“Why bother so incredibly much?” – Student perspectives on PISA science assignments

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Sammanfattning på svenska
Storskaliga kunskapsmätningar, såsom *Programme for International Assessment*, PISA, spelar en allt större roll i vår tids skolpraktik och skolpolitik. Samtidigt ifrågasätter alltfler forskare mätningarnas validitet, reliabilitet och i vilken utsträckning de utgör trovärdiga representationer av elevers kunskaper. I ljuset av sådana kritiska röster utgår denna artikel från ett sociokulturellt perspektiv med syftet att undersöka mötet mellan elever och de provfrågor i naturvetenskap som deras kunskaper utvärderas utifrån. I studien är det av särskilt intresse att undersöka hur elever hanterar uppgifter som beskriver ”situationer från verkliga livet” (real-life situations) vilka vanligtvis presenteras som relevanta för att kunna mäta elevernas naturvetenskapliga allmänbildning. I enlighet med vår ansats har vi närmat oss elevernas meningskapande av naturvetenskap så som den framträder i uppgifterna. Ett viktigt fokus i studien är att undersöka situationer när elever samarbetar med PISA-uppgifter i små grupper, vilket möjliggör för oss att studera mötet mellan elev och prov *in action*. Datamaterialet består av videoinspelningar av 71 svenska 15-åringar som arbetar med tre frisläppta uppgifter från PISAs naturvetenskapliga del. Analysen visar att de ”situationer från verkliga livet” som beskrivs i provet framstår som problematiska eftersom eleverna positionerar sig gentemot de fiktiva elever som framträder i provtexterna. Det är framförallt de fiktiva elevernas användning av ett naturvetenskapligt och akademiskt språkbruk som skapar avstånd och motstånd till uppgifterna. Användningen av ett strikt naturvetenskapligt

språk och vetenskapliga metoder i vardagliga situationer får de fiktiva eleverna i uppgifterna att framstå som ”små vetenskapsmän” och stereotyper i den naturvetenskapliga kulturen. Vi drar slutsatsen att denna typ av uppgifter egentligen riskerar att utgöra implicita mätningar av kulturell samstämmighet. Även om förståelse av den naturvetenskapliga kulturen är ett viktigt mål för skolans naturvetenskapsundervisning i sig, så blir det problematiskt att resultaten från OECD endast kommuniceras som ”elevers kunskap i naturvetenskap”. Denna studie, i likhet med flera andra, manar till försiktighet när det gäller att tolka resultaten från PISA-mätningarna och betonar att förståelsen av elevers “kunskaper” i naturvetenskap är betydligt mer komplex än vad som vanligtvis kommuniceras i dessa mätningar.

Peter: *Do you understand this?*
Ali (reading the test question aloud): ***“****They used mineral oil ‘cause it lets through most of the sun” (points at the text)… Hmmm, I don’t know.*
Damien: *But why would they care about which sun cream to use? Err … or sunscreen …*
Ali: *They aren’t <u>tested</u> [the mineral oil and the zinc oxide] because they already know what they do (.) That zinc oxide–*
Damien: *I know… But why bother so incredibly much that they do … well … <u>that</u> [experiment]?*
(Extract from Peter, Ali, and Damien working with PISA item “Sunscreens”)

International organizations for assessment, such as the OECD (Organisation for Economic Co-operation and Development), which produces the *Programme for International Student Assessment* (PISA), present their results as robust evidence of the knowledge and skills of young people around the world (e.g., Gorur 2011). The results are also broadly used to compare the effectiveness and qualities of schools and educational systems at regional, national, and international levels. In recent years, the PISA organization has undertaken a crucial modernization of the science education test culture by introducing the framework of Scientific Literacy (OECD 2006), which aims to assess the socially relevant scientific knowledge and skills of students. According to the framework, the test questions are “framed in situations of general life and not limited to life in school” (p. 26) and measure students’

ability to identify scientific issues, scientifically explain phenomena, and use scientific evidence.

However, when a sociocultural understanding (Wertsch 1991) of human knowledge and action is adopted, as is the case with the present article, concerns can be raised about the certainty of claims of large-scale knowledge assessments. In PISA tests, there is an implicit assumption that individuals' knowledge can be elicited through clear-cut test questions without any problems. We argue that this assumption must be problematized given that little is actually known about how students approach and engage in test questions of this type (cf. Sjøberg 2007). Previous studies on large-scale assessment within other theoretical perspectives have stressed that the test questions may not accurately represent the scientific knowledge held by students, and that students often seem to "misunderstand" the questions (e.g., Harlow and Jones 2004). From a sociocultural perspective, such as that taken in the four studies of Jan Schoultz (2000), the students' "misinterpretations" must be understood as being related to the very meaning of the test questions, as seen from a student perspective. Schoultz (ibid) argues that the structure and framing of test questions actively contributes to how students perceive questions and answer them. Therefore, it is not possible to say exactly what the students are responding to in the test situation; the only clues are pencil marks in the multiple-choice boxes or some short inscriptions to open-ended questions.

We argue that, in order to explore the students' perspectives it is important to create situations in which their meaning-making of the test questions can be observed and analyzed. From a sociocultural methodological perspective (Wertsch 1991), the meaning-making processes should be observed in action (Jakobsson, Mäkitalo and Säljö 2009). Therefore, in the present study we have intentionally created situations in which students in small groups are asked to answer test questions collaboratively, which, in action, requires them to negotiate the meaning of the questions. In this way, the students' meaning-making can be seen as

reflections of the interaction between the students and the test assignments and items, in the sense that it mirrors how students, with their experiences and readings, and the test, with its particular ways of describing situations in the world, encounter and mutually interact. It is also important to explore how students interact with their peers in such situations. Therefore, our main focus is not on the students as science learners in test-situations, but on how they engage in action and thereby express certain kinds of identities and not others.

We intend to analyze the meaning-making that can emerge and be observed in students' collaborative encounters with three selected units from PISA Science. Here, we have chosen to analyze such encounters through the notion of *discursive identity* (Brown, Reveles and Kelly 2005), which captures how students discursively position themselves towards each other and towards the image of science as it emerges in test questions.

Sociocultural Perspectives of Science and Learning about Science

Donna Haraway (2004) describes the traditional intra-disciplinary view of science as "the culture of no culture" (p. 223). The sociocultural stance argues that science constitutes social, historical, and cultural practices (Rogoff 1990). Therefore, "learning science" involves understanding and appropriating the specific norms, meanings, and social languages that are inherent to these practices and developing specific ways of acting, all of which combine to create decisive tools for accessing science as an intelligible and meaningful activity (Lave and Wenger 1991). As James Wertsch (1998) puts it, science can be seen as a cultural tool that must be appropriated and mastered by relating to and learning specific social languages (Bakhtin, Holquist and Emerson 1986) or discourses (Gee 1999). Among others, Troy Sadler (2009) has suggested that the learning of science can be perceived as the incremental participation in specific "communities of practice" (Wenger 1998). Hence, a student's "scientific literacy," as depicted by PISA (returned to later in this article), could be understood as his or her "willingness" or "ability" to participate in the "scientific practice",

described in the test. According to Sadler (2009), however, being part of scientific practice involves appropriating the increasingly sophisticated discourses of the practice and their specific characteristics; for instance, specific semiotic structures (Halliday and Martin 1993) such as lexical density, a passive voice, and nominalizations (Liberg, af Geijerstam and Folkeryd 2011). Some sociocultural theorists have suggested that additional tools include the values and attitudes that must be appropriated or mastered during science learning activities (Wells 1999). Hence, scientific meaning includes the values of scientific inquiry, such as objectivity, control, and transparency. However, Wertsch (1998) stresses that the appropriation of cultural tools and ideas (such as models and theories in science) is also intimately related to *resistance*; specifically, tools are intertwined and imbued with the different intentions (Bakhtin 1981) that come with their appropriation and use. As such, tools are carriers of meanings and intentions from the past to the future. Wertsch (1998) describes resistance as the emerging tension between the perceived demands from the environment and the values encompassed by the individual in action. As Wertsch stresses, the use of material cultural tools (often associated with the term "artifacts") causes changes in the agent who is acting with them (1998, p. 31). In this way, these tools can be seen as non-human actors that contribute to, or even shape science education (Roehl 2012, p. 112). In accordance with the above-mentioned sociocultural views of science, science as test or school practice must be understood as cultural practices (Lemke 2001) that are different from academic science (Yerrick and Roth 2005) and are shaped by institutional traditions of instruction and canonical knowledge.

Students' Engagement in Science

The present study explores how students make meaning of written questions from a science test and thereby make use of the cultural tools they have at hand. In so doing, their activities become interwoven with the values and judgments that emerge (cf. Wells 1999). Therefore,

the background for the study can be reflected in research about students' engagement in school science (conceptualized, for instance, as students' "attitudes," "orientations," or "perceptions" of school science). From the literature in this area, we propose identity as a conceptual tool with which to approach our data.

A number of studies have observed decreasing engagement in school science among young people in Western countries (for an overview, see Fraser, Tobin and McRobbie 2010). Here, we mention a few such studies that might relate to our results. For instance, Camilla Schreiner, who bases her arguments on the *Relevance of Science Education* study (ROSE; Schreiner and Sjøberg 2004), suggests that this decreased engagement is a result of youth identity construction in modern societies (Schreiner 2006). Another suggested approach to students' engagement is to understand the interplay between young people and the way in which science is constituted and presented in science education. Some researchers have argued that the representation of science can also be seen as being connected to the ways in which identities can be expressed in science activities.

Nancy Brickhouse (2011) argues that identity should be studied as a social and cultural phenomenon that is contextually situated. In concordance with the nature of our data, a useful conceptualization of identity is the way in which a person is "being recognized as a certain 'kind of person' in a given context" (Gee 2000, p. 99), which positions identity in the eye of the viewer. Questions of such expressed identities (Ideland and Malmberg 2012) are closely related to discursive actions. For instance, as Bryan Brown, John Reveles, and Gregory Kelly (2005) suggest, the appropriation of scientific discourse actually imposes a scientific identity. This means that using scientific discourse implies certain ways of being or acting and functions as a signal of cultural membership (Brown 2004). Therefore, students can take on different *discursive identities* and "choose to employ some and not others as markers of affiliation or alienation" (Brown, Reveles and Kelly 2005, p. 784). How can this be acted out

in the lives of young people? A recent study by Louise Archer, Jennifer Dewitt, Jonathan Osborne, Justin Dillon, Beatrice Willis, and Billy Wong (2010) uses science as an identity discourse to conceptualize how students construct representations of science and scientists. The researchers describe young students' constructions of "being a scientist" in terms of science as, for example, "hard/brainy", and "scientists as boffins," and as "clashing with popular hegemonic forms of masculinity and femininity" (p. 628). As Jin Sook Lee and Kate T. Andersen (2009) argue, some students reject the idea of identifying themselves with any kind of scientific discourse. Lee and Andersen refer to these students as *oppositional identities* (2009, p. 196).

In this article, we do not intend to describe individuals, who they are, or what they want, but rather how they act and engage as a group, and what identities they express, when responding to the PISA science items.

The PISA Framework and Real-life Situations

As noted above, the OECD underscores the importance that the PISA assessment places on "scientific knowledge in the context of life situations" (OECD 2006, p. 23), as captured by the term *scientific literacy*. The PISA framework states:

> An important aspect of *scientific literacy* is engagement with science in a variety of situations. In dealing with scientific issues, the choice of methods and representations is often dependent on the situations in which the issues are presented. The situation is the part of the student's world in which the tasks are placed. Assessment items are framed in situations of general life and not limited to life in school. (OECD, 2006, p. 26)

Hence, the framework highlights the significance of the situations by which the test items are framed, in terms of situating science in a more general context. Further, according to *Science Competencies for Tomorrow's World* (OECD 2007), the PISA assessment material aims to be "relevant to real-life situations" and the outcome of the assessment "seeks to describe the extent to which students can apply their knowledge in contexts relevant to their lives" (p. 37). However, Per M. Kind (2011) argues that students are not assessed by a test's theoretical framework, but rather by the items or the assignments in the test. Accordingly, what is

essential is how the test questions concretize real-life situations and whether the students perceive them as such.

Although very few studies have explored how students' actually engage with science test items, some studies have approached this question using interviews with students (for instance Schoultz, Säljö and Wyndhamn 2001). Moreover, research studying student encounters with test items *in action* is rare. However, two empirical research studies, one by Jens Dolin and Lars Brian Krogh (2008) and the other by Florence Le Hebel, Pascale Montpied, and Andrée Tiberghien (2011), have been conducted on PISA science items with the aim of gaining knowledge from such student and item encounters. While both studies used a collaborative setting with students' engaging with the items in pairs or groups while videotaping, they had different purposes. Dolin and Krogh were interested in the achievement that was possible as students' knowledge became explicit when working with the items while having access to a laboratory setting that was designed to reflect the assignments. Dolin and Krogh concluded that when the students were allowed to use relevant equipment in the problem-solving process, the achievements far exceeded those of the regular PISA test. Le Hebel and colleagues were primarily concerned with the consistency between the theoretically described science competencies that relate to PISA assignments and those that the students actually performed. They concluded that, "[for the] same question, students' effective competence when constructing their answer can differ from PISA competence corresponding to the question" (Le Hebel, Montpied and Tiberghien 2011). The purpose of the present study, in contrast, is to explore how students make meaning of the real-life situations described in the test questions.

Research Problem

In our view, the PISA assignments and items, with their framing stories and situations, tables, charts, and figures, constitute the "image of science" such as that depicted by the PISA

assessment. This means that the language used in the test, the situations and persons described, and the questions at issue all contribute to the overall picture of what science is, what kind of people science experts are, and what knowledge they should have. Therefore, interaction with scientific literacy test questions involves interacting with a set of materialized images of science.

The adequacy of the items included in the tests is validated by PISA field trials (see, for instance, OECD 2006, p. 108, 125–126). However, the field trial only determines whether the test questions work statistically, while the way that students approach the questions remains unexplored.

Therefore, with the intention of exploring this gap by producing situations in which students and item encounters could be studied in action (Wertsch 1998), our study approaches students' experiences of and engagement when solving PISA items and assignments. The aim of the study is to observe how students make meaning of and from three selected PISA science items when working collaboratively in small groups, and to explore their discursive positioning towards each other and the image of science as negotiated in that situation.

Methodological Considerations

We have already emphasized the significance of studying meaning-making and discursive identities in action. The importance of this factor is grounded in sociocultural theories, according to which only the actions with which people's thoughts are intertwined, not the actual thoughts, can be subjected to research (Wertsch 1998). Of course, there are some methodological consequences to insisting on such a stance. First of all, the focus on *student* perspectives, as we see it, calls for minimal adult intervention. This view is based on other studies, within sociocultural perspectives, on students' understanding of test items (see, for instance, Schoultz, Säljö and Wyndhamn 2001), which have argued that students' answers in adult–student interview situations seem to be shaped by what the students think is expected of

them within an institutional school practice (where the adult "knows" and the student is a "learner"). Furthermore, from a theoretical perspective in which thoughts are not believed to pre-exist in the mind, but rather to come into existence in sociocultural practice (Wertsch 1998), we have aimed to study student meaning-making where it appears in what could be considered authentic school practice. Therefore, video recording of *student group activities* was settled upon as the most convenient data collection method. This also enabled us to place emphasis on *all actions* mediated in the situation, rather than just the spoken utterances. Hence, we also make use of a *group* of students in which individuals' meaning-making actively is being negotiated and thereby becomes observable. It is important to note that the students in the present study worked with the assignments in a school setting and as a school task, and were well aware that their performance and engagements could be addressed by their teachers, which could have affected the students' actions. It is also important to consider the influence that peer interactions in a group could have on the students' actions (see, for example, Filer and Pollard 2000).

The perspective proposed here is produced socioculturally in dialogical peer-reviewed processes, at conferences and research seminars at which our findings and analyses have been discussed. To enhance the reliability of the study, we submitted the analysis of the transcripts to the informants for their discussion and confirmation (Bryman 2012, p. 390).

However, our perspective is neither relevant nor fruitful for describing and analyzing students' utterances as indicators of individual thinking. Instead, particular utterances are contingent on emerging communicative patterns; that is, they are contributions to the specific discourse.

Setting and Participants

The participating students and teachers were aware that our purpose was to obtain information from them about how students approach and solve questions from an international science test (PISA 2006). The school in question is a Teacher Education partner school situated in a semi-rural small commuter town located in a greater urbanized area in the south of Sweden. Three teachers agreed to make their classes available for the project, which resulted in 71 ninth-graders from four science classes being divided into groups of between two and four students. The students worked collaboratively in group activity rooms with selected PISA units during school science lessons; they were given the task of discussing how they could solve certain problems and then agreeing on one written answer per group. The groups were teacher-constructed and were expected to have a discussion-friendly climate. The items used for the study had to meet the following criteria: (1) be considered to trigger conversations among the students; (2) have been used more than once in the PISA assessments in 2000, 2003, and 2006; (3) fairly reflect the remaining non-released items of the PISA assessment (which we discussed with the Swedish and Danish national PISA teams at the time); and (4) cover as many aspects of PISA science as possible (that is, represent the various PISA science competencies and proficiency levels on the PISA scale). We selected three released PISA 2006 units (Acid Rain [S485], Greenhouse – fact or myth [S114], and Sunscreen [S447]) (https://mypisa.acer.edu.au/images/mypisadoc/pisa_relitems_sc_2006ms_eng1.pdf.)

Each PISA *unit* (OECD 2006, p. 14) is comprised of an introductory text that, together with tables, charts, figures, and the like, frames the questions, or *items*, that are asked. The text and the associated questions were designed to contextualize the scientific content, to make it "part of the student's world" (OECD 2006, p. 26). We have termed this contextualization as the *backstory*.

A Sociocultural Approach to Data and Analysis

All of the students' work was audio- and video-recorded and the material consists of a total of 16 hours of group discussions regarding various PISA items and assignments. The written responses from the groups, which were also collected, represent the contextual data for analyzing the students' interactions.

We conducted an initial content analysis of the interactional data in order to identify general patterns in students' meaning-making of the PISA problems. In order to demonstrate what meanings and discursive identities are being negotiated, we selected and transcribed the students' *meta-discussions* about the items, their meaning, and content. We chose all such episodes in order to provide a more detailed semantic analysis (Mäkitalo, Jakobsson and Säljö 2009) of the negotiations, with a focus on the *gaps* (Wickman 2004) in students' interaction. Gaps are defined as the tension – or empty space (observable as either awaiting silence or negotiation) – that occurs when there are different ways to understand a text or an assignment that causes the students to negotiate words and meanings in order to explore and create a shared platform (Mäkitalo, Jakobsson and Säljö 2009). We also used the analytic concept of *meaning potential* (Rommetveit 1974) to capture the "range of possible meanings" (Lemke 1995, p. 42) of language that depends on its meaning in different contexts and on how it is perceived from different social, cultural, and historical perspectives. In line with Åsa Mäkitalo, Anders Jakobsson and Roger Säljö (2009), meaning-making is conceived of as an "act of contextualization" (p. 23), where the gaps often point to conflicts in framing the relevant context or social language. Moreover, the students' discussions are understood as objects of our own meaning-making in the process of analysis.

Following the example of Mäkitalo, Jakobsson and Säljö (2009), our semantic analysis viewed human actions not as isolated, but rather as *mediated actions* (Wertsch 1998, p. 24) that are mutually interlinked with previous and subsequent actions in a Bakthinian sense. According to Mäkitalo and colleagues (2009), this means that an utterance is "crafted to fit

the unique circumstances of its performance" (p. 12), but, at the same time, responds to a previous utterance that partly shapes its situated sense *and* anticipates the next response (which will establish the conditions for the subsequent actions).

Based on our data, we have categorized situations of verbally or bodily expressed individual and social (or collective) *resistance* (Wertsch 1998), such as distancing and rejecting, in relation to testing, test language, scientific and academic language, and matters of appropriating the culture of science. As we emphasized earlier, we have understood appropriation and resistance as being interconnected and intimately tied to identity and action/activity. In a metaphorical sense, we have considered identity as "clothes" rather than as "skin," and as being tied to social practices and discussed in terms of *discursive identities* (rejecting proposed identities in particular) that result from the students' conscious and unconscious discursive positioning of themselves.

The present article reports five illustrative and representative episodes from three of the groups. These excerpts are not unique in the material as a whole; they reflect a common aspect of the students' approach to the items, which is apparent in roughly half of the 21 groups.

The analytical unit, the mediated action, is emphasized in the transcript legend (see the end of the manuscript). The legend (in our elaborated version) is borrowed from Furberg (2009), where each turn of the transcript represents a mediated action (overlapping actions are marked as interposed). We also wanted to distinguish the students' own statements by having them read aloud from the test. This was accomplished by reproducing the "reading aloud utterances" in "`Courier New`", **`bold face`** font.

Episodes from Student Negotiations about PISA Assignments

Imaginary Students Talking Like "Little Scientists"

Many of the PISA items share the same design: they are enacted by fictional, "made-up" students, which we refer to here as "imaginary" students. In our first example ("Greenhouse – fact or myth" (S114)), the backstory briefly describes what is meant by the term "greenhouse effect" and then how two imaginary students, André and Jeanne, study two graphs in a library book – of CO_2-emission and the Earth's temperature – and discuss whether the greenhouse effect is caused by CO_2-emissions. The second question in this unit is formulated as follows:

Question 5: GREENHOUSE

André persists in his conclusion that the average temperature rise of the Earth's atmosphere is caused by the increase in carbon dioxide emission. But Jeanne thinks this conclusion is premature. She says: "before accepting this conclusion you must be sure that other factors that would influence the greenhouse effect are constant."

Name one of the factors that Jeanne means.

Figure 1. Item S114: "Greenhouse – fact or myth"

Neither the backstory nor the following questions in this item contain any other description of Jeanne apart from her utterances, which therefore become the sole reflections of who she is. In our first extract, a group of four students (one of whom – Victor – is silent) are discussing imaginary Jeanne's ways of acting. Christian, who is the most active student of this group throughout the whole activity, starts the discussion by giving his opinion about Jeanne:

1	Christian	**Another** – Oh I HATE Jeanne – Have you read through all the questions?	*Looks at the other group members*
2	Christian	(.) Jeanne is a bitch--	*Starts reading quietly*
		/…/	
3	Christian	Look now again she [Jeanne] is really = listen	
4	Christian	**André persists in his conclusion that the average temperature rise of the Earth's temperature is caused by the increase in the carbon dioxide emission. But Jeanne thinks this conclusion is premature. She says: "Before accepting this conclusion, you must be sure that other factors that could influence the greenhouse**	*Starts reading aloud* *Disguises his voice*

		effect are constant.”	
5	Christian		*Rolls his eyes and looks at the other group members*
6	Emma	that is almost like you	*looks at Christian with a smile*
7	Christian	YES? I use to talk like that? =	
8	Lina	no but aren’t you a besserwisser	
9	Christian	**= be sure that other factors that could influence the greenhouse effect are constant**	*Disguises his voice* *Laughs scornfully*
10	Lina	yes but you are sometimes a besserwisser	*Gazes at Christian*
11	Christian	always has to be right?	

Figure 2. Episode 1. Group I: Christian, Emma, Lina, and Victor. S114 Q03 (30.17-32.14).

In this episode, the language use and the action patterns of imaginary Jeanne are being negotiated and their possible meaning emerges through Christian’s explicit claims about Jeanne and through Lina’s and Emma’s contrasting real-life Christian and imaginary Jeanne. What is it that triggers Christian to claim he hates Jeanne? It is clear that Jeanne represents something that Christian has observed and wishes his group to notice. In his first three utterances, Christian draws the group’s attention towards imaginary Jeanne (turns 1–3). When reading Jeanne’s utterance aloud, Christian distances himself from the text he is reading by using a disguised voice (turn 4). In turn 5, Christian reinforces the distance he has already made by rolling his eyes. The conversation takes a new direction when Emma says “*That’s almost like you*” (turn 6), perhaps comparing Christian, as she knows him, with the imaginary Jeanne. Christian opposes her statement (7) and repeatedly uses a disguised voice when citing imaginary Jeanne to question comparisons between himself and Jeanne (9). Meanwhile, Lina twice claims that Christian is a besserwisser (a person who thinks he knows better) (8, 10), which is affirmed by Christian (11) completing (or interpreting) Lina’s utterance with “*Always have to be right.*”

Scientific meanings, carried out as scientific semiotic practice, implicitly permeate this item through the presence of imaginary Jeanne. Christian clearly does not wish to admit any "Jeanne" in his own personality, so he refuses the position offered to him and starts to negotiate another. If Christian is a besserwisser, but also like imaginary Jeanne, we can assume that, from Lina's perspective, Jeanne is a besserwisser. There are two clear descriptions of Jeanne: she is a bitch and a besserwisser. From a student perspective, what can we assert that these designations mean? The negative allusion in the episode is clear, but there are several meaning potentials. From a gender perspective, we could suggest that Christian is rejecting the idea of Jeanne; that is, the girl as a scientist. Still, as was shown in turn 7, Christian opposes what Jeanne says and makes no specific utterances about her being a girl.

Another possible reading of the at least seven actions (1–3, 4, 5, 7, 9) that Christian made in relation to Jeanne concerns her language. Imaginary Jeanne, as she appears in this item, is socialized into a very specific language game (Wittgenstein 1967) or social language (Bakhtin, Holquist and Emerson 1986): the scientific, academic, social language. Jeanne makes use of her scientific language in her fictional everyday life while talking to André, with expressions such as "accepting this conclusion" and "factors that could influence" (cf. item S114 above). Compared to an everyday discourse (Gee 1999) or even to what we could consider as constituting an everyday youth school discourse, Jeanne's discourse seems rather exclusive. However, it is not just Jeanne's words that could be the possible sources of Christian's irritation, but also the fact that the words she uses entail an academic *course of action*. This is reflected for instance in the impersonal way that Jeanne criticizes André's conclusion ("Before accepting this conclusion, you must …"). Jeanne's scientific discourse distances her from young people's everyday life. We argue that the meaning potential of "*bitch*" and "*besserwisser"* is to be found in the discourse that embeds the words that Jeanne uses and her academic way of using them. Therefore, we assume the meaning of bitch to

reflect a sense of exclusion from the group. It may even be proposed that a bitch *per se* has a hidden agenda.

So what about being a besserwisser? While Christian elaborates on the designation of bitch when enacting Jeanne's utterances Lina suggests him to be a besserwisser. Christian himself gives his interpretation; namely, that a besserwisser "*Always has to be right*" (11); someone who thinks he or she knows more and better than other people, which leads him or her to act superior. In all, this leads us to question from a student's perspective: Who wants to be like imaginary Jeanne? We argue that Jeanne implicitly represents a scientific identity that the three students reject: Christian by opposing himself from Jeanne's utterances, and Emma and Lina by suggesting that Christian is sometimes like Jeanne (6). By mocking Christian, Emma and Lina position themselves as being not like Jeanne, taking an oppositional discursive identity (Brown, Reveles and Kelly 2005) as a signal of their different cultural membership. The students' negotiation of the apparent attributes of the imaginary Jeanne shows that Jeanne emerges as being apart from the real students' wished identities. Furthermore, the historical connections of science, as tied to an intellectually elite culture (Lemke 1990), rise to the surface by Jeanne's scientific discourse. In sum, introducing imaginary, fictional personalities in PISA, in this particular case, seems to create a distance from the real-world students.

Imaginary Students Acting Like "Little Scientists"

Imaginary students appear in the backstories not only through their use of scientific discourse, but also as "acting" teenagers who "do science" (Lemke 1990). It might be worth recalling that what is purported here as "doing science" is within the image of science as portrayed in the assignments and does not refer to what professional scientists do or do not do.

In two of the PISA units in this study, "Sunscreens" and "Acid Rain" (S447 and S485), the imaginary students do just this through planning and/or conducting scientific experiments. In "Acid Rain," imaginary students conduct an experiment to investigate how marble reacts with

acid rain. The backstory describes how they place marble chips in vinegar, which has a similar acidity as acid rain. One of the following test questions is:

Question 5: ACID RAIN

Students who did this experiment also placed marble chips in pure (distilled) water overnight. Explain why the students included this step in their experiment.

Figure 3. Item S485 Q05.

Two episodes are used to illustrate the actions of the imaginary students in this item, perceived from a student perspective. The following example returns to Christian, Lina, and Emma (from our first extract), who have now worked for almost 40 minutes and appear to be tired. Christian reads the last question of the "Acid rain" unit and waits for the group members to suggest an answer.

1	Lina		*Resting her head on the table*
2	Christian	**Explain why the students included this step in their experiment**	[Reads the task aloud]
3	Lina		*Raises her head up*
4	Lina	'cause they didn't have a life?	*Looks at Christian*
5	Christian	no	
6	Emma	they wanted to see how it got without –	*Looks at Christian, fiddles her hair*
7	Christian	no (.) = it's that-- they like wanted to <u>see</u> if the rain hadn't been contaminated = and was acidic = they would see if something happened write that	*Looking at Emma* *Whispers*
8	Emma	what shall I write?	
9	Christian	that- <they- want- to test- how- marble- reacted- with rain- slash-water>- that was not contaminated	*Dictates*
10	Lina	ahh	

Figure 4. Episode 2. Group I: Christian, Emma, Lina, and Victor. S484 Q05 (38:56-39:11).

In the gap (Mäkitalo, Jakobsson and Säljö 2009) that occurs between Christian reading the assignment aloud, Lina and Emma each suggest one answer (4, 6), both of which Christian turn down (5, 7). The episode ends with Lina approving of Christian's dictation (9) of the answer for Emma to write on their sheet (10), though not explicitly including the information about the rain as "acidic," which he mentioned when he first explained his suggested answer

(7) to the group. Therefore, this group's written answer lacks the detail that would gain it a full score in the assessment (according to the guidelines for scoring in Egelund 2007, p. 82). Meanwhile, the proposition given by Lina must also be considered analytically.

How can we understand what Lina means by her utterance "*cause they didn't have a life*" (4)? The analysis demands an understanding of the expression itself; the notion of "having a life" (or *not* having a life). Whilst the sense of *having a life* implies an enviable life, the imperative "Get a life!" addresses an annoying person or a "nobody". This utterance itself encompasses several meanings in this specific situation. Of course, Lina may utter this in order to make the other group members laugh (although they do not in this case) by describing this activity as meaningless. However, it is reasonable to believe that her allusion indicates her understanding of the pictured activity – namely performing experiments overnight with distilled water and marble chips – and that she does not appear to share the value of the activity (cf. Wells 1999). However, the question this utterance raises remains a barely surfaced side-track while the group directs its activities towards solving the problem.

In the third extract, another group from another science class, consisting of Ali, Peter, and Damien, discusses the same item (Acid Rain Q05). The discussion here develops into a meaning-making process about and positioning to this imaginary experiment, while an acceptable answer appears to have subordinated priority for the group. The boys read the item quietly (cf. S485Q05, figure 3) and then attempt to explain why the imaginary students placed the marble chips in water overnight.

1	Ali	yes 'cause = they're stupid?	
2	Ali		*Giggles*
3	Peter	(.)	*Hesitates*
4	Peter	are we answering that = they're nuts or what?	
5	Ali		*Giggles*
6	Damien		*Smiles*
7	Damien	I agree on that	
8	Ali	'cause =	
9	Damien	'cause they have nothing better to do?	

10	Ali	= to see the difference =	[Suggests a correct answer]
11	Ali		*Laughs*
12	Ali	Yeah, right?	

Figure 5. Episode 3. Group B: Ali, Peter and Damien. S485 Q05 (part 2 08:15-08:29).

For many of the students in this study, the meanings of scientific practice, such as performing this experiment, are salient. Here, Ali's initial description of the imaginary students as "stupid" (1) forms a thematic pattern that is being negotiated throughout the excerpt. The only exception occurs when Ali, in a subordinated clause, proposes the correct answer (10). The discussion ends with Damien suggesting that the imaginary students conduct the experiment "*'cause they have nothing better to do*" (9).

We have discerned two possible ways of understanding the first utterance, in which Ali labels the imaginary students as stupid. One is that he is saying that the outcome of the imaginary action proposed in the assignment (placing marble chips in water overnight) would be obvious. We will come back to this interpretation soon. The second understanding is that Ali believes this experiment is a silly thing to do. This interpretation seems to be the same as Peter's: his hesitation in turn 3 evolves into a clarifying "*Are we answering that = they're nuts or what?"*(4), in which Ali's word "*stupid*" translates into Peter's: "*nuts*". The boys' continuous smiling and giggling (6–11) make it evident that Ali, Peter, and Damien know that neither of the suggestions are acceptable answers, given the institutional rules, but still confirm that the action of conducting overnight experiments with marble and water may be considered "stupid" or "nuts". Damien's utterance, "*I agree on that*" (7) follows his smiling (6) and Ali's giggling (5), all of which provides approval for the common theme first suggested by Ali (1). Damien's summarizing utterance (9) might be his interpretation of what Ali meant by "stupid," in which he asserts that the reason for doing this experiment is a lack of better alternatives.

By examining the item "Acid Rain," we can also reflect on the depicted activity as such: this experiment involves the students placing stones (marble chips) in water (pure, distilled).

We assume that this type of activity has been done by many children while playing with everyday objects (at least placing some kind of stone in some kind of water), and that it is therefore a shared experience for many people, and even tightly related to "general life". On the other hand, the result of such an experiment must be considered rather obvious (that is, "nothing happens," either from a general life or a scientific perspective). This clashes with the traditional expectations of a scientific experiment (Mortimer and Scott 2003), where there would be central interest in a more or less spectacular reaction. In the Swedish version of the test, one additional sentence makes the result quite clear, as it goes: ”No change was observed.”.

This episode demonstrates how the boys negotiate the meaning of scientific experiments such as the one described and how they choose to relate to it: by resistance and distance. By smiling, laughing, and labeling the imaginary students, the boys position themselves as different from them, as oppositional identities (Lee and Anderson 2009): as people who are not stupid, who have more important things to do, and ultimately express identities that do not aspire to the depicted scientific community as "people who would want to understand the world scientifically" (Brickhouse, Lowery and Schultz 2000).

The point of these two extracts is to situate this item in the perspective of some real-world students who, based on their utterances, do not talk about the given frame as their real world. As we have shown, the actions of the imaginary students cause them to emerge as small scientists. Through their imaginary experiment where stones must be put in water, they become human distillates of the disconnected scientist. As such, they can be subjected to the resistance of the real-world students. These two extracts are reversed images: In the first extract, Lina's question *"'cause they didn't have a life?"* was never picked up on by the others. On the other hand, Ali's *"'cause = they're stupid?"* mediated several actions on the theme.

Nevertheless, these extracts point in the same direction: these groups do not just have one discourse *in science* at play. Meanwhile, important positions and statements *about science* are being negotiated. These two discourses, in and about science, are parallel and simultaneous and indicate that the real lives of *these* students, as opposed to those of the imaginary students, are never disconnected. The discourse about science can sometimes be a side-track, constituted by single utterances, such as Lina's (in episode 2), and it can sometimes constitute the main-track, as in the case of Ali, Peter, and Damien (episode 3). Whatever track it takes, it appears for some of these students as though the "scientist as artifact" is central for their level of engagement, and utterances such as "*nuts*," "*stupid*," "*didn't have a life*," and "*nothing better to do*" demonstrate how the artifact itself, the imaginary scientist, represented by imaginary students, has created the resistance.

Relevance of Imaginary Everyday Context

The final two extracts focus on the students' experience of what we refer to as an *everyday context* in the items and how this confounds with both hidden and expected (implicit and explicit) scientific meanings. By *everyday context*, we mean the insertion of objects from day-to-day life that are not specific to a school science context. In our data, these objects are exemplified by vinegar, marble, and sunscreen. Prior to the fourth episode, Amy, Kevin, Carol, and Nigel have been working with the "Acid rain" unit for a few minutes when Amy suddenly admits that she does not know what marble is.

1	Amy	the guys must know 'cause I don't even know what marble is	[Directs her question towards Nigel and Kevin]
2	Kevin	what the hell has that got to do with guys?	
3			*Nigel and Kevin are looking at each other*
4	Carol	yes?	*Looking at Amy*
5	Amy	yeah you should know about such stuff	*Hiding herself behind a test sheet*
6	Kevin	why the HELL should I know about that?	
7	Amy	'cause I want you to	*Still behind the sheet*

8	Nigel	well I've had a marble plate in my house	*Looking at Kevin*
9	Kevin	so have I, but – what the [hell] – you think I put it in 'fucking' vinegar or what?	
10	Nigel		*Laughs*
11	Nigel	no	[Affirms]
12	Kevin	no	[Point made]

Figure 6. Episode 4. Group H: Amy, Kevin, Carol, and Nigel. S485 Q03 (20:26-21.15).

Amy thus reveals that she does not know what marble is and directs the issue to the boys (1). Kevin questions why boys should know more about that than girls (2) and returns to this twice (6, 9). When Nigel asserts that he does know through his experience of "*marble plates in my house*" (8), it becomes clear that Kevin is also familiar with marble. Their everyday life experience of marble plates is then considered by Kevin in light of the suggested experiment: "*So have I but – what the [hell] – you think I put it in 'fucking' vinegar or what?"*(9). Nigel then acknowledges Kevin's point and stops trying to solve the problem (10). After this episode, Carol makes a few fruitless attempts to get the group back on track, but the other three group members, and soon enough Carol herself, are no longer engaged and start to make jokes about their lack of smartness. The group eventually fails to answer the question.

In the meaning-making process of understanding this imaginary experiment, a gap has emerged in the group's encounter of marble as "marble chips" that are placed in vinegar. In order to explore and create a shared platform (Mäkitalo, Jakobsson and Säljö 2009), the negotiation fails in the sense that the group does not find a meaning of "marble" that makes sense to them in this specific situation. Amy's statement about not knowing what marble is (1) positions her in this situation as someone who does not know such a thing. There can be different reasons for this, although we wish to focus here on how the boys handle the task: Nigel suggests using an everyday experience of marble, both according to his utterance here and to a statement some minutes before this episode ("*a stone, a heavy stone*") to understand the experiment. However, his experience is from marble not as "chips" but as "plates" (8). There are two possible meanings for Kevin's counter-action, which questions the sense of placing marble in "*fucking vinegar*" (9). One possible meaning is that his experience of

marble plates at home (which, according to other groups in our material, could be from windowsills, kitchen sinks, etc.), clashes with the idea of putting them in vinegar (because of their use and size, for instance). The other possible meaning is that he really opposes the proposed action (as suggested in other episodes by Lina, and by Ali and Damien) and rejects the idea of conducting scientific experiments with marble and vinegar. This group may have found their own experiences to be useless in this situation.

In the fifth episode, the bringing of products from everyday life into a PISA item is demonstrated by the "Sunscreens" unit, in which imaginary Mimi and Dean investigate sunscreens. The backstory describes how Mimi and Dean decide to conduct an experiment on the effectiveness on the four sunscreens (S1, S2, S3, and S4) by placing drops of the creams on light sensitive paper next to drops of mineral oil and zinc oxide.

Question2. SUNSCREENS

Which one of these statements is a scientific description of the role of the mineral oil and the zinc oxide in comparing the effectiveness of the sunscreens?

A Mineral oil and zinc oxide are both factors being tested
B Mineral oil is a factor being tested and zinc oxide is a reference substance
C Mineral oil is a reference substance and zinc oxide is a factor being tested
D Mineral oil and zinc oxide are both reference substances

Figure 7. Item S447 Q02.

Prior to this episode, Peter, Ali, and Damien read the backstory in quiet and were just about to answer the above multiple choice question regarding the role of the mineral oil and the zinc oxide.

1	Peter	do you understand this?	
2	Ali	**They used mineral oil 'cause it lets through most of the sun**	*Points at the backstory text*
3	Ali	(.) mm I don't know	*mumbles*
4	Damien	but why would they care about which sun cream to use? erh (.) or sunscreen --	
5	Ali	they aren't tested [the mineral oil and the zinc oxide] because they already know what they do (.) that zinc oxide-	

6	Damien	I know. (.) but why bother so incredibly much that they do – well – <u>that</u>=	*smiling and looking curious*
7	Ali	it must be – or--	*Starts to laugh*
8	Ali	yeah <u>I know</u>	[Affirms]
9	Ali	I guess it's =	
10	Damien	it's just to go to the store and buy it or stay at home and [inaudible]	
11	Ali	BOTH must be reference substances because they know what both are	[Gives the correct answer]
12		(.)	
13	Damien	so take that	*Annoyed voice*
14	Ali	because they know what mineral oil and zinc oxide do--	
15	Damien	YES enough	*Interrupts*
16	Peter		*Writing*
17	Damien		*Yawns*

Figure 8. Episode 5. Group B: Peter, Ali and Damien. S447 Q02 (22:30-23:16).

In turns 1–3, Peter and Ali, by reading parts of the backstory aloud, engage in a problem solving process that proceeds in parallel (5, 7, 11, and 14) with Damien's argumentation. In turn 4, Damien asserts an idea with which to understand the proposed action by uttering "*But why would they care about which sun cream to use?"* Ali continues reasoning about an answer and successfully finds one that is correct, but Damien insists on pursuing his argumentation: "*I know. (.) But why bother so incredibly much that they do – well – that="* (6). His arguments refer to the imaginary students, Mimi and Dean ("*they*" in turn 4 and 6) and about how they "*care*" (4) and "*bother so incredibly much*" (6) about "*that*" (4 and 6).

What Damien does not accept, and what his resistance is addressing, seems to be the reasons for conducting the imaginary experiment ("*that*"). Why would anyone care so much, he asks? According to Damien's utterances here, there are no reasons in the lived world to investigate these sunscreens because "*It's just to go to the store and buy it*" (10). One could argue that even though one would have to know the sunscreens' relative effectiveness, such information is printed on the bottle (in the real world). Within the institutional practice of school, Damien could fulfill this assignment without asking for the reason. Still, for this 15-year-old boy, the reasons that might be apparent to the scientist (that almost anything is

interesting enough to be investigated) are far from evident. We argue that, based on the amount of action he takes to advance his argument – while Ali goes for the answer – this lack of reason is a critical issue to Damien. How can anyone "bother so incredibly much" (6)?

Kevin and Damien are both faced with the same problem: a context in which scientific meanings such as the reason for conducting experiments should not be questioned. To Kevin and Damien, the problems seem to emerge as pseudo-problems. When they are confronted with "real-life situations" and familiar objects like vinegar and sunscreen, they see no point in using scientific methods or entering the scientific culture. Thus, the methods and questions that are so taken for granted in the scientific community, as represented by "innocent" school experiments (in the sense that they are about everyday life objects and about students of the real students' own age), which are intended to raise interest and relevance, instead become transacted into remoteness and irrelevance.

In this study, students who did not seem to find the test itself difficult, such as Christian and Ali, raised issues in their groups about the meanings and reasons for scientific practice and expressed identities that sought to oppose the strict, academic, and science-engrossed little scientists that emerged from the test.

"Willingness to Engage" – or Resistance Towards a Stereotyped Image of Science?

The aim of this study was to gain knowledge about students' encounters with science as portrayed in a scientific literacy test. This was done by studying 15-year-old students' interactions with the backstory texts and test questions of three selected PISA Science units when working collaboratively in small groups. The methodological aim of observing the students' meaning-making *in action* (Wertsch 1998), and therefore choosing the group as research design, also enabled an analysis of the students' discursive positioning towards each other and the image of science as negotiated in that situation. It follows that it is not possible

from this design to deduce whether encounters and negotiations such as those presented here occur in actual individual test situations. However, the results do point at some important concerns connected, among other things, to the "real-life situations" depicted in the test (all though the overall purpose of this study has not been to assess or evaluate the PISA items per se). In this context, we wish to clarify that the concept of student *resistance,* related to the content and especially to the imaginary students in the items, first emerged as a salient feature of the data and has been used thereafter as an analytic tool to shed light on the students' reactions. However, it is important to understand what it is that actually mediates this resistance and why. A common theme for many of the students has been the questioning of the scientific meanings embedded in the test, which they demonstrated by expressing explicit discursive identities (Brown, Reveles and Kelly 2005). These identities were found to be clearly different from and opposed to those of the pictured imaginary students who appeared in the backstories of the test assignments. One example is the students' resistance to the imaginary students' use of a scientific and academic language, which often caused dissociation among the real-world students. (Examples of these expressions are: "your conclusion is premature" or "you must be sure that other factors that would influence the greenhouse effect are constant".) This is close to the stereotyped image of science as "socially sterile, authoritarian, non-humanistic, positivistic, and absolute truth" (Aikenhead 1996, p. 11). We argue that the imaginary students, through their fictional use of the scientific language and methods, emerge as "little scientist caricatures", despite the fact that they seem to represent ordinary students of about the same age as the real-world students and that they act in "everyday situations".

According to our analysis, the meanings and artifacts that appeared as the most salient to the students' in our material can be categorized as pertaining to an academic language and to embedded scientific meanings that reflects *the scientist* and *the scientific experiment* as

cultural artifacts. In relation to this, the analysis also indicates the possible existence of some severe assessment problems, especially when it comes to assessing scientific literacy with items strongly entangled with this academic and scientific culture. We have seen how, when students work with knowledge-assessment tasks (such as PISA science items), the cultural artifacts are active and create resistance, not least to the everyday life culture of the real-world students. The "knowledge measurement" then runs the risk of becoming a measurement of cultural engagement; that is, how well the students pass the border of scientific culture in order to approach the content. Indeed, learning to understand the scientific culture is a very important goal for science education. According to the OECD (2006), "being" scientifically literate involves having a "willingness" to engage in science-related issues (p. 23). One could conclude from this that the assessment measures exactly what it stresses. Yet, for several reasons, we argue the opposite. One problem we see is that the reported inferences from OECD are more loosely communicated by statements about the level of students' "scientific knowledge" or "scientific literacy" and the results are presented as valid country rankings or league tables across the participating countries.

Moreover, our data demonstrates the problem with "the dynamic nature of tasks" (McCormick and Murphy 2008). As stressed by Rosalind Driver, Paul Newton, and Jonathan Osborne (2000), among many others, science is not the "value-free" practice that is supposed to be accessible for neutral measures of knowledge; instead, science culture's "practices, norms, meanings, values, and identities" (Lave and Wenger 1991) are seen to come to the surface and are constantly being negotiated in the interaction between the students and the assignment. As we have argued, even implicit hints in the backstories about scientific practices, academic patterns of action, and specific language use are raised in students' discussions as salient and problematic. In this way, intended meanings in the test are being translated into other meanings, emphasizing aspects that are due to relations within the groups

of students, to missing and existing discourses and identities (Archer, Dewitt, Osborne, Dillon, Willis and Wong 2010), and to shared experiences. We also note how the test as a non-human actor contributes to shaping science education (Roehl 2012) as carrier of particular meanings.

Furthermore, we see that inserting issues of "relevance for everyday life" (OECD 2006, p. 7) in the backstories does not automatically make the test easier or more interesting for the students. Instead, we see how new problems are introduced. There appear to be significant differences between what test constructers and youth feel comprises "everyday life" and the relevance that science has in students' everyday life. The data from this study indicates that the backstories of constructed "general life-situations" may have a restraining influence on the problem-solving activity. Science, as depicted by PISA and exemplified by some released items, emerges as an elite and remote activity that is separated from the everyday youth context, despite its intentions to frame science in general life situations and in personal context. The students often position themselves as either unwilling to engage in the problem solving activity (which is the very condition for attaining a result) or as too uninterested to achieve.

The findings of this study adhere to many other studies that advise caution in not over-interpreting the PISA results and stress that understanding students' "knowledge" about science is much more complex than what is communicated by the international assessment organizations. As a final note, we wish to stress that in our view neither the collaborative situation that we have produced in our study nor the situation of individual testing represent the "true" student encounters with science; encounters are unique and always by their nature social and cultural, and, therefore, pieces that might all give insights in young people's engagement with science.

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Transcription legend

[ ] Text within two square brackets represents clarifying information
= Indicates the break and subsequent continuation of a single utterance
? Rising intonation
Underlined: Emphasis in talk
(.) Short pause in the speech
Indention: overlapping speech
- Single dash in the middle of a word denotes that the speaker interrupts himself or herself
-- Double-dash at the end of an utterance indicates that the speaker's utterance is incomplete
CAPITALS: Loud speech
Italics Context descriptions
<text> Indicates that the enclosed speech was delivered more slowly than usual for the speaker
`Courier New`: Students' reading from the text in the test is typed in Bold Courier New font

References

Aikenhead, G. S. (1996). Science education: border crossing into the sub-culture of science. *Studies in Science education, 27*, 1-52.

Archer, L., Dewitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). "Doing" science versus "being" a scientist: examining 10/11-year-old school children's constructions of science through the lens of identity. *Science Education, 94,* 617–639.

Bakhtin, M. M. (1981). Discourse in the novel. In M. Holquist (Ed.), *The dialogic imagination by M.M. Bakhtin* (pp. 259-422). Texas: University of Texas Press.

Bakhtin, M. M., Holquist, M., & Emerson, C. (1986). *Speech genres and other late essays.* University of Texas Press.

Brickhouse, N. W. (2011). Scientific literacy for bringing in the outsiders. In C. Linder, L. Östman, D. A. Roberts, P. Wickman, G. Erickson & A. MacKinnon (Eds.), *Exploring the landscape of scientific literacy* (pp. 193-203). New York: Routledge.

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? the construction of school science identities. *Journal of Research in Science Teaching, 37,* 441–458.

Brown, B. A. (2004). Discursive identity: assimilation into the culture of science and its implications for minority students. *Journal of Research in Science Teaching, 41,* 810–834.

Brown, B. A., Reveles, J. M., & Kelly, G. J. (2005). Scientific literacy and discursive identity: a theoretical framework for understanding science learning. *Science Education, 89,* 779–802.

Bryman, A. (2012). *Social research methods*. Oxford: Oxford University Press.

Dolin, J., & Krogh, L. B. (2008). *Den naturfaglige evalueringskultur i folkeskolen – anden delrapport fra VAP-projektet [The scientific culture of evaluation in compulsary school – second report from the VAP project]*. Copenhagen: Københavns Universitet, Institut for Naturfagenes Didaktik.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84,* 287–312.

Egelund, N. (2007). *PISA 2006 – danske unge i en international sammenligning*, Køpenhavn: Danske Paedagogiske Universitetsforlag.

Filer, A. & Pollard, A. (2000). *Social world of pupil assessment: Processes and contexts of primary schooling*. London: Continuum.

Fraser B. J, Tobin, K. & McRobbie, C. (2010). Second International Handbook of Science Education. New York: Springer Verlag New York Inc.

Furberg, A. (2009). Socio-cultural aspects of prompting student reflection in web-based inquiry learning environments. *Journal of Computer Assisted Learning, 25,* 397–409.

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education, 25,* 99–125.

Gee, J. P. (1999). *An introduction to discourse analysis: Theory and method*. London: Routledge.

Gorur, R. (2011). ANT on the PISA trail: following the statistical pursuit of certainty. *Educational Philosophy and Theory, 43,* 76-93.

Halliday, M. A. K., & Martin, J. R. (1993). *Writing science: literacy and discursive power.* Pittsburgh: University of Pittsburgh Press.

Haraway, D. J. (2004). Modest_Witness@Second_Millenium. *The Haraway reader* (pp. 223–250). New York; London: Routledge.

Harlow, A. & Jones, A. (2004). Why students answer TIMSS science test items the way they do. *Research in Science Education, 34,* 221-238.

Ideland, M., & Malmberg, C. (2012). Body talk: students' identity construction while discussing a socioscientific issue. *Cultural Studies of Science Education, 7,* 279-305.

Jakobsson, A., Mäkitalo, Å., & Säljö, R. (2009). Conceptions of knowledge in research on students' understanding of the greenhouse effect: methodological positions and their consequences for representations of knowing. *Science Education, 93,* 978–995.

Kind, P. M. (2011). Assessment frameworks in PISA, TIMSS and NAEP – historical background and future challenges. Presentation at network meeting in Uppsala, October 11th, 2011.

Lave, J., & Wenger, E. (1991). *Situated learning: legitimate peripheral participation.* Cambridge: Cambridge University Press. (Learning in doing).

Le Hebel, F., Montpied, P., & Tiberghien, A. (2011). *Which effective competencies do students use in PISA assessment of scientific literacy?* Paper presented at ESERA, Lyon 7th of September 2011.

Lee, J. S., & Anderson, K. T. (2009). Negotiating linguistic and cultural identities: theorizing and constructing opportunities and risks in education. *Review of Research in Education, 33*, 181-211.

Lemke, J. L. (1990). *Talking science: Language, learning, and values.* Ablex Publishing Corporation.

Lemke, J. L. (1995). *Textual politics discourse and social dynamics.* London: Taylor & Francis.

Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of Research in Science Teaching, 38,* 296–316.

Liberg, C., af Geijerstam, Å., & Folkeryd, J. W. (2011). Scientific literacy and students' movability in science texts. In C. Linder, L. Östman, D. A. Roberts, P. Wickman, G. Erickson & A. MacKinnon (Eds.), *Exploring the landscape of scientific literacy* (pp. 74-89). New York: Routledge.

Mäkitalo, Å., Jakobsson, A., & Säljö, R. (2009). Learning to reason in the context of socioscientific problems. Exploring the demands on students in 'new' classroom activites. In K. Kumpulainen, C. Hmelo-Silver & M. Cesar (Eds.), *Investigating classroom interaction. Methodologies in action.* (pp. 7-26). Rotterdam: Sense Publishers.

McCormick, R., & Murphy, P. (2008). Curriculum: the case for a focus on learning. In K. Hall & P. Murphy (Eds.), *Learning and practice: agency and identities* (pp. 3-18). Los Angeles; London: Sage.

Mortimer, E. F., & Scott, P. (2003). *Meaning making in secondary science classrooms.* Buckingham: Open University Press.

OECD (2007). *PISA 2006: Science competencies for tomorrow's world. Volume 1: analysis*. Paris: OECD Publications.

OECD (2006). *Assessing scientific, reading and mathematical literacy. A framework for PISA 2006.* Paris: OECD Publications.

Roehl, T. (2012). Disassembling the classroom–an ethnographic approach to the materiality of education. *Ethnography and Education*, *7*, 109-126.

Rogoff, B. (1990). *Apprenticeship in thinking: cognitive development in social context.* New York: Oxford University Press.

Rommetveit, R. (1974). *On message structure: a framework for the study of language and communication.* Oxford, England: John Wiley & Sons.

Sadler, T. D. (2009). Situated learning in science education: socio-scientific issues as contexts for practice. *Studies in Science Education, 45,* 1-42.

Schoultz, J.(2000). *Att samtala om/i naturvetenskap. Kommunikation, kontext och artefakt. (To talk in/about science. Communication, context, and artifact),* diss. Linköpings universitet

Schoultz, J., Säljö, R., & Wyndhamn, J. (2001). Conceptual knowledge in talk and text: what does it take to understand a science question? *Instructional Science, 29,* 213–236.

Schreiner, C. (2006). *Exploring a ROSE garden: norwegian youth's orientations towards science – seen as signs of late modern identities*. Faculty of Education. Oslo University. Oslo: Department of Teacher Education and School Development.

Schreiner, C. & Sjøberg, S. (2004). *Sowing the seeds of ROSE: background, rationale, questionnaire development and data collection for ROSE (the relevance of science education) – a comparative study of students' views of science and science education.* Oslo: Department of Teacher Education and School Development. (Acta Didactica No. 4).

Sjøberg, S. (2007). PISA and "real life challenges": mission impossible? In Hopman, S. (Ed.), *PISA according to PISA - does PISA keep what it promises?* (pp. 203-224). Wien: LIT Verlag.

Wells, G. C. (1999). *Dialogic inquiry*, New York: Cambridge University Press.

Wenger, E. (1998). *Communities of practice: learning, meaning, and identity*. New York: Cambridge University Press.

Wertsch, J. V. (1998). *Mind as action.* New York: Oxford University Press.

Wertsch, J.V. (1991). *Voices of the mind: a sociocultural approach to mediated action*. Cambridge, Massachusetts: Harvard University Press.

Wickman, P. (2004). The practical epistemologies of the classroom: a study of laboratory work. *Science Education, 88,* 325–344.

Wittgenstein, L. (1967). *Philosophical investigations*. Oxford: Blackwell. Wyndhamn, J. & Säljö, R. (1997). Word problems and mathematical reasoning: a study of children's mastery of reference and meaning in textual realities. *Learning and Instruction, 7,* 361–382.

Yerrick, R., & Roth W-M. (2005). Introduction: the role of language in science learning and teaching. In R. Yerrick & W-M. Roth (Eds.), *Establishing scientific classroom discourse communities: multiple voices of teaching and learning research* (pp. 1–18). Mahwah, NJ: Lawrence Erlbaum Associates.