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Learning biology and mathematics outdoors: effects and attitudes in a Swedish high school context

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This research suggests that learning biology in an outdoor environment has a positive cognitive and affective impact on 13–15-year-old, Swedish high school pupils. Eighty-five pupils in four classes participated in a quasi-experimental design. Half the pupils, taking a biology course in ecology or diversity of life, had several lessons outdoors and the other half were taught indoors. All of the classes, but one, also had mathematics lessons outdoors once a week. Twenty-one pupils were interviewed five months after the course and all were positive towards the new learning environment they had experienced outdoors in biology and/or mathematics. They also valued the higher degree of interaction among the pupils. Other findings from the interviews were that the pupils from the outdoor classes showed a higher degree of long-term knowledge retention. They remembered both activities and contents better than the pupils in the indoor classes. An essay-type question assessing their biological understanding qualitatively according to the Structure of Observed Learning Outcome taxonomy revealed no differences between the groups. The results are discussed in the light of neurocognitive models of long-term memory.

Keywords: *Outdoor learning; High school; Biology; School ground*

Introduction

This study was part of an outdoor teaching intervention project in a Swedish urban high school. The school is a traditional Swedish high school, where the pupils were only occasionally taught outdoors. The objective of the intervention project was to increase outdoor teaching and study possible effects on pupils' health and learning outcomes. The school is situated in one of the outer suburbs in a medium-sized Swedish city and had access to both open grassy areas and wooded areas. In this

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study, two classes, one Grade Seven and one Grade Eight, took six of their lessons in biology outdoors whereas two classes served as control groups, having only one or two lessons outdoors. The purpose of this study was two-fold: firstly, to ascertain whether the setting of biology learning impacted on pupils' cognitive and affective outcomes; and secondly, to explore pupils' views about their learning and teaching via semi-structured interviews.

Teaching and learning outdoors is not common in Swedish schools. Reviews globally (Rickinson et al., 2004; Smith, 2004) reveal that the picture is similar in many countries worldwide, in spite of efforts to increase the amount of time spent outside of the classroom. There are several reasons for implementing new ways of teaching and learning although this idea is by no means new. The American pragmatic philosopher John Dewey argued more than 100 years ago that authentic experiences were of great importance for creating a meaningful learning situation (Dewey, 1916/1997). More recently, authors such as Braund and Reiss (2006), Gruenewald (2003a, 2003b), Lugg (2007), Nicol (2003), Smith (2002) and Woodhouse and Knapp (2000) have all pointed to the need for a closer connection with the places we inhabit and extending the use of out-of-school experiences, both as a way to increase content knowledge, interest and motivation and to improve social and ecological accountability.

This study focuses on learning biology outdoors. Previous research indicates that learning biology outdoors might have positive effects on both knowledge and attitudes toward biology. In Uitto, Juuti, Lavonen, and Meisalo's (2006) study of Finnish 15-year-old pupils, out-of-school experiences were the most important factor correlating with an interest in biology. This study does not focus on interest in biology but explores pupils' attitudes toward outdoor learning in biology and mathematics in general. There has been some research attempting to examine whether and in what ways learning biology in outdoor environments has a positive impact on cognitive outcomes. Hamilton-Ekeke (2007) compared a class taught ecology indoors with a class taught partly in the field, and he shows that field work is an important aspect when learning ecology in secondary school. The pupils that had first-hand experiences in the field scored higher on a multiple-choice test in ecology after the course.

Prokop, Tuncer, and Kvasnicak (2007) compared primary students' understanding of ecology where one group were taught traditionally indoors and one group learned ecology during a field trip at a field centre. The group attending the field trip showed a better understanding in ecology based on a multiple-choice test and open questions and drawings three days after the field trip. They also scored higher on positive attitudes toward biology. Another comparative study reveals improved learning outcomes from a half-day programme in ecology contrasted to traditionally classroom teaching (Eaton, 1998). Openshaw and Whittle (1993), on the other hand, question the effectiveness of ecological field teaching at field study centres, and point out that a visit must be well prepared to make the pupils feel comfortable and motivated to learn and that positive cognitive outcomes are not always easily discerned. However, Stewart (2003) demonstrated that pupils' recollections from an excursion to a botanical garden were in line with teachers' expectations of cognitive outcomes.

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Apparently, studies of outdoor learning in biology most often take place at specific places away from ordinary school surroundings, as field trips or visits to outdoor/environmental education centres. Therefore it is not surprising that learning outcomes are well remembered by the students afterwards. There are few studies concerning outdoor learning as part of ordinary school work. Rickinson et al. (2004) acknowledge this and ask for more studies on outdoor learning in school grounds and community settings. Thorburn and Allison (2010) also highlight the limited amount of research on school-based outdoor learning. In this study, outdoor lessons were part of ordinary school work and they took place on the school grounds or in a nearby forest within walking distance of the school. In this way, the study makes a contribution to research on biology learning outdoors by exploring possible effects of school-based outdoor learning.

Many previous studies have a quantitative design where content knowledge is tested by multiple-choice tests or questionnaires rather shortly after the visit or field trip. This study wants to broaden this approach by using a mixed-method design where qualitative data were collected five and six months after the teaching module. In a qualitative study on teacher students' reflection on their own learning in outdoor settings (Magntorn & Helldén, 2005), field trips were perceived as a significant part of learning ecology. During the field trips the students had the possibility to explore, discuss and link theory to practice.

Attempts to explain improved knowledge and understanding as a result of learning in outdoor settings often involve the more intense sensory stimulation from first-hand experiences outdoors and embodied learning. When learning takes place outside the classroom, one difference is expanded multi-sensory perception (Auer, 2008). While a traditional classroom lesson stimulates mostly visual and auditory sensory perception, outdoor teaching has the possibility to involve more senses as well as motor activity (Auer, 2008; Grønningsaeter, Hallås, Kristiansen, & Naevdal, 2007; Mygind, 2007). However, research concerning the outcome of using several sensory perceptions in learning and memory is predominantly found in the area of communication technology (Moreno & Mayer, 2007) and neuropsychology (Cerf-Ducastel & Murphy, 2006). Moreno and Mayer conclude that, 'the most effective learning environments are those that combine verbal and non-verbal representations of the knowledge using mixed-modality presentations' (2007, p. 310). In accordance with Moreno and Mayer's conclusions, learning in natural outdoor contexts might be beneficial for learning biology, which is the study of the living world around us. Thus, the research questions guiding this study are the following.

Research questions

1. What are the long-term effects of outdoor teaching in biology on high school pupils' knowledge of ecology and classification?
2. What are high school pupils' attitudes towards learning biology and mathematics outdoors compared with indoor teaching?

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Methodology

Design of the study

A mixed-methods research approach was applied. This is a methodological approach aiming at being a 'third way', in-between quantitative and qualitative methods and methodologies (British Educational Research Association, n.d.; Bryman, 2008; Johnson & Onwuegbuzie, 2004; Morgan, 2007). Jonhson and Onwuegbuzie define mixed methods as: 'research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study' (2004, p. 17). For advocators of mixed-methods research, the commonalities between the quantitative and qualitative research paradigms are emphasised instead of the differences, and a pragmatic approach to research is applied where the practical outcomes are more important than, 'each camp dismissing the others' work as based on wholly incompatible assumptions' (Morgan, 2007, p. 71). The practical arguments for using mixed-methods research are several. One major argument is for maximising the strengths and minimising the limitations of single methods. Other arguments are that triangulation of methods and data increases internal validity and that a pragmatic stance to choice of methods provides researchers with a better chance of answering specific research questions (British Educational Research Association, n.d.).

The rationale underpinning the choice of a mixed-methods research approach in this study was that combining qualitative and quantitative methods was perceived as a more useful approach to receive a fuller understanding and bring together benefits from both methods. The two research questions guiding this study seemed better answered by a mix of quantitative and qualitative approaches. This study was the first exploratory study in a wider longitudinal research project on outdoor teaching and learning. The aim of this study was to explore possible effects, cognitive as well as affective, of outdoor teaching and learning as broadly as possible by comparing two groups of students; one taught indoors and one taught partly outdoors. Thus, qualitative data in the form of semi-structured interviews were used to capture qualitative cognitive and affective differences between the different groups of participants. The benefit with qualitative data is the possibility to generate rich contextual data but from a limited number of participants. To be able to reach a larger number of participants, qualitative data in the form of an essay-type question to all participants about content knowledge were used. Using a mixed-model design (Johnson & Onwuegbuzie, 2004), results from the qualitative data analysis of the essay-type questions and interviews were subsequently analysed quantitatively using the Mann–Whitney U-test.

Setting and participants in the study

The study was conducted at an urban high school in southern Sweden from September 2008 to March 2009. Participants were two classes in Grade Seven (7A, $n = 22$, 7B, $n = 23$) and two classes in Grade Eight (8A, $n = 19$, 8B, $n = 24$). The pupils were 13–14 years old in Grade Seven and 14–15 years old in Grade Eight. All classes were taught biology by the same biology teacher. This study was part of a bigger intervention project and therefore also all classes included in the study, apart from 8B, were taught mathematics outdoors. This study does not focus on comparing content knowledge in mathematics, but rather on how the outdoor lessons in mathematics influenced the pupils' responses to Interview Questions 2 and 3 (see Appendix 1) and that is the reason why mathematics is included along with biology in Research Question 2. The outdoor mathematics lessons were compared with the regular mathematics lessons focusing on teamwork and problem-solving in small groups. There were also activities with teams solving mathematics problems in competition with each other. The pupils also played games. Lessons were guided by the same curricular goals regardless of whether the lesson was held indoors or outdoors.

All classes were taught a biology course between September and October 2008. The biology curriculum for Grade Seven was an introductory biology course, 'The Living World', containing evolution theory, cell biology, phylogeny (classification and taxonomy) and diversity. The biology curriculum for Grade Eight was ecology. The units were each about eight weeks long. The four classes were divided into two groups. The corresponding classes in Grades Seven and Eight, respectively, received similar but not identical teaching. The experimental group consisted of the two outdoor classes, 7B and 8B, and they received six 60-minute outdoor lessons each. The control group consisted of the two indoor classes, 7A and 8A. The indoor classes received two 60-minute outdoor lessons.

Both the indoor and outdoor Grade Seven classes spent time outdoors collecting samples of various plants and animals for subsequent watching under a magnifying glass and microscope. Both classes played an outdoor game about resource competition. In addition, the outdoor class in Grade Seven spent time outdoors playing a game about evolution, they examined invertebrates and native trees and worked with classification and taxonomy outdoors. In Grade Eight, the indoor class spent two lessons outside watching different birds and going on an excursion to a forest. Otherwise, they worked indoors with their textbook, studying articles and interactive food webs and population dynamics. They also wrote a smaller essay on the different types of branding of organic products. The outdoor class in Grade Eight worked with quadrants in small groups (four or five pupils in each group). They measured abiotic parameters such as soil–water content, temperature, pH and light and they examined flora and fauna. They also played web-based food games and performed exercises on competition and population dynamics.

Data collection

An essay-type question about the biology course content knowledge was given to the pupils about two weeks into the course, and the same question was asked again six months after the course had been completed.

The question in Grade Seven was: 'Describe how we try to bring order to the diversity of life to make it easier to understand'.

The question in Grade Eight was: 'There are many different plants and animals living in a lake or in a meadow. Try to explain/describe factors that affect their interrelations.'

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Five months after the completion of the biology course, semi-structured interviews were also conducted with 21 of the pupils, four from 7A, five from 7B, six from 8A and six from 8B (see Appendix 1). The interviews took place in school and lasted about 10–20 minutes. They were audio-recorded and later transcribed. The opening question was: 'Could you tell me about the course The Living World or Ecology you had last semester?' Follow-up questions were: 'What did you do?' and 'What do you think of that course?' The interview also contained questions about what they thought about outdoor teaching and learning after having experienced it in biology and/or mathematics and what differences they found between indoor and outdoor learning.

Data analysis

Essay-type question. The essay-type questions aimed at answering the first research question: 'What are the long-term effects of outdoor teaching in biology on high school pupils' knowledge of ecology and classification?' The written answers were read several times and categorised according to the Structure of Observed Learning Outcome (SOLO) taxonomy (Biggs & Collins, 1982) in order to evaluate the pupils' level of understanding. SOLO comprises a set of categories that differ with regard to both quantitative and qualitative aspects of understanding. The five different levels of understanding are: pre-structural, uni-structural, multi-structural, relational and extended abstract. (See Table 1 for the use of the SOLO taxonomy in the context of classification and ecology.) The taxonomy for the ecological task is based in part on work by Magntorn and Helldén (2007).

For answering the essay-type question in Grade Seven, some description and explanation of the structure of a hierarchical classification system was expected. In Grade Eight, the pupils were expected to include some of the categories often used when explaining and understanding components in ecological interrelationships. These components are abiotic factors such as temperature, water or light, biotic factors such as food chains, competition or diseases, human factors such as pollution or population control/extinction, and historical factors such as geology and evolutionary aspects. Describing energy flow and cycling of matter was also expected.

Interviews. The results from the interviews provided answers to both of the two research questions: 'What are the long-term effects of outdoor teaching in biology on high school pupils' knowledge of ecology and classification?' and 'What are high school pupils' attitudes towards learning biology and mathematics outdoors compared with indoor teaching?' One aim was to ascertain whether the different teaching methods revealed any differences in cognitive outcome such as long-term knowledge retention or other aspects related to course contents. Another objective was to examine pupils' views of the outdoor environment as a learning environment.

The subsequent analysis was inspired in part by the process of grounded theory (Bryant & Charmaz, 2007; Charmaz, 2006; Strauss & Corbin, 1998). The grounded

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Table 1. The SOLO levels in relation to the phylogenetic and ecological content knowledge.

SOLO level		Classification task	Ecology task
Level 1: pre-structural	The responses are often inadequate and the pupils frequently refer to irrelevant aspects.	Only fragmentary statements such as division into groups (e.g. plants and animals).	The responses are often inadequate and the pupils frequently refer to irrelevant aspects.
Level 2: uni-structural	The learner focuses on the relevant domain and chooses one aspect to work with.	Mentioning hierarchical levels but without explanation and with inconsistent examples.	Brief statements such as climate and food or mentioning a simple food chain without further explanation.
Level 3: multi-structural	The learner chooses increasingly relevant or correct features, but does not integrate them.	As above, but more consistent descriptions and some relevant examples.	As above, but also trivial multi-step links between biotic and abiotic components such as plants needing nutrients and light. Mention of several factors such as climate, diseases, water, food chains. Human impact or evolutionary factors as single statements without explanation.
Level 4: relational	The learner now integrates the parts with each other so that the whole has a coherent structure and meaning.	As above, but with illustrations with cladograms or in corresponding words showing some understanding of the phylogeny behind the classification. Exemplification with some relevant organisms from different levels.	Energy flow and/or cycling of matter in ecosystems is described, linking the sun with plants and consumers. Human impact on or evolutionary factors in ecosystems are discussed.
Level 5: extended abstract	The learner now generalises the structure to include new and more abstract features, representing a new and higher mode of operation.	As above, but with correct levelling and exemplification. Able to generalise and include several examples of both plants and animals. Clear understanding of phylogeny behind the classification system.	General conclusions about energy and cycling of matter as well as time components and human impact.

Source: Biggs and Collins (1982) and Magntorn and Helldén (2007).

theory approach seeks to construct categories from themes in the data without too many preconceptions influencing the results. The aim is to qualitatively interpret data in a way that allows for constructing theory about a phenomenon, grounded in data, and revealing different categories and their interaction and relation to each other. In this study, the traditional interplay between analyses, theorising and new data collection is, however, not applied due to the design of this study.

The first step in the analysis process is an initial open coding, which enables descriptive codes close to the data to be created (Charmaz, 2006). One way of doing this is line-by-line coding, which was used as a first step in this study. Examples of open codes included talk about content, talk about activity, talk about activity and content, fresh air, fun, variation, and teamwork. Line-by-line coding is followed by focused coding when different codes are further elaborated, refined and compared. Focused coding included categories such as 'activity and content', 'feelings', 'authenticity' and 'interaction'. One category developed from the analysis of the data, 'activity and content', was quantified with regard to frequencies in the two groups, and analysed statistically using the Mann–Whitney U-test. Group differences in the number of biology-related words used in the interviews were also analysed using the Mann–Whitney U-test.

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Results

This section will initially present answers to the first research question: 'What are the long-term effects of outdoor teaching in biology on high school pupils' knowledge of ecology and classification?' Data from both interviews and the essay-type questions comprised answers to the first research question. Findings about content knowledge from the interview are first presented and thereafter findings from the essay-type questions. Another aim of this study was to explore whether outdoor teaching and learning had any impact on pupils' views of their learning environment. Answers to the second research question, 'What are high school pupils' attitudes towards learning biology and mathematics outdoors compared to indoor teaching?', are presented last in this section. Only the interviews comprised data to answer the second question.

Findings from interviews: differences in long-term knowledge retention and way of talking about course content and activities

An interesting finding was that the pupils talked quite differently about the course and its content in the indoor and the outdoor classes, respectively. After five months, many pupils had some difficulties remembering activities and content of the lessons but the outdoor classes performed better than the indoor classes (see Figure 1). In the outdoor classes the pupils used more course-related words (e.g. plants, animals, leaf, bird, adaption, Darwin, food web, consumers, photosynthesis, carbon dioxide) than in the indoor classes, $n_1 = 10$ and $n_2 = 5.5$, and the difference was significant (Mann–Whitney U-test, $p < 0.05$, $Z = -2.12$).

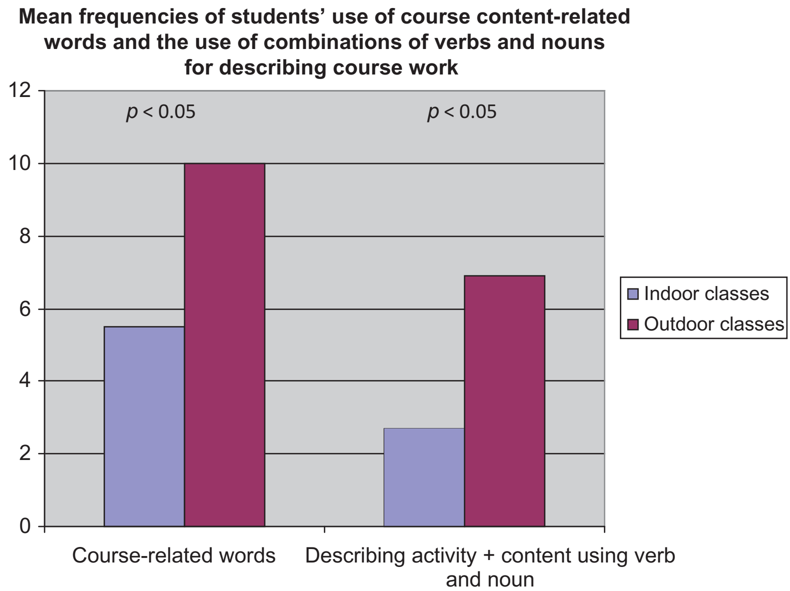

Figure 1. Long-term retention of content and experiences in indoor ($n = 2$) and outdoor ($n = 2$) biology classes.

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When talking about the course content the indoor class gave more vague and diffuse answers, remembering just content or an activity, and seldom explained how they had worked with a particular content item. The indoor classes often mentioned teacher-oriented activities but the outdoor classes more frequently gave vivid descriptions of activities (often student-centred) and content using both verbs and nouns. The latter difference was significant (Mann–Whitney U-test, $p < 0.05$, $Z = -2.8$) with a mean of 6.9 statements in the outdoor classes and 2.7 in the indoor classes (Figure 1).

Examples of responses in the indoor classes to the question 'Can you tell me about the biology course you had last semester?' include:

> He wrote on the blackboard, we worked in books, he talked first (Claire, Grade Eight).
>
> We wrote, we read, we had words to learn, we were outdoors, we wrote about different things, had assignment (Joanna, Grade Seven).
>
> It was mostly, well environmental friendly. And then, mostly about the earth and such things, environmental friendly (Anne, Grade Eight).
>
> Well, we talked about photosynthesis and such things, combustion (John, Grade Eight).

Examples of responses in the outdoor classes to the question 'Can you tell me about the biology course you had last semester?' include:

> We were out looking at trees, collected soil, looked at it in microscope, and looked at leaves in microscope (Emily, Grade Seven).
>
> We answered questions about the forest, we were out in the forest, we were in our quadrant, and we wrote a story about our quadrant (Anthony, Grade Eight).

> We were outdoors a lot, we made questions to and a story about our visit in the forest, and a lot about interrelations in ecology (Eric, Grade Eight).

The interviews revealed two quite different stories about the biology lessons. Whereas the indoor classes talked about a rather context-free biology education, if they at all remembered what they had done, the outdoor classes told stories where context, hands-on activities and content knowledge were all relevant parts of their biology teaching and learning.

Findings from the essay-type question: differences in long-term knowledge retention in ecology and classification

The answers to the essay-type questions in each grade were analysed according to the SOLO taxonomy. However, some other interesting findings from the essay-type questions apart from the SOLO taxonomy analysis are also presented in this section.

In Grade Seven one of the course learning outcomes was knowledge about classification, and the essay-type question was as follows: 'Describe how we try to bring order to the diversity of life to make it easier to understand'.

Most of the pupils in Grade Seven could give examples of, and to some extent explain, the contemporary classification system six months after the course. The level of understanding according to the SOLO taxonomy did not differ between the indoor and the outdoor class in Grade Seven. The mean was 2.1 in both classes. Some pupils included organisms as examples although the ability to make a correct matching differed markedly. A significant difference between the outdoor and the indoor class was that the outdoor class twice as often ($n_1 = 12$ and $n_2 = 6$) illustrated their classification system with examples of organisms (Mann–Whitney U-test, $Z = -1.93$, $p < 0.05$). The answers could range from only mentioning animals and plants to efforts to exemplify several classification levels: 'animals and plants can be ordered in classes, families, genera, and species. For example, vertebrates or invertebrates, fish or insects, etc., a particular genus like felids and a particular species like the cat'.

In Grade Eight one of the course learning outcomes was knowledge about interrelationships, and the essay-type question was as follows: 'There are many different plants and animals living in a lake or in a meadow. Try to explain/describe factors that affect their interrelations.'

Food webs were the dominant answer to the question about what factors contribute to ecological interrelations. Several pupils also mentioned abiotic factors such as climate and other biotic factors (e.g. competition and niches). Human impact was also a common answer. No difference between the classes could be found when the answers were analysed according to the SOLO taxonomy. Both classes showed a rather low level of understanding with a mean of around level 2.

Thus, there were no differences in levels of understanding ecology and classification according to the SOLO taxonomy in either Grade Seven or Grade Eight. However, another interesting finding was that the outdoor group in Grade Seven more often included examples of organisms in their answers about classification. In Grade Eight

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some interesting findings emerged when comparing the essay-type question and interview data. Four pupils mentioned biotic factors in addition to food webs in the indoor class both before and after the study, while in the outdoor class the number had increased from three to eight pupils. The indoor class mentioned food webs more often than the outdoor class in the post test (73% and 60%, respectively). Despite this attention to food webs in the written answers, no one in the indoor class discussed the concept in the interviews compared with five out of six pupils in the outdoor class.

Findings from interviews: high school pupils' attitudes towards learning biology and mathematics outdoors compared with indoor teaching

Since outdoor teaching was rather new to these pupils, the novelty dimension was a major theme emerging from the interview data. This was different to normal classroom work and this difference resulted in new experiences and feelings. Other dimensions of the outdoor environment of relevance to the pupils were authenticity, interaction and positive emotions.

Novelty and variation. The interviews revealed that in the outdoor environment the pupils mainly talked about the novelty and variation compared with the classroom environment. Fourteen of the 21 pupils brought up variation as a reason for why they liked outdoor teaching. Indoor teaching was often seen as boring and tiresome even if some pupils were satisfied with the regular classroom-based way of learning. Many pupils talked about classroom teaching as never-ending sitting, reading and writing tasks. Different contents and subjects blurred together, with the same procedures every day and every hour. The outdoor environment *per se* was also considered much more stimulating and fun than the everyday school environment, which many pupils found boring, old and poorly ventilated:

> You get tired you see, you get tired very easily of sitting, the same chair, the same bench, you see, classroom, classroom, classroom, you walk all the time, back and forth. You are hardly outside at all during the day (Peter, Grade Seven).

Many pupils said they were more focused outside and felt more alert. The reasons were the novel, more interesting environment and the exposure to fresh air.

Authenticity. The outdoor environment also stimulated a more authentic way of learning that many pupils appreciated. They realised that working with different materials and objects in mathematics and biology gave them a deeper understanding and that it was easier to remember when they could relate theory to practical things they had done themselves and seen with their own eyes:

> You begin to think what it really looks like, you don't think about how many organisms that live in such a small area (Nicolas, Grade Eight).

> There's more free thinking than inside. You can use different objects and keep on moving them and so, I think I learn more outside (Maria, Grade Seven).

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> You have confirmed it yourself in some way. That it's true, not just something on a sheet of paper. (John, Grade Eight).

Working with books was regarded as being somewhat artificial. The things they were doing outside were described as more relevant to the pupils and it gave them opportunities for more motor activity. Seven out of 21 pupils (four girls, three boys) mentioned increased motor activity as something positive about working outdoors, but all of them described tasks involving motor activity when asked what they did outside:

> You are more involved than if you just sit on a chair and listen, you do things instead (Anna, Grade Seven).

> Well, we do things outside . . . it's not like sitting in an isolated classroom with no air and teachers who just . . . (Peter, Grade Seven).

> When we go outside, then we don't work with books and it's more like we have different subjects together, we work more in a group and you do things all the time, there is some difference (Steve, Grade Seven).

Interaction. The teachers obviously designed the outdoor activities mainly as group activities. This was considered to be something positive by seven out of 21 pupils (four girls, three boys), whereas the other pupils did not make any comment about it. The difference was particularly obvious in mathematics. Mathematics indoors consisted almost entirely of individual work in the mathematics book. Science lessons in general were seen as more fun than other lessons due to the more interactive, laborative way of working. The personal benefits of group work were that it was easier, more interesting and more efficient as a result of several pupils working together compared with being alone. In comparison with the individualistic view, there was a more general view that the outdoor lessons elicited an increased level of involvement from all one's classmates and that this also benefited all of them. It became a positive circle. The aspects of competition and games in the outdoor lessons could probably explain why there was a higher level of participation in outdoor lessons. The social aspect of group work was also regarded as something positive in outdoor work:

> It is fun [to be outside] because you spend more time together (Sally, Grade Seven).

> All participate . . . because outside you have to cooperate, and maybe this is more fun, and then you want to participate, you know (Emily, Grade Eight).

Affect/feelings. All pupils were positive about the outdoor teaching, even if some of them also mentioned negative aspects such as cold and wet weather, more noise, difficulties in hearing the teacher and concentrating outdoors. The first answer most of the pupils gave to the question about how they experienced the outdoor lessons were that they were 'fun' or 'nice'. One major benefit was the exposure to fresh air, which seemed to be lacking indoors, especially in the afternoon, although many of the pupils could not give an explanation: 'It was just fun'.

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Summary

The interviews revealed interesting differences in the way the pupils talked about and remembered their biology course and course content. The pupils taught only indoors talked about a rather teacher-centred education if they remembered the course at all. Pupils from the outdoor group remembered clearly the course activities and used more content-related words in their answers. Their experiences were a more participatory and contextual education. The essay-type question did not reveal any significant differences in content knowledge in Grade Eight. The level of understanding did not differ in Grade Seven either, but the outdoor group in Grade Seven illustrated their classification systems with examples of organisms twice as often as the indoor group. The interviews revealed that the pupils enjoyed outdoor teaching and that they appreciated the break from the daily routines. They also appreciated increased interaction between pupils and the contextual learning environment.

Discussion

Affective outcome

The pupils in this study all described positive experiences regarding the outdoor lessons. When answering the question of what they thought about the outdoor lessons, all of them spontaneously uttered remarks such as ‘it was fun’ or ‘it was nice to be out’. Not all of them could give an explanation as to why they felt this way, but the ones who did explained that they appreciated the fresh air outside and that the opportunities for activity made them feel more alert. In this study, being outdoors was associated with positive feelings, and the stress-reducing aspect of nature (Kaplan, 1995; Ulrich, 1983) could well be one explanation. These authors propose theories from somewhat different perspectives while involving nature as a stress-reducing agent. Nature is seen as rich in characteristics necessary for restorative experiences. There are a number of studies that support the positive impact of nature experiences on well-being (Björk et al., 2008; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Ottoson, 2007; Stigsdotter, 2005; Wells & Evans, 2008). However, since there was no control group working outdoors in a more urban environment, it is difficult to draw any conclusions about the impact of the natural outdoor environment compared with an urban outdoor environment. Another explanation could be that since indoor education was most often regarded as rather boring and monotonous, the variation offered by the outdoor lessons was highly valued. Similar results to this study, that outdoor education impacts on affective, social and intellectual development, have been documented by Dismore and Baily (2005) in Grade Five pupils.

Several studies and reports conclude that interest in and motivation for studying science are decreasing (OECD, 2006; Osborne, Simon, & Collins, 2003; Skolverket, 2008) but the pupils in this study did not confirm this picture. The pupils in this study appreciated science and regarded also the indoor science lessons as variable and interesting. Traditional curricula in school science have been criticised for being distanced from the real world and for presenting knowledge in a fragmented way with lack of relevance and transfer (Braund & Reiss, 2006; Osborne & Collins, 2001). If the classroom work could be extended to also include areas outside the school building, pupils would probably feel more involved and interested. The data from this study suggest that outdoor lessons in outdoor environments have a positive impact on the pupils' interest and motivation. This is in accordance with Osborne and Dillon's (2008) recommendations on how to improve science education. For example, they ask for 'more attempts at innovative curricula and ways of organizing teaching', and argue that 'engagement in science is best achieved through opportunities for extended investigative work and "hands-on" experimentation' (Osborne & Dillon, 2008, pp. 8–9).

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Cognitive outcome

One major finding was that outdoor lessons clearly had an influence on what the pupils remembered five months later. Many pupils in the indoor class, especially those in Grade Eight, had difficulties remembering what the lessons actually were about. They remembered a rather teacher-oriented activity but could not easily separate the biology lessons from other lessons. They all followed the same schedule with writing on the blackboard, worksheets and lots of reading and writing. For many of the pupils, the content of what they read and wrote was diffuse. The pupils that remembered the topic did not often relate the topic to any activity but discussed the content of the lessons in a rather abstract way. That pupils have difficulties in seeing the relevance of school science (Aschbacher, Li, & Roth, 2010; Bennett & Hogarth, 2009) and in transferring knowledge from school to out-of-school contexts has been shown in earlier studies (Aypay, Erdogan, & Sözer, 2007). By using outdoor lessons more regularly, probably both these difficulties could be reduced. Gruenewald (2003b) and Smith (2002) argue that schools must be better at including the world outside; the rigid boundary between school and nature and society needs to be removed. In doing so, we give the pupils a more solid understanding and their knowledge becomes situated in authentic experiences. To become a citizen in today's information society, pupils need not only to learn from textbooks, as is often the case in the normal classroom, but also to learn from all sorts of real experiences, the nearby natural environment and urban world as well as global connections and relations via the Internet. Learning to know the local environment could be the first step towards becoming interested in more remote areas.

The pupils in the outdoor classes gave richer descriptions of their experiences during the lessons. The outdoor context had a big impact on their long-term memory and they clearly remembered and discussed both the activities and the contents in an integrated way. This long-term memory of both process and content differed significantly between the indoor and the outdoor classes. The difference was most clearly seen in Grade Eight. Since both classes in Grade Seven collected the material outside and afterwards used a microscope to examine their findings, this was the most common

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memory for both classes. The indoor classes talked about content and activities but seldom related them to each other. They were separate memories. Recent research in neuroscience may contribute to explanations of the findings reported above. The neurocognitive model of how human long-term memory works is based on three distinct systems: episodic, semantic and procedural memory (Tulving, 2002). Memory of personally experienced events is called episodic memory, and multi-sensory experiences as well as spatial information play key roles in generating rich episodic representations (Mayes, Montaldi, Spencer, & Roberts, 2004; Nadel & Hardt, 2004; Tulving & Markowitsch, 1998). Research in neuropsychology and physiology has indicated that the neural bases of episodic and semantic memory differ (Mayes & Montaldi, 2001; Mayes & Roberts, 2001). Today, there is an alternative model suggesting two cognitive systems, the declarative/explicit and the non-declarative/implicit working in parallel (Björklund, 2008; Rajah & McIntosh, 2005). In the latter model, episodic and semantic memory could both be seen as part of the declarative system. However, both these models assume that there are differences in long-term memory retrieval due to both conscious and unconscious aspects, sensory perception, emotions and novelty (Björklund, 2008; Damasio, 1994; Krebs, Schott, Schutze, & Duzel, 2009; Wittman, Sciltz, Boehler, & Düzel, 2008). For the pupils, multi-sensory perceptions, positive emotions and a novelty aspect could contribute to the difference in recalling course content and activity. Since going outdoors was a rather new experience for the pupils, it is not unexpected to find that the lessons outdoors had a large impact. Nevertheless, the large difference in long-term knowledge retention should be noted as an important finding and further studies may reveal whether this difference is consistent even when outdoor education is used regularly.

Another difference in cognitive outcome was that the outdoor class in Grade Seven not only answered the question about classification with descriptions of hierarchical levels such as species, genera, family, class, phyla, and kingdom, but also gave examples twice as often as the indoor class. The rich multi-sensory stimulus in the outdoor environment compared with relying on visual input from textbooks indoors might explain this difference. When the pupils were exposed to examples of organisms from different classification levels, they seemed to understand and remember the concept of classification better. Multi-sensory learning has positive effects on learning and memory. Several studies reveal that, for example, field trips are more beneficial for deep learning as well as long-term memory compared to classroom teaching (Rickinson et al., 2004). These two concepts are by no means identical but remembering the learning outcome is definitely a prerequisite for understanding it. In their study of collaborative ecology learning, Rozenszayn and Assaraf (2010) assume that long-term knowledge retention indicates meaningful learning. They were able to show that collaborative learning outdoors was successful when it came to remembering the reason for coexistence between rodents in the Israeli desert.

There was no significant difference between the indoor and the outdoor classes in their level of understanding according to the SOLO taxonomy. Both the indoor and the outdoor classes gave the expected answer, 'food webs', to the traditional textbook question about ecological components. But in the interviews, nobody in the indoor class brought up the concept while five of six in the outdoor class did so. The indoor class had a theoretical understanding of ecology but the concept of food webs was not a memorable concept, even though it is a major topic in the ecology course. According to Rozenszayn and Assaraf (2010), this suggests that the indoor pupils did not regard food webs as meaningful learning to the same extent as the outdoor class, even though both classes showed a good understanding of the concept as revealed in their answers to the written question. The outdoor class both worked practically with quadrants and played games where the pupils took on the role of different organisms in the food web. The indoor class also worked a lot with food webs, but the authentic experiences seemed to have a larger impact.

Conclusions

Although this was a small-scale study, the results revealed positive effects of outdoor education. One was definitely increased motivation among the pupils. They enjoyed the lessons outdoors and appreciated the increased focus on teamwork outdoors. A major theme brought up by the pupils was the pleasure of variation from indoor teaching, which mostly consisted of reading and writing according to the pupils. The opportunities to engage in more practical and interactive ways of learning were highlighted when the pupils discussed outdoor education. The method of teaching also had a long-lasting effect on cognitive outcomes. The pupils who were taught biology outdoors seemed to have experienced a more contextualised, hands-on science education where they were active participants. Five months after the course they could tell a story about themselves doing science, compared with the pupils who were taught indoors who instead talked about what the teacher did. This was especially predominant in Grade Eight. The small sample, only about 20 pupils in each class, makes it difficult to statistically evaluate learning outcomes based on the SOLO taxonomy, but in a study with a larger sample there might be opportunities to find more differences in learning outcomes resulting from indoor or outdoor teaching. Implications from this study are that outdoor teaching and learning is an appreciated and effective complement to traditional classroom teaching. It may be a way to bring school science more in consonance with pupils' everyday life and to widen their understanding of what science is all about. By learning science outdoors the pupils hopefully see it not as something only to read about in books but as something they can be part of and that is relevant in their everyday life.

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Appendix 1. Interview questions

1. You read about ecology/the living world last semester. Can you tell me about that?

   Is there anything particular you remember?
   What did you do?
   How did you like it?
   Why?
   What did you learn?
   What was most interesting/fun with that topic?
   What was not so interesting/fun with that topic?

2. Have you had lessons outdoors sometimes?

   In what subjects?
   What do you think about that?

3. What do you think of outdoor lessons compared to indoor lessons?

   What are the differences?

4. Would you like to have more outdoor teaching?

   Why/why not?

5. What do you think about science education?
6. Is there anything else you would like to tell me?

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