelling, listening, moving around the classroom and working with artefacts. In a specific educational situation, some ways of using the body are regarded as more appropriate and reasonable than others. For example, in the school subject of physical education (PE), it is reasonable and expected that children will throw hard objects, such as a ball, in over hand throws and that the teachers will assess their ability to do this. In other contexts, this would seem an odd thing to do (Larsson and Quennerstedt 2012).

In the last 20 years, a variety of perspectives have been developed in the social sciences in an attempt to understand the relevance of the body in relation to for example culture, identity and experience. Empirical studies have paid attention to how and why specific meanings of the body are created in different contexts and how and why embodied views of learning drawing on anthropology (e.g., Lave and Wenger 1991), sociology (e.g., Evans et al. 2009; Shilling 2008) and Dewyan philosophy (e.g., Beckett and Hager 2002) have been used. This focus on the body and embodiment in the social sciences has also had an impact on educational research (cf. Evans and Davies 2011).

However, apart from studies of school subjects foregrounding embodied aspects and the learning of practical knowledge, e.g., handicrafts or PE, little is known about how students' and teachers' bodies and embodiment interact in educational situations and the learning in other school subjects. As this aspect has been largely neglected in didactical research and subject specific didactics, many school subjects are treated as dis-embodied.

An obvious example of research on embodied learning is research in PE, a school subject seen as an important location through which bodies are constructed (e.g., Evans et al. 2004; McCuaig et al. 2013; Öhman 2010). There are expectations for bodies to be 'healthy bodies', for teachers to be 'appropriate', fit and skilful role models and for students to display a fit body that is often equated with health. Several scholars have explored how students, teachers and policymakers communicate knowledge in PE, and concepts like corporeal device have been developed to understand embodied learning in terms of teaching and educational values (e.g., Evans et al. 2009).

In contrast, the embodied aspect of learning is regarded as a somewhat novel perspective on learning in other areas of research on didactics. For example, in studies of science education (SE), cognitive and sociocultural theories of learning have mainly focused on students' concept development. The pronounced discussions between perspectives in the field focus on the different ways of understanding cognition (Lidar et al. 2010). Here, the focus is either on students' mental models of for example gravity and the shape of the earth (Vosniadou 1994), or how students use tools, e.g., language and artefacts, as being decisive for cognition, which has placed children in a different communicative position (Lidar et al. 2010; Schoultz et al. 2001). With notable exceptions (e.g., Arvola Orlander and Wickman 2010;

Hwang and Roth 2011; Fleer 2009), little attention has been paid to embodied learning and the relation to thinking and learning in scientific practices.<sup>1</sup> When the human body is focused on in didactical studies in SE, it is often treated as a concept belonging to the areas of anatomy and physiology (e.g., Lombardi et al. 2014).

Given these differences between the subject didactics of PE and SE, respectively, and given this specific research gap in SE, the purpose of this article is to explore and discuss embodied aspects of learning in SE by using the specific insights from PE and thus employing a comparative didactic approach.

In many countries the use of comparative approaches is quite new in didactical research. In French speaking countries, comparative didactics is devoted to exploring the institutional “boundaries” where knowledge, teaching and learning unfold (Caillot 2007). A special issue entitled “Vers une didactique compare”, coordinated by Mercier et al. (2002), contains articles specifically related to comparative empirical studies. These articles focus on ‘didactical transposition’, the study of transformational processes of disciplinary content, and ‘didactical contract’, studies of the logic around which collective habits in the classroom grow. With the insights gained from this tradition, and the knowledge and methods drawn from previous research on learning and embodiment in PE, this article explores a subject area in which these aspects of learning are currently absent.

Comparisons are productive in two different ways: (1) they create new knowledge about possible ways of organising the teaching of the same subject content and (2) what is being compared, in this case embodied aspects of learning, acquires new meaning through the comparison (cf. Sensevy et al. 2005). The differences and similarities identified in the studies will also help to describe the embodied aspects of learning in each school subject more precisely and thereby generate new knowledge about learning in different school subjects.

## A Pragmatic Perspective on Teaching and Learning

The approach in the article is underpinned by a pragmatic perspective on teaching and learning inspired by Dewey (cf. Dewey 1938; Dewey and Bentley 1949) and the later work of Wittgenstein (1967). This theoretical strand directs the focus towards students’ participation in activities that constitute the content of the teaching *and* the values, norms and views that dominate the subject (Almqvist and Östman 2006; Östman and Almqvist 2011; Quennerstedt et al. 2011; Quennerstedt 2013). It is based on the idea that knowledge is constituted in a social context, and that communication between people is crucial for learning in terms of how the individual makes ‘the world’ understandable in a certain situation. In contrast to research using sociocultural perspectives, often criticised for their limited focus on the body, we follow Hodkinson et al. (2008) use of Dewey’s ideas of embodiment.

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<sup>1</sup> We searched the database Education Research Complete on 30 June 2014 for research articles in peer reviewed journals for the years 2011–2014. We got 626 hits on (body\* AND science AND education), 258 hits on (body\* AND science AND education NOT conception\*), 29 hits on (embodiment\* AND science education) and 85 hits on (body movement and science education). From these hits only two were in line with our interest in this article: Hwang and Roth (2011) and Larsson and Quennerstedt (2012).

They argue that we must go beyond the dualism between body and mind in our studies in order to facilitate an understanding of knowledge production and learning (cf. also Quennerstedt et al. 2011).

Although knowledge is very much embodied in habits, bodily reactions, actions and our being and becoming embodied, it does not just involve learning bodily movements or investigating the body alone. It also involves a specific intellectual competence in which body and mind are integrated. In the article this will be dealt with empirically, since language does not merely refer to speech or text, but has a wider significance, namely that which has meaning and has been made into language (Quennerstedt et al. 2011). Verbal and bodily actions can thus be taken into account and bridge the dualism between cognitive and embodied learning criticised by Dewey. As Hodkinson et al. (2007) argue: 'learning entails the embodied engagement with practice' (p. 417). In accordance with a transactional perspective, student learning is understood in terms of individuals' embodied engagement and functional coordination with their environment (Biesta and Burbules 2003). As we accordingly need to understand how the physical, practical, emotional and cognitive aspects of learning are intertwined in all situations, the specific interest of this article is to investigate the functional coordination of teachers' and students' actions in SE and PE, respectively.

When dealing with teaching and learning in a pragmatic perspective, we also need to take the participants' use of artefacts into consideration (Almqvist and Östman 2006). In educational settings, as in most other human activities, artefacts are used to achieve things that would not otherwise be possible. Access to and the ability to use artefacts is an important aspect of the meaning making process. In PE, for example, teachers use balls, lines on the floor, goalposts, vaulting horses and such like to perform different activities. The meaning of PE would not be the same without the use of these artefacts (Quennerstedt et al. 2012). In SE, in much the same way, artefacts like computers, books, whiteboards, chalk, test tubes and microscopes are used for teaching and learning purposes (Almqvist 2005). Hence, this article focuses on the embodied engagement with artefacts in PE and SE practices.

## Research Design

The study reported in this article is one of a number of pragmatic studies of teaching and learning to have been performed in our research group Studies of Meaning-making in Educational Discourses (SMEDs) over the last decade. These studies are based on a large collection of video recordings, interviews, surveys and texts from educational practices in Swedish compulsory schools.<sup>2</sup> The members of the research group focus on teaching and learning in various subject didactics. In our discussions it has become clear that there are obvious similarities and differences between our fields, but also that we have learned very much in the comparison between our

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<sup>2</sup> In PE we collected data in two projects, consisting of approximately 40 h of recorded lessons (Quennerstedt et al. 2014). In SE we collected data during the period 1999–2005 (cf. Almqvist 2005; Lidar et al. 2010; Lundqvist et al. 2012) and from autumn 2013 and onwards consisting of approximately 200 h of recorded lessons.

fields. The study presented here is a result of this collaboration. We have chosen to highlight the notion of embodiment in PE and SE, respectively due to the differences between these subjects. In this explorative study we are using examples from teaching and learning in the two subjects. The examples are chosen as illustrative cases of problematic situations in practice concerning the issue of how the body is part of the meaning making process.

Comparative didactical studies do not only require comparable empirical material, but also a specific reason as to why comparisons are interesting and important. Given that in this article we foreground the in-depth analysis of embodied aspects of learning in SE and that we have not been able to identify very much previous research on this issue, we decided to compare SE with PE, where the body is very much in focus. Hypothetically these two subjects are completely different, and there are potential differences concerning the body.

The comparative design of our study is in line with what Flyvbjerg (2006) calls information-oriented selection (as opposed to random selection), and specifically with the ambition to try to maximise the variation between the practices studied. There are of course similarities between the educational content of SE and PE too, especially the common focus on physiology and anatomy, but for the purpose of this article we point to at least three major potential differences.

First of all, different expectations are expressed in the curriculum for the two subjects. In the curriculum for the compulsory school in Sweden, the aims for PE have a strong focus on movement, physical activities and discussions about health and embodiment. In contrast, in the aims for SE (biology, chemistry and physics) there is very little mention of the body. Instead, the curriculum focuses on intellectual abilities such as thinking and speaking as a scientist. However, a generous interpretation is that the use of the body is implicitly stated in the curriculum in that all the activities listed require a body to perform them. Participating in SE does not “only” consist of skills associated with conceptual understanding, such as listening, reading, thinking and speaking, but also walking, using different types of information sources, handling artefacts and using scientific methods. Consequently, we suggest that it is fruitful to explore the similarities and differences between PE and laboratory work in SE in terms of the embodied engagement with artefacts in PE and SE practices.

Secondly, different teaching traditions may influence practice in the various subjects. In our studies, questions about whether and how traditions influence practice are treated as empirical questions. We have shown how one and the same subject can be influenced by different traditions in different contexts (Lundqvist et al. 2012), but our hypothesis is that there are major differences between the subjects.

Thirdly, and as a consequence of the two former, different expectations on teaching and learning, different ‘didactical contracts’ are expressed in practice (cf. Tiberghien 2007), such as how students are expected to use and talk about their bodies and how the kind of ideal body that is being constituted differs in PE and SE practices.

In the following we begin by describing one case in PE and one case in SE. These are then compared and discussed in relation to each other and in relation to issues of

further research in comparative didactics. In both case studies the focus is on how students are expected to use their bodies in the meaning making process. The selection of empirical illustrations has been made in order to illustrate a variety of bodily activities. In PE, the use of and talk about the students' own bodies is an educational content in itself. In SE, on the other hand, this is not the case. However, in our study of SE practices presented in this article, it is obvious that students learn how to use their bodies in different ways. In fact, teachers and students use their bodies in specific ways in lectures as well as in laboratory work and other kinds of educational activities, and these specific ways influence the meaning making in the classroom (Hwang and Roth 2011).

## The Body in PE

The educational setting for this illustration is a series of PE lessons as part of a theme of fitness training in an upper secondary school in Sweden (Quennerstedt et al. 2014).<sup>3</sup> At the beginning of each lesson the teacher states that the purpose of the lesson is physical training in terms of exercising at different levels of maximum heart rate. During the lesson the students are asked to measure their heart rates during the different activities.

## The Use of the Body

At the beginning of the second lesson the teacher says:

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1	Teacher 1:	We are going to start with a classic warm up. After that we will add a warm-up with basketballs.
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During the warm-up the teacher walks around in a circle and the students run at different speeds in an opposite circle and imitate all the movements the teacher makes.

All lessons during the theme are organised as a classical warm-up, main activity and stretching sequence following basic principles of physical training from a physiological perspective, where warm-up is carried out for performance enhancement and to reduce the risk of injury. However, in our example the warm-up seems to be something that should be done in PE and not because it is necessary for the activity (cf. Quennerstedt 2013). In the illustrated lesson, the level of activity is just as high and sometimes even higher during the warm-up than during the main activity.

In the lesson, the warm-up has the function of warming up the instrument—the body—that is about to be used and investigated. No major problematic situations regarding the body arise in the lesson. It seems obvious to the students and the

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<sup>3</sup> Data for the illustration was gathered in connection with a project funded by the Swedish Research Council (Physical Education and Health: A Subject for Learning? Grant number: 2010-5182).

teacher that physical training is on the agenda. In this way, the physically fit body becomes the subject matter, or content of the lesson.

### Using Artefacts to Measure the Body

Introducing artefacts into the lesson, in this case a clock for measurement and a basketball in a game, does not change the main purpose of the physical training. Rather, it seems as though the basic ideas around physical training and sport go quite well together.

At the beginning of the lesson activities the teacher initiates a discussion about physical training.

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- 2 Teacher 1: We are going to play [basketball] for a couple of minutes and after that I will blow the whistle, and what will you do then?
- 3 Student 1: Heart rate!
- 4 Teacher 1: Heart rate! You write it on the board ... and then you rotate to get new opponents.
- 5 Student 2: Which A is it today?
- 6 Teacher 1: Yes, which A is it today?
- 7 Student 3: A3?
- 8 Student 4: A4?
- 9 Student 5: A2?
- 10 Teacher 1: A2 today – which heart rate should we keep then?
- 11 Student 4: 130
- 12 Student 6: 130? 140? 160?
- 13 Teacher 1: Now we start from the beginning.
- 14 [Here a discussion starts about what the different levels of training A 1-4 mean. The teacher, for example, instructs and tells the students that A1 is aerobic training at a heart rate between 50-60 % of max heart rate, approximately 120-130].
- 15 Teacher 1: A2, which we are doing today, is under roughly 160. So that's where we will be today. It should be your ambition to find that workload.
- 16 Student 6: I said so didn't I?
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In lines 5–6 the students refer to experiences from previous lessons regarding exercise at different levels of maximum heart rate. There is a fixed scale used in the exercise to be measured against, and the students' physical bodies are the objects of the measurement. Here, the body is constituted as educational content in terms of what to learn, and at the same time as the object of the investigation. It is also constituted as an individual body that can be measured in a generalised way, because the different levels A 1–4 are supposed to be valid for all bodies, regardless of individual differences related to common biological variances in maximum heart rate (14).

At the same time, by using heart rate students experience a measurement that is sometimes difficult to manage.

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17	Student 1:	I must work harder. Something is wrong ... did I work hard enough?
18	Student 2:	Yes!
19	Student 1:	Yes!
20	Student 2:	He was running all the time.
21	Student 1:	Yeah!
22	Teacher 1:	Measure your heart rate!
23	Student 1:	It could be the thing with the counting.
24		[The student measures his heart beat by lightly pressing his fingers on his throat and looking at a clock].
25	Student 1:	I can't count this ...
26	Teacher 1:	Should I try? ... because if you think like this ... if you miss ... you said you had 36 [in 15 sec] ... then it is really low ... if you miss 5 beats in 15 seconds then you have 41 ... then you are on an A2 straight off!
27	Student 1:	But I am so bad at feeling the pulse
28		[The teacher measures the student's heart rate. The teacher looks confused].
29	Teacher 1:	Run two laps around the gym ... I want to see what you can get up to
30		[The student runs two laps quickly and after that the teacher again measures the student's heart rate].
31	Teacher 1:	45 ... now you are at 180
32	Student 1:	The worst thing was that I was really working hard
33	Teacher 1:	I saw that ... then it could be that you missed
34	Student 1:	I could have gone down to 32
35	Teacher 1:	Yes ... and that's good.

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In this sequence we can see how a seemingly objective measurement of levels of physical training normalises students' bodies as active (17–20), and that it is a measurement that is difficult to use (23–27).

In a comment by one of the students during the lesson, '132 ... how embarrassing' (Student 5), the normalisation of the measurement also means that bodies can fail if the student indicates that he ought to have reached a higher heart rate. Additional questions from the teacher after measuring the heart rate, such as 'how did you feel in your body ... light ... heavy?' and not expecting an answer from students, adds to the idea that bodies can be measured using an exact heart rate scale while at the same time being a feeling more subjective body.

## The Use of Artefacts 2

The use of artefacts in PE is often related to the use of equipment created for competitive sport rather than for education (Quennerstedt et al. 2012). When the basketball is introduced in this lesson (see line 1) the main purpose of the physical training does not change. On the other hand, it also becomes a two versus two game of basketball with a basketball, baskets, lines on the floor, rules of the game and opponents. By introducing an artefact, the students' bodies are both organised and related to other bodies, even though the main purpose stated by the teacher is



physical training. During one of the breaks, when all students have written their heart rates on the board, the teacher says:

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- 36 Teacher 1: ... if we look at your heart rates ... here we have 190 ... that is an A3!  
 37 Teacher 1: [playing basketball] ... can you get up to this?  
 38 Student 1: eeh?  
 39 Teacher : Yes of course you can ... but the focus ... you have a ball ... 138 ...slightly low ... A2 yes? ... and 122 what does that mean?  
 40 Student 2: A1  
 41 Teacher 1: Yes A1! ... basketball is a great sport for physical training. You can get your heart rate up.
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In this situation the teacher argues that basketball is physical training (41). At the same time, several students have lower heart rates than for the other measured activities (39). The teacher also stops the game on several occasions to talk about rules and how the game can be improved.

During the game the effect of the physical training is limited by the students' techniques, the artefact, rules of the game and by other students. So, why use basketball for physical training? A clue can be found at the end of the lesson:

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- 42 Teacher 1: If we look at the lesson today and look at the heart rates. As a whole we have reached our goal [physical training]. We are doing something enjoyable, we help each other, we participate, 100 percent, AND we reach our goal ... physical training.
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In contrast to physical training without artefacts, the introduction of a basketball limits the level of physical training. However, aspects such as enjoyment, feelings of participation and that the training becomes a collective matter are consequently delegated to and by the artefact (42).

## Summing Up

In this illustration from a PE lesson we have shown how the body becomes the object of investigation. It is the students' bodies that are to be trained and measured in relation to a fixed objective scale, and at the same time provide subjective judgements about what physical training feels like. It is about training the body and, as a consequence, learning how to train. The physically trained body becomes the subject content. By introducing an artefact like a basketball, elements of fun, participation and judgements of enjoyment, physical training becomes a collective issue involving several bodies and the content of the lesson is changed.

## The Body in SE

In this case study the educational setting is laboratory work on the qualities of different alcohol samples. The task that the participants (two classes of students aged 13–14 years) are expected to work with concerns the qualities of five different alcohol.

What are the qualities of alcohol?

- (1) Look and sniff gently at the various alcohol samples. Use small plastic jars. Write down your observations in the table below and explain in more detail in your report.
- (2) Examine the pH using indicator paper. Dip and read the colour of the scales.
- (3) Investigate solubility in water by pouring water (2 cm) into a test tube. Add alcohol. Look closely. Shake. Have they dissolved?
- (4) Try flammability by pouring a few drops of the liquid on a watch glass and igniting it. Note the colour of the flame.

In the recording it is obvious that the students are used to doing these kinds of experiments and handling the equipment. It is also obvious that they know what to do: they know how to read the instructions, they understand the words and sentences, they find the artefacts they need and know how they are supposed to use them.

However, the problematic situations that arise in the setting include issues about how the body should be used in the meaning making process. Similar to the results from our case study of PE, we identified two categories where the body is used in different ways. We call these categories ‘the use of the body’ and ‘the use of artefacts’.

It should be noted that in all the recorded situations the teacher and the students use artefacts, such as the school building, desks and clothes. Of course, some of the activities could be performed without the aid of artefacts. The alcohol samples could be poured into the students’ hands instead of plastic jars, and so on. Nevertheless, the use of artefacts is central to the practice, and some of the activities could not be performed without them. For example, they use books, protective equipment, indicator papers and five different types of alcohol; methanol, ethanol, pentanol, glycol and glycerol.

## The Use of the Body

Students 7 and 8 are working on the task to “Look and sniff gently at the various alcohol samples”. They have poured the alcohol into small plastic jars and are now trying to identify the smell.

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43	Student 7:	Can we write that it smells like a hospital? I think it smells like that.
44	Teacher 2:	Yes.
45	Student 8:	It almost smells like ...
46	Teacher 2:	You should be like wine tasters; they would know exactly what it smells like.

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The students struggle with the problem because they do not know which terms they should use to describe what the alcohol smells like. In order to bridge this gap, they use their experiences from outside the classroom. In line 43, Student 7 wonders if they can write that it smells like a hospital. The teacher confirms that this is a valid answer (44).

Student 8 says “It almost smells like ...” (45). This is the general form of the utterance used in the setting. All the groups smell the different alcohol samples and compare with their experiences outside the classroom. The suggested smells include paint, a garage, wine, fish and banana. The problem is that the students do not have access to a language that can describe what they are sensing. The teacher (46) refers to a profession with a specific language for describing the smell of something—“You should be like wine tasters, they would know exactly what it smells like”. However, it seems as though this kind of language does not exist in the science classroom, at least not for the student.

Hence, students refer to their earlier experiences of various kinds of smells and reply accordingly. For educated scientists this may not be difficult in that they have a language for describing what different substances smell like. Student 9 says:

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47 Student 9: Yes, but I think it’s hard because when I smell something, I usually say it smells like ethanol, when I think it smells like ethanol.

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This would mean that the question posed for the task, “Look and sniff gently at the various alcohol samples. Use small plastic jars. Write down your observations in the table below and explain in more detail in your report”, is much more difficult than it may seem at first glance. The students are expected to describe what the alcohol samples smell like without knowing what kind of answer is relevant, or even why it is relevant to smell the alcohol samples in the first place. They consequently need to use their bodies and the embodied experiences from outside school in order to perform the task.<sup>4</sup> This is about learning to use their bodies in order to do the scientific experiment. Here, the body is an instrument of exploration.

### The Use of Artefacts

Artefacts are used in our educational setting in order to do things that would otherwise not be possible. For example, the students use equipment to measure various properties. In the following example, the students are expected to measure the pH of the alcohol samples.

Our analysis of the recorded setting show that the students, in an embodied and habitual way, know how to use most of the available artefacts, and that they take them for granted. But the analysis also shows that the role of the artefacts becomes

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<sup>4</sup> It should also be noted that the students have the same kind of problem with descriptions of what the alcohol samples look like. For example, one of the groups writes that “all except Glycerol was thin and flimsy. Glycerol was thick and transparent”.

obvious for the participants when the technology fails, or when they learn to use new artefacts (cf. Almqvist 2005).

The task that the students are working on is to: “Examine the pH using indicator paper. Dip and read the colour of the scales”. Most of the groups solve this task rather quickly, but one of them asks for help. The teacher tries to instruct the students in the group how to use the indicator papers correctly, but realises that there is something wrong with the equipment. He fetches a new box of papers.

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- 48 Student 10: Here, let's try again. Can you throw those away please; we've got a new box. Here you are.
- 49 Student 11: Thanks.
- 50 Student 10: You're welcome.
- 51 [Both girls measure with their indicator paper]
- 52 Student 10: It works much better.
- 53 Student 11: Yes, it looks different now.
- 54 Student 10: This one has number five.
- 55 Student 11: Yeah, it's pH-value five.
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In this situation, the students dip the indicator paper in the alcohol samples and compare the colour on the paper with the colour scale provided on the box. Instead of smelling the alcohol, they now have a pre-defined scale to use—if the equipment works, that is. Whether they understand the concept of pH or not, and what they have learned about it, is not possible to tell from this case. All we know is that they can use the artefacts correctly and that this is enough to answer the question about the pH-value.

## Comparisons and Discussion

A principal condition for participating in an appropriate way in educational settings is related to the body. In some subjects, such as PE, this is explicitly expressed and taught. The physical training of the body to perform specific actions, like playing basketball or learning how to swim, is a central part of the stipulated educational content. In other subjects, like SE, the use of the body is more implicit and often seems to be taken for granted. SE can accordingly be seen as disembodied, at least when approached in research.

In PE the ideal is a strong, fit and healthy body, in our illustration expressed as a body that performs physical training as a content of the lesson. The body is thus explicit in terms of learning *about* the body, learning *through* the body and *training* the body physically. In SE, on the other hand, this is not necessarily the case. At least not as long as a scientist works indoors and does not need to dive, climb, walk and so on. This is a significant difference between the subjects. In PE the training of the body is explicitly formulated and discussed, whereas in SE the body is taken for granted and, in this sense, becomes invisible.

However, the well-trained body of the scientist does not just include the ability to move around indoors or outdoors and work with different kinds of artefacts (even though these are central parts of the practice). Scientists also need to know how to use their noses, eyes and ears and to name and talk about the discoveries they are making. The most obvious example of this is when the students in our example are asked to decide on and write down what the alcohol samples smell like and they use their everyday experiences to solve the problem. The teacher refers to the language of wine tasters (e.g., when describing the taste of liquorice, red berries and the earthiness of the wine). If you ask a scientist about the smell of the pentanol that she or he is working with, he or she would probably say that it smells like pentanol. As we have seen in our empirical example, this is also something that one of the students highlights: “I usually say it smells like ethanol, when I think it smells like ethanol.” In this sense, the experiment itself becomes an embodied habit.

We have shown that the body is very much a part of the SE practice, for example through the use of senses like smell, through embodied reactions, through referring to previous embodied experiences, and through students’ habits to conduct experiments in the SE classroom. We would argue that the scientific method is in many ways dependent on bodies and embodiment. However, this embodiment seems to be present in order to cognitively develop concepts. This idea builds on a separation of mind and body. In SE the ideal body is one that can perform experiments, rather than one that learns. SE is thus learning *about* science by learning *through* the body. In this article we have also shown that the body is present in the educational and learning situations of both PE and SE, albeit in different ways. The body is also schooled in SE. We would argue that this difference could be described as *the practising and the trained body in PE* versus *the inquiring and researching body in SE*, a difference that can be discussed in relation to the diverse purposes of SE and PE, respectively.

If teachers want students to learn embodied knowledge, such as learning how to identify ethanol, why are they expected to smell and use concepts from everyday knowledge? If embodiment is made part of the assignment in the first place, the assignment would be different, i.e., if there was any body in SE, teachers would teach differently and probably give the students different assignments. If teachers disregard the inquiring and researching body in SE, they will teach science in terms of concept development, and not science for becoming an inquiring and researching ‘scientist’.

In this article we have shown the problems of dichotomising mind and body in educational studies and have illustrated that this is not fruitful if we want to understand learning in SE. In terms of focusing on the body and embodiment in educational empirical studies, we would add that comparative didactics can contribute to: (i) showing how embodied experiences, including the use of artefacts, can be seen as a central part of the learning that is taking place, and (ii) that how meaning making about and through the body and in terms of becoming embodied is an empirical question that will inevitably differ between school subjects, countries, situations, etc. Given these results, and given the notion of the differences between practices, we call for further research and discussions on the question of whether there is any body in SE.

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