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‘Beating about the bush’ on the how and why in elementary school science

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In this article we examine teacher instruction on scientific literacy tasks and teacher expression of ultimate and subordinate purposes during one teaching sequence of a science unit. By using a Practical Epistemology Analysis and Systemic Functional Grammar we can provide a view of the direction learning takes and the consequences for student text production. The material comprises transcribed audio recordings of teacher instruction, students’ pair work and written texts. The results show that the students are mainly involved in hands-on activities while aspects of scientific literacy are not foregrounded. Language use is dominantly spoken and, when written text is requested, no explicit instruction on how to write is given, resulting in a variety of texts from ‘more-spoken-*like*’ to ‘more-written-*like*’ without adhering to scientific genre. Ultimate purposes are never expressed while subordinate purposes are to some extent made explicit, but obscured by the dominant focus on ‘doing’, resulting in uncertainty about why the activity is requested. As a result, the learning direction is not always in accordance with teacher intention.

Keywords: elementary school science, purpose, scientific literacy

Introduction

In this article we examine teacher instruction on scientific literacy tasks and teacher expression of ultimate and subordinate purposes during one teaching sequence of a science unit. By doing this we can provide a view of the direction learning takes and the consequences for student text production.

A central prerequisite for developing the kind of knowledge expected by the school system is to learn how to use the specific language connected to a subject. Each school subject has its specific ways of structuring knowledge and students have to be able to handle the lexicogrammar, i.e. both the words and grammatical structure of the subject. Science teachers have commonly focused on the technical terms while it is more the grammar that poses the greatest difficulties for understanding or, as Halliday and Martin (1993:71) put it, “it is the total effect of wording – words and structures”. In all subjects, language is the key to understanding and presenting content as well as managing activities (Schleppegrell, 2004). Lemke expresses this as “the mastery of science is mainly a matter of learning how to *talk* science” (1990:153), i.e. learning how the meanings of words are related to each other, and to understand what is relevant to talk about in a given situation (Halliday, 1994; Holmberg & Karlsson, 2006).

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When the "scientific literacy" concept was introduced (Halliday & Martin, 1993), the focus expanded further to include reading, writing and later on multimodal ways of expressing scientific content. An important difference between spoken and written text is that speech normally accompanies action while written text is contextually more independent and can stand alone. For a learner, reading, writing and multimodality involves drawing on grammatical resources other than speaking, such as controlling the referential items in understanding and creating a context-independent text. Christie (2003:292) formulates this as "the language of a written text *constitutes* the meanings involved, while speech is more typically ancillary to it". Students have to recognise the linguistic usage that is relevant in a specific situation and be able to move between scientific language and everyday language (Carlsen, 2007; Halliday & Martin, 1993; Martin, 1993; Reveles & Brown, 2008). The acquisition of the linguistic resources needed for school learning is connected to exposure to reading and writing experiences. Students acquire speech "naturally", but for reading and writing they need a mentor, be it parent or teacher (Wells, 1999). The pedagogical consequence is that students have to be introduced to and guided through the language of schooling and to the linguistic patterns of different subjects. In science, the technical language adds precision and simplifies the scientific discourse while at the same time constructing reality in a way that results in a distancing from everyday speech (Wells, 1999).

Previous research

The importance of teachers as conversational partners is highlighted by Peterson and French (2008). They investigated how preschool children's vocabulary and scientific understanding were promoted by teachers' supportive questions during hands-on science activities. The result shows how teachers' scaffolding talk enhanced children's opportunities to predict and explain what would happen when different colours were mixed. They conclude that collaborative conversations are important when preschool children are learning to talk science and learning to investigate scientific phenomena.

The role of scientific inquiry in enhancing students' learning of science as well as their linguistic development has resulted in a mixed picture that depends on how language use is described (Amaral, Garrison & Klentschy, 2002; Dawes, 2004; Haneda & Wells, 2010; Wallace, 2004). Dawes (2004:693) contends that scientific inquiry is beneficial to learning science as it "involves encouraging children to find ways to verify or establish a joint understanding", which hence demands a specific use of language. Likewise, Wallace (2004) means that scientific language gets its meaning when incorporated with authentic experiences. Amaral et al. (2002) used the STC programme (Science and Technology for Children) when investigating how scientific activities in bilingual classrooms in elementary school hold significance for learning science and for students' linguistic development. They argue that scientific inquiry enhances English language learners' (ELLs) learning of science as well as their learning of English as it promotes students to talk and investigate in cooperative groups. By working together, students

talk about the experiences using words that are somewhat new to them supported by the teacher. Accordingly, it is argued, students' vocabulary is increased as they learn to use new words when involved in scientific activities (Amaral et al., 2002). However, in her often cited magnetism example, Gibbons (2006) showed the differences between four texts connected to ten-year-old students' scientific inquiry in relation to the texts' situation on a continuum from 'more-spoken-*like'* to 'more-written-*like'*. Text one is spoken, face-to-face, with exophoric references like (*this, these, that*). Text two is spoken monologue presenting results from a personal point of view. The third text is written with a time distance between action and presentation acknowledging the request for nominal explicitness. Finally, the fourth text is from a child's encyclopedia making use of lexical density, nominalisation and process details common to science texts.

The pedagogical point made by Gibbons (2006) is that if science inquiry is to expand students' proficiency in expressing themselves on a scientific topic there has to be a variety of linguistic activities connected to the action. To merely talk when doing the investigation does not evoke the need to use technical terms or scientific grammar. Instead, students benefit from a guided sequence with a variety of linguistic demands when moving from spoken to written scientific language. In this study we will analyse the various linguistic activities appearing in the science classroom to make evident the students' possibilities to move between every-day language and scientific language.

Roberts (1982) analysed textbooks and found seven curriculum emphases which could be said to answer the question "Why should I learn this?", i.e. the purpose of a part of a textbook. Moreover, the significance of an explicitly presented purpose in science topics has been underscored for students' possibilities to act in meaningful ways (Johansson & Wickman, 2011; Wickman & Ligozat, 2011). Johansson and Wickman (2011) distinguish between *proximate* or student-centred *purpose* and *ultimate* or overall purpose, which together constitute the *organising purposes* of a teaching sequence. They give as an example young students investigating why cars have tyres. In this situation the proximate purpose of the investigation, learning why cars have tyres, was made explicit to the students. However, the ultimate purpose, learning about friction, was implicit, meaning that the organising purposes were not related. Metz (2004) presents a parallel taxonomy for scientific purposes when she argues that the goal structure is hierarchical. Her notion of a top-level goal can be seen as synonymous to Johansson's and Wickman's (2011) ultimate purpose and the suggested sub-goals can be compared to proximate purposes. The sub-goals proposed by Metz (2004) open up the possibility of dividing proximate purposes into several subgroups, thereby constituting a hierarchical structure. In this study, we will use *ultimate purpose* for the overall purpose, i.e. the purpose of the topic, and *subordinate purposes* for the *explicitly* or *implicitly* indicated purpose of each activity.

In this article, we examine how ultimate and subordinate purposes of a science unit are presented to and understood by elementary school students and the consequences of teacher instruction and literacy tasks for students' language use.

Theoretical framework

Practical Epistemology

A practical epistemology takes its stance in Dewey (1938/1997), the later Wittgenstein (1953/1992) and socio-cultural perspectives. Learning is considered as active and as a part of the meaning-making process. Actions are seen as situated in whole activities having consequences for *how* the ways of learning influence *which* route learning takes (e.g. Harré & Gillett, 1994; Wertsch, 1995). This is in line with Lave (1996), who argues that learning is always taking place. Consequently, experiences from a specific purpose are continually transformed in interaction with the surrounding world, which is in accordance with Dewey's (1938/1997) principle of continuity. Yet there might be a problem in that learning does not always proceed in the intended direction demanded by, for example, a teacher (Rogoff, 1990). This can be due to a lack or indistinctness of purpose. Dewey (1938/1997:67) believed "a purpose is an end-view", making it possible to foresee the consequences of our actions. Hence, purpose is tied to Dewey's principle of continuity. Moreover, we take our stance in Wittgenstein's language-games. Wittgenstein (1953/1992) argued that words obtain their meaning in use in a specific situation which constitutes a language-game. Accordingly, we have to study a particular situation, itself situated in a language-game, in order to understand the meaning of the words used (Harré & Gillett, 1994; Wittgenstein, 1953/1992).

When employing a Practical Epistemology Analysis (PEA) the unit of analysis is similar to that in socio-cultural perspectives, meaning that a PEA is concerned with actions as situated in whole activities (e.g. Harré & Gillett, Wertsch, 1995). A PEA comprises four operational terms, i.e. *stand fast*, *relation*, *gap* and *encounter* (Wickman, 2004; Wickman & Östman, 2002). In order to maintain an interaction, the interlocutors need to agree on what the discussion is about in a specific situation. The concept used in a PEA for this agreement is *stand fast*. That which stands fast is what is immediately intelligible to the interlocutors and not questioned. Something that stands fast is not static but changes with a specific discourse in different encounters between people and between people and the surrounding world, including earlier experiences. Accordingly, relations to what is standing fast are construed in encounters and one example to illustrate this came from Maj and Ode when observing a soil test, sand, using magnifying glasses:

> Maj: Look! This is black. Under here it is black…Look! It looks like a worm…It looks like a worm… Look! It looks like a worm.
> Ode: Yeah, a worm.

Maj immediately construed the relation *looks like a worm* to *this,* i.e. something black, which was fully intelligible to Ode, it stood fast to her, which was shown in

her saying *Yeah, a worm*. Accordingly, the girls noticed a gap, *under here it's black,* which to them was strange as sand is usually not black. In construing relations to what stands fast, there is a need to notice gaps and mostly gaps are filled immediately as in the above example or questions might be asked in order to clarify the meaning. If gaps are not filled with new relations, they are said to be lingering. In such situations, learning either comes to a halt or takes a direction other than that intended by the teacher. Accordingly, construing relations to what stands fast from a specific purpose has consequences for what is learned. In this study, this is connected to the presentation and understanding of the *ultimate purpose* of the topic and the *explicit* or *implicit subordinate purposes* of each activity.

Systemic functional grammar

Functional grammar builds on Halliday's (1994) Systemic Functional Grammar (SFG). Within SFG, the focus is on people's relations to each other (as opposed to PEA where a relation is construed with what is standing fast) and how meaning is expressed in different ways in different situations (Holmberg & Karlsson, 2006). SFG describes language as systematically organised according to the functions it has to fulfil (Holmberg, 2011). Language is seen as a system of resources for making meaning and the focus is on the linguistic choices people make in different contexts. SFG has contributed to our knowledge of both language development and language education and has, in Australia, constituted a basis for writing instruction with a focus on minority and second-language speakers. Over the years, the analysis of written texts has expanded to all school subjects focusing on the specific genres typical of each subject (Halliday & Martin, 1993; Schleppegrell, 2004; Veel, 1997). Genres central to scientific discourse are *procedures* for observing and experimenting, *procedural recounts* for reporting on observations and experiments, *reports* that classify and describe and *explanations* of causes and effects (Martin & Rose, 2008; Veel, 1997). There is an overall understanding about the difficulties in scientific discourse and Halliday and Martin present a list of general difficulties characterising English scientific discourse: interlocking definitions, technical taxonomies, special expressions, lexical density, syntactic ambiguity, grammatical metaphor and semantic discontinuity (1993). The pedagogical assumption is that explicitness about a subject's linguistic demands is particularly beneficial for learners' successful achievement (Magnusson, 2009).

An ideational grammatical analysis, i.e. how the grammar describes experiences of the world, of the teacher's instruction, students' speech and writing, will be performed to reveal how the texts are grammatically construed and how the texts elucidate content and message. An ideational transitivity analysis of the abovementioned texts will be made, focusing on the processes and primary participants (Hallesson, 2011; Karlsson, 2011). Four processes will be distinguished: material, mental, verbal and relational. The respective primary participants in these processes are actor in material processes, senser in mental processes, speaker in verbal and carrier, the identified or

the existing in the relational processes (Halliday, 1994). By analysing process meaning clause by clause it is possible to see what happens in the texts and how relations between the participants are built.

The use of both PEA and SFG is an attempt to bring together and combine analytical tools from the fields of science education and linguistics. The different units of analyses yield different contributions. When using a PEA one can examine the direction learning takes in a specific situation. A SFG analysis gives visibility to language use and registers. Together, PEA and SFG strengthen the analyses and connect the two fields.

The study setting

The material in this study was collected by one of the authors (Britt Jakobson, henceforth BJ) in a suburban school in Sweden, chosen for its mix of mono- and multilingual students and the teacher's science teaching. The participating teacher had joined in-service courses, which is a prerequisite for using the material in the STC programme (Science and Technology for Children) to be able to teach science since science was not included in his teacher education. The STC programme has been developed in the USA to promote young students' learning in science and comprises teacher guides, students' work sheets and big boxes with the artefacts to be used during hands-on inquiries. BJ visited one grade 2 class (8–9 years old) during a science unit that lasted for three months. The 31 students were involved in a hands-on inquiry unit in geology, *Soil,* which is part of the Swedish version of STC. The Soil unit involves whole class interactions as well as pair and small group inquiries. The students were told that the researcher was interested in them talking science in class and in what they learned during the discussions. As the students were young, their parents or custodians were informed and asked to give written consent to their children participating in the study with the right to withdraw the consent at any time. The students' and teacher's names are fictitious in the study.

In this article, we present the results from one lesson taking place in the middle of the unit. The reason for choosing this lesson was that the students were involved in a hands-on inquiry and, in addition, had been asked to write a longer text on the topic taught, in contrast to generally filling in work sheets. The collected material consists of audio recordings of pair or small group conversations and students' written texts during one lesson that lasted about 2 hours. This means that audio recordings were made of four group conversations and of the teacher's, carrying a microphone, instructions, resulting in about 10 hours of audio recordings, most of which were transcribed. In addition, the researcher was present in the classroom during the recordings, observing the students' actions at large and taking notes of what occurred to facilitate an interpretation of the recordings. The teacher instruction, students' oral production presented in this study are typical of all teaching sequences. The two written texts are representative for the longer texts written on the above mentioned occasion. Literal translations of the transcriptions in a written standard from Swedish to English are given in the text.

The ultimate purpose of the Soil unit is for students to learn what soil consists of, how to recognise different types of soil and the significance of soil for living organisms and human beings. Moreover, a formulated ultimate purpose for all STC units is for students to practise their communicative proficiency through talking, reading and writing, as well as recognising patterns and structures in science. The subordinate purposes of the topic are connected to each individual investigation, explicitly or implicitly indicated.

Results

According to the STC manual and in order to facilitate students' learning about soil, the teacher introduced a number of hands-on activities which the students carried out. Initially, one example of teacher instruction is presented, i.e. procedure, related to the ultimate and subordinate purpose. Secondly, we demonstrate what this means for how students apprehend the subordinate purpose during the following hands-on activity. Finally, the students' written texts, i.e. procedural recounts or reports, are analysed in relation to the subordinate purpose and text genre. The analysis method used is specified under the subheadings.

Procedure

All of the lessons during the Soil unit started with a revision of the previous lesson followed by teacher instruction prior to the students' actions and mostly dealt with practical issues. The teacher frequently told the students what equipment to use and how to use it. Although the students were told that the class would work with the Soil unit, the ultimate purpose was obscured by the focus on procedure. In the middle of the unit the teacher started by asking the students what they had done during the previous lesson, which the students expressed in whole class discussion. The subordinate purpose during the previous activity was to observe what happened to the different soil types (humus, sand and clay) when shaken in water. The test tubes now had been left in mugs for a week and the students were instructed to observe the result. The implicit subordinate purpose was to understand different effects of water on various soil types. The teacher gave the following instruction:

1. Teacher: What you are going to do now... [distributes a worksheet]. It is like this that you are going to get back the tests that you did last time. How were you placed then?... It is like this you see, you are getting back...You are getting back your tests, you see. So I tell you and you come and get them. But now it is like this, they have been standing still for a long time, haven't they ...That is why it is important that when you get mugs, if you think that this is your mug, so you just do not get back to your desk. Look! Look! Look! Because if you shake them then you will be back where you were last week, won't you? That is why you have to carry them really carefully and put them down carefully.

Okay. Do you understand? And what you are going to then, when you have got the worksheet in front of you, it says "After a couple of days the test looks like this" [reads]. So you write exactly as last time, "humus, sand and clay". And then you sit down and draw exactly what it looks like. And then you can look through the magnifying glasses to see what it looks like. What differences are there? Has it become different or is it similar or is it? Do you understand?

2. Several students: Yeah.
3. Teacher: And what kinds of similarities there are. So I will read the name written on [the test tube] and that person comes and gets it [distributes the test tubes].

The students were acquainted with the different test tubes, meaning that it was, from a PEA, immediately intelligible to them what the teacher was talking about. The teacher started by instructing the students how to carry out the investigation construing relations as *be back*, *last week* and *careful* to what was standing fast. The teacher's request for care was important because if the test tubes were shaken there would be no possibility of observing what had happened after a week. He went on reading the text of the worksheet to the students, telling them what to write and draw. Finally, he explicitly expressed a subordinate purpose when asking them to observe the soil samples by construing relations in terms of "differences" and "similarities" between the results a week ago and the current results. Student responses to the teacher's instruction indicate that they understood. However, the subordinate purpose "to understand the effects of water on various soil types" was implicit.

From a SFG analysis, the ideational transitivity analysis of this teacher monologue focuses on processes and primary participants, i.e. actors, to see what happens in the text and how relations between participants are built. Four process types are in focus: material, mental, verbal and relational. As expected in a spoken text of an instructional type the processes are overwhelmingly material (63%). A smaller portion of the clauses are relational (28%) and some mental (7%) as well as verbal clauses (2%) appear. The material processes concretely inform how the students are supposed to act when receiving their soil samples from last week, e.g.: *you are going to get back the tests, and then you can look through the magnifying glasses*. The primary participants in the material processes are the students addressed as "you". The relational processes appear when the teacher makes statements or describes different situations, e.g.: *it is like this*. Through these processes the teacher's point of view is expressed as mere fact. A common type of primary participant in the relational clauses is the impersonal carrier "it". The mental processes are few and address the students' cognitive processes, *do you understand?* The primary participant, the senser, is the student. The verbal processes are the least common which is quite logical since the text is a mere monologue by the teacher. The only verbal process is an explicit expression of what the teacher is doing, *so I tell you,* with the teacher as the primary participant.

The purpose of the teacher's instruction was to get the students to act in a certain way during the activity. In a written instruction the processes would be expressed in the imperative, but in this face-to-face instruction it is natural to mainly use the present tense and address the students with the general 'you'. Connected to time, the teacher uses some linking words: *when, then*. The materials to be used are in front of the teacher and the students, but still named by the teacher along with a specification of the methods to use when analysing the samples. Throughout the instruction, the students are given detailed information on **how** (*carefully, exactly*), and **when** (*after you have got the worksheet in front of you, after you sit down*) to act.

Activity

Hands-on activities dominated the Soil unit and during those activities the students were encouraged to talk to each other in groups or pairs. During those discussions the students were focused on what to do and what to observe. However, the subordinate purpose was not always apprehended in the same way, meaning that the students were engaged in somewhat different activities. At the end of the teacher instruction described above, the students were told to compare the results from last week with the tests being left aside and notice differences and similarities (1). Matilda and Bertrand observed what had happened to sand in water using magnifying glasses:

4. Bertrand: Oh! Look what has happened. Look! The sand is at the bottom. Almost. [...]
5. Matilda: This is the sand.
6. Bertrand: Has it become like that?
7. Matilda: Look!... But you are stiiiring.
8. Bertrand: Light, light yellow... Cool. Look!
9. Matilda: It looks the same... This one is dirty. No, but stop!

By using a PEA it was shown that Bertrand immediately construed relations to what was standing fast, i.e. the mixture of sand and water. He was positively surprised by what he saw, as shown in the relation *oh*, an aesthetic judgement, construed to sand followed by *Look what has happened. Look!* (4). Bertrand was eager to tell Matilda what he had observed and wanted her to look as well. It is not clear if she shared Bertrand's joy. Bertrand continued by construing the relations *at the bottom* and *almost* to *sand*. He observed that the sand had sunk to the bottom, at least almost, which was quite intelligible to Matilda (5). Bertrand asked Matilda a question which she did not answer, meaning there was a lingering gap (6). When Bertrand started to stir the mixture, Matilda got a little annoyed as they were especially told not to stir or shake the test tubes. However, Bertrand continued the observation and construed relations to what was standing fast, i.e. the stirred mixture, in terms of *light yellow* and *cool*. Again he used a positive aesthetic judgement, *cool*, to emphasise that what

he saw was something nice and worth observing, which he wanted Matilda to see as well. Matilda, though, did not seem to share Bertrand's joy as she construed the relations *looks the same* and *dirty* to *it* and *this one,* respectively. It is unclear what she was referring to, but it is possible that she had compared it to how the mixture appeared a week ago. It is also conceivable that she again became irritated by Bertrand continuing to stir the mixture (9). In spite of this, the students proceeded with the activity and made more observations:

10. Matilda: It really looks disgusting. It looks like that…
11. Bertrand: It looks like my pee.
12. Matilda: Noo, I will say. It looks like mallow.

Matilda construed the relation *disgusting* to *it*, i.e. the stirred mixture. Accordingly, she used a negative aesthetic judgement in order to express her repugnance to the mixture of sand and water. She also construed the relation *looks like*, but she did not complete the sentence. However, Bertrand followed up and construed the relation *looks like pee* to *it*, which Matilda did not agree with. Instead, she construed the relation *looks like mallow*, to *it*. In this situation the students construed relations in terms of metaphors, i.e. *pee* and *mallow*. In that way the students reconstructed their earlier experiences which were transformed in this situation, meaning that they were able to discuss and carry on with the activity. However, they did not construe any relations concerning similarities and differences between the results from last week and the results from this observation, with one possible exception, i.e. the relation *looks the same* construed by Matilda (9). Accordingly, the students proceeded with the activity, but not in the direction intended by the teacher. Instead, they again observed a newly stirred mixture, which hindered comparisons between the result of last week and the current one. Hence, the students' earlier experiences were reconstructed and transformed in terms of metaphors (cf. Jakobson & Wickman, 2007). The students frequently used metaphors when observing the soil tests, meaning that the subordinate purpose of the activity was implicit to them, i.e. observing differences and similarities between the different soil tests. When observing the test tube which contained sand, using a magnifying glass Maj noted that there was something in the sand:

13. Maj: Look! This is black. Under here it is black… Look! It looks like a worm… It looks like a worm… Look! It looks like a worm.
14. Ode: Yeah, a worm.
15. Maj: Yeah, look!

Maj observed that *it*, the sand, was *black under* (13) and then continued construing a relation in terms of a metaphor, *like a worm*, to *it*, i.e. *black*. The metaphor was quite intelligible to Ode, who agreed. The students hence construed relations to the soil test

from their earlier experiences of worms, which were reconstructed and transformed in this situation without comparing the different soil types. Instead, like Bertrand and Matilda they compared the soil test to what it looked like by using a metaphor.

Using a SFG analysis it is shown that, parallel to Gibbons' (2006) first text, these two texts are also spoken, accompanying the students' investigation of sand. Bertrand and Matilda started off by naming *the sand* and then referred to the tube containing sand as *it*. Likewise, Maj and Ode referred to sand as *this* and *it*. Since this is a face-to-face context, the students' use of an exophoric reference (*this, that*) is expected and unproblematic. The task in this activity is to make comparisons and, to accomplish this, the students used adjectives (*light yellow, dirty*) or nouns (*pee, mallow*).

Procedural recount or report?

The students documented their findings during hands-on activities through reading, writing and drawing on worksheets. The written demands were generally limited and at most amounted to a single sentence. However, in the middle of the unit there was an excess of time at the end of a lesson. BJ suggested that the students could write an individual text. The teacher agreed, formulated and performed the following instruction:

16. Teacher: As well as you can you are going to write "What I know about soil" and then you are going to write what you have learned so far. Everything you have learned! Which colours, what it consists of. Everything! Everything you can remember. Just about soil. About this unit, what we have done sort of. What have you learned? [distributes writing paper] Your task thus is, as well as you can, write what you have learned. Colours, forms, how it feels, smells, what does it consist of? Everything! Everything we have done. If you like you can tell what you remember that we have done during this STC unit... You shall write what you have learned and what you have done. Go ahead and write!

In this instruction the teacher explicitly expressed two subordinate purposes: "write what you have learned and what you have done". From a SFG analysis, the first purpose directs the students towards a descriptive report of their present knowledge while the second is more likely to lead to procedural recounts of the actions that had taken place. Two student texts are analysed, text 1 by Tammy and text 2 by Kenneth. (Relational processes in italics, material processes underlined and mental processes in bold).

Text 1 What I [know] about soil

The soil *contains* "sand"clay"humus". When we <u>shake</u> "sand"clay" humus" then it *gets mixed* into different colours. Humus *contains* dead "plants"animals"trees"shit"bacteria". Sand *contains* "stones" (small, small). Under water there *is* soil under the sand.

When asked to write this text the students had spent six weeks building their knowledge of the field. However, from a SFG point of view, they had not written procedural recounts or descriptive reports earlier since all writing during the topic had been confined to short sentences or single words in the worksheets. On one occasion the teacher referred to descriptions made in Swedish lessons, but no explicit teaching on science genres had occurred. Accordingly, the teacher did not give an explicit instruction on how to write; instead, he focused on the two aspects "write what you have learned and what you have done".

Tammy's text is 'more-written-like', a text of type three according to Gibbons (2006) and 'language as reconstruction' according to Martin (1984). There is a distance between the writing and the investigations Tammy has performed on soil and the unseen receiver of the text is manifested in the opening general statement Tammy provides as a context for what follows: *The soil contains "sand "clay "humus"*. By this, Tammy has acknowledged that "written texts cannot rely on shared assumptions and a writer must recreate experience through language alone" (Gibbons 2006). The written mode is also emphasized by the use of quote marks, even if not altogether correct. There is one material process: *shake* while the rest are relational: *contains, is* all in simple present tense and *gets mixed* expressing passive meaning. The descriptive language is factual and precise rather than imaginative; *sand contains stones (small).*The three final sentences are generalisations: *Humus contains dead "plants"... Sand contains "stones"* and "*under water there is soil..."* a preferred form of expression in science. The technical terms are represented by *humus*, *bacteria* and *plants*. Except for the second sentence, the writing is in a relatively formal and objective style. The use of first person pronouns (I, we) and the writer's opinions are not at the core of this type of writing. Altogether, Tammy's text is more of a descriptive report than a procedural recount.

The use of a PEA showed that Tammy construed a lot of relations to the soil test. Tammy construed the relation *contains "sand "clay "humus"* to what stood fast, i.e. *soil*. He continued to construe relations as *different colours* to *mixed* soil types and to humus and sand in terms of what they consist of, i.e. *dead "plants" "animals" "trees "shit "bacteria*" and small "*stones*". Accordingly, his text was descriptive and scientifically explanatory. However, there was an unnoticed gap concerning *"there is soil under the sand"*, meaning that Tammy did not view sand as soil.

Text 2 What I know about soil

> It *is* brown, black and grey. We have shaken different experiments. It *was* clay, sand and humus. Soil *is* worm, shit. When clay dries – it *becomes* very hard. Clay *is* very sticky. Humus **feels** – humid. The clay **feels** smooth. And the sand **feels** rough. When you shake the humus it looks like a lava lamp. When you shake the clay then it *becomes* like a fog. The sand stays put when you shake it really properly.

When analysing Kenneth's text using SFG it is obvious that this text also represents 'language as reconstruction', but is closer to Gibbons' type two than three. Material

processes describing behaviour, *shake, dry, look, stay,* are slightly more frequent than relational in addition to mental processes. Kenneth does not open his text with a general statement. Instead, he demands shared assumptions by the reader when he jumps right into *it* being *brown, black and grey*. Kenneth's second sentence, like Tammy's, opens with the personal pronoun *we*, not so appropriate for a descriptive report. However, there is also a display of factual and precise descriptive language: *Soil is worm, shit, Clay is very sticky*. Generalisations are expressed by the third person pronoun *you* (Swe. *man*), *when you shake*. The technical terms are represented by *experiments, humus, worm* and *humid*. Kenneth's text is slightly 'more-spoken-like' than Tammy's making it more of a procedural recount than a descriptive report.

From a PEA, Kenneth started by construing relations in terms of colours to *it*, soil, and *shaken clay, sand and humus* to *experiments*. He went on construing relations to features of the soil types, e.g. *humid*, *smooth* and *rough*. Moreover, he construed relations in terms of metaphors: *like a lava lamp* to the shaken *humus*, and *like a fog* to the shaken *clay,* thus reconstructing and transforming earlier experiences. Consequently, the metaphors made him observe certain things about the mixtures while others were obscured. In addition, he observed certain things about *sand* to which he construed the relations *stays put* and *really properly* when shaken, implying that he had made a close observation of what happens when sand is mixed with water.

Discussion

In this study we have shown the significance of student awareness of the subordinate purpose (Johansson & Wickman, 2011; Wickman & Ligozat, 2011) of two science activities. Notwithstanding the fact that the activities carried out differed, one being a hands-on activity and the other a writing activity, the explicitly expressed subordinate purpose of each activity had consequences for the students' proceedings. Although the students were actively involved in the hands-on activity, the explicitly formulated subordinate purpose was weakened for the benefit of "doing", as stressed by the teacher (1), resulting in the students acting on their own purposes (4-12, 13-15). Consequently, the learning direction was not always in accordance with the teacher's intention (cf. Rogoff, 1990). Instead of comparing differences and similarities between former and current results, the students compared the current results to something that was already known to them in terms of metaphors like *pee* and *mallow* (11-12). Accordingly, if students are frequently unaware of the subordinate purpose, learning may take another route than intended or even come to a halt. This became even more obvious when for example Kenneth, while wetting the soil samples to roll them into a ball, asked his classmate: *I wonder why we have done this*? If students frequently experience scientific activities as puzzling, not purposeful and with no reference to their own lives, they might turn away from science, thinking that they do not belong (Jakobson & Wickman, 2008).

When involved in the writing activity, the teacher instruction was partly focused on doing, *what you have done,* and partly on what the students had learned, *what you have learned* (16). This expressed twofold subordinate purpose directed students to write texts including both the hands-on activities and what had been learned. The subordinate purpose for writing the text was again partly concealed in the teacher's instruction. Hence, the students were given no guidance on how to express themselves in 'more-written-like' science texts using precise technical language and to thus add a scientific register to their repertoire (Gibbons, 2006; Martin, 1993). Instead, the unfocused teacher instruction led to the unconscious use of every-day language without developing the students' scientific literacy (Texts 1 and 2).

Moreover, in this teaching sequence the ultimate and the subordinate purposes were not continuous (Johansson & Wickman, 2011; Wickman & Ligozat, 2011), meaning that the hands-on activity (4-12, 13-15) was out of context as the students were not told about the significance of the effect of water on soil types in, for example, agriculture, forestry and the building industry. Instead, the sole focus on subordinate purposes like differences and similarities between the soil types made the students proceed in their own ways. Hence, throughout the teaching sequence the students were unable to bring the different parts together to form a whole in accordance with the ultimate purpose. Consequently, the ultimate and subordinate purposes were not related in the teaching sequence (Johansson & Wickman, 2011; Wickman & Ligozat, 2011).

The hands-on activities during the teaching sequence are intended to build the students' knowledge of the field. However, opportunities for the students to express themselves on the topic mainly comprise every-day talk using exophoric referencing (*this, that)* without a need for technical concepts and scientific grammar (Gibbons, 2006). Apart from one written task, sustained text is neither read nor written. Yet the written texts also show a limited use of technical terms and scientific grammar and thus restricted possibilities for the students to move between every-day and scientific language (Lemke, 1990; Martin & Rose, 2008).

Further, the activities are neither explicitly fitted into the unit's ultimate purpose – to learn what soil consists of, how to recognise different types of soil and the significance of soil for living organisms and human beings – nor do they fulfil the ultimate purpose of all STC units, i.e. for students to practice their communicative proficiency through talking, reading and writing, as well as recognising patterns and structures in science. Therefore, as argued in Axelsson and Jakobson (2010), the reading of a short explanatory text from the teacher's guide on soil creation processes combined with a graphic taxonomy illustrating these processes would improve the students' meaning-making.

Guiding students to express their scientific knowledge orally and in writing needs to be a regular part of science instruction and comprise the joint unpacking and construing of scientific texts as well as understanding of graphics (Christie, 2003; Schleppegrell, 2004). Students need to be involved in model work on each genre connected

to a subject. Such modelling might include the deconstruction of nominalisations, a switching back and forth between every-day and scientific language, summarising science texts for another audience etc. (Fang & Schleppegrell, 2008; Gibbons, 2006). The students' spoken and written communicative proficiency in the material varies and could possibly be bridged through explicit guidance on how to construct the text due to the specific situation and genre involved (Veel, 1997).

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