ISSN 1648 - 3898 Journal of Baltic Science Education, No. 2 (6), 2004-10-30; pp. 22-33.

SCIENCE TEACHING AND THE SCHOOL - WHEN CONCEPTS MEET CONTEXT

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Abstract. *With this paper we want to discuss possibilities and problems for pupils to learn science. Exploratory studies have been carried in science classrooms. The science lesson exists in a context of its own but classroom interaction reveals parallel discourses and many research studies show that pupils have great difficulties to move from an everyday discourse into a science discourse and to acquire the special language of science and the special ways of seeing the world.*

Key words: *science education, experimental work, concepts, school science project, culture of school science.*

Science – a culture within a culture

Throughout the centuries, people have developed cultures with different sets of ideas, values and knowledge. Knowledge is stored in various discourses, linguistic contexts, and acquires meaning and significance only in these contexts. I.Marková, (Marková, 1982) describes this connection in the following manner: "Different social realities provide different experiences. They lead to different ways of seeing the world and consequently lead to different beliefs concerning our apprehension of the world. "(p.2). Words and terms which are used acquire meaning in the contexts where they are used. "Language use and the constructions of meaning are always social processes dependent on people who interact, and meaning is always relative to options and constraints that are present in social situations". (Säljö, 1996, p.85).

The relevant perspective within a sector is decisive for how a question, a problem, a statement is to be interpreted, what is interesting, pertinent and objective. The sectorisation of society has led to different professional groups and institutions acquiring a professional language of their own. The institutionalisation of different concept worlds is conducive to a continued formation of knowledge within the sector but at the same time leads to difficulties of understanding between sectors (Agar, 1985; Lemke, 1990; Linell, 1988; Fairclough, 1994). In this way learning and development become ways to learn concepts and gain knowledge, which is being developed and has been developed in a special culture. Seen from this perspective, science could be viewed as a specific culture or indeed a group of sub-cultures, which have developed over a long period of time.

Within these sub-cultures distinct ways have evolved for perceiving and understanding reality and for thinking, speaking and using material (Sjøberg, 2000). A scientific discourse contextualizes reality in a way, which differs from a more everyday way of reasoning, and the essential meaning of words and terms here is different. Here, moreover, communication works with the aid of various concepts and terms, which can be foreign to our more everyday language (Lemke, 1990). In a similar way a set of specific practices has grown up around science subjects and other subjects taught in schools, and it would be possible to see school subjects as sub-cultures (Siskin, 1994; Aikenhead, 1996; Bruner, 1996; Hultman, 1998, 2001). The teaching of science in schools is an example of a social and cultural activity, which exists between the professional knowledge cultures and the everyday ones (Andrée, 2002). O.Eskilsson, (Eskilsson, 2001) calls this knowledge culture a project-world, and views it as a reconstructed world with elements from both the reconstructed world of scientists and from the everyday world. Learning science is about being a participator in activities, which offer a scientific way of thinking and acting. But this is not easy and perhaps not even possible in a school context. The pupils must in this context cross over certain discursive, linguistic borders. G.S. Aikenhead (Aikenhead, 1996) calls it border crossing. "If students are going to cross the border between everyday subculture and the subculture of science, border-crossing must be explicit and students need some way of signifying to themselves and others which subculture they are talking in at any given moment"(Aikenhead, 1996 p.17). But the distance between the everyday world and the scientific "world" of the school is often so great that the pupils cannot benefit from the teaching (Jakobsson, 2001). Learning science means, according to Lemke, learning to control the use of scientific language. It also means learning to use this specialised conceptual language in reading and writing, in reasoning and problem solving, and in guiding practical action in the laboratory and in daily life. It means learning to communicate in the language of science and act as a member of the specific practice (Lemke, 1990 p.1).

By using language in a special way we construct a picture of reality, which dovetails with the traditions, which apply, and with the needs, which exist in a certain activity. Language is an important tool for creating understanding and for being understood. But it is also a way for individuals to converse even though they are in different worlds and understand things differently. We may even misunderstand each other (i.e. teacher versus pupil) and this remark becomes important when we see schools and school subjects as subcultures**.** It is not easy as a student to discover what the teacher wants you to discover. It is obvious to the teacher but not to the pupil (Bergquist, 1990).

L.S.Vygotsky (Vygotsky,1986) was of the view that each individual's ability to think and learn is dependent on the activities and social contexts, which he/she is a part of Learning means when you take a sociocultural perspective**,** that you gradually increase and intensify your participation in the discourse. The person who is learning appropriates and develops knowledge and skills, which are useful in a specific culture. By participating in various activities with social relationships the learner gradually creates a general idea as to what practice is and he/she learns to master the discourse. The school as a special culture has been discussed by among others I. Carlgren (Carlgren, 1999) where she emphasises the differences between schools and authentic practices. Understanding science means also not just to know what the concepts mean but also how they are connected to each other and what is relevant to talk about at this given moment, J. Lemke (Lemke, 1990). To learn science means among other things, therefore to acquire scientific concepts and to know about their communicative opportunities and to be able to use them in functional contexts, i.e. be a master of the scientific field both as regards content and form. In order to be able to take part in conversations with scientific content it is necessary to know how the scientific terms are connected to each other and which terms are relevant for use in a specific situation. An important task for the teacher then is to help the pupils across this language barrier and into the world of science, which the school is offering. In this paper we have chosen among other things to illustrate how the pupils learn a mastery of materials and scientific concepts and how they use those concepts in conversations about different scientific phenomena. We now turn to an introduction of the school development project that we use as an arena for our reflections**.**

NTA - a school development project in Sweden

The school project NTA (Natural Sciences and Technology for All) started in 1997 and is owned jointly by the Royal Swedish Academy of Sciences and the Royal Swedish Academy of Engineering Sciences[1]. It is being carried out in collaboration with Swedish local authorities and free-schools. The objective is to improve general knowledge about science and technology as well as to persuade more young people to choose a career in the sciences and technology and in a profession focussing on these fields. To help them the teachers in question have at their disposal 14 thematic units with materials and guides for both pupils and teachers. The units cover a large part of the syllabus goals of the compulsory school but not all. Within the NTAs project there is also a basic training module for teachers within the selected theme unit where it is possible to familiarize oneself with the working material. This article is a description of some of the results, which have up to now become available from the research project "Science in the compulsory school – the content

[1] This is a Swedish version of the US-project Science and Technology for Children (STC)

and form of teaching". In this we follow pupils and teachers work within the science classroom. In this way the project will be a natural experiment and the results of which will provide valuable knowledge about learning science. The aim is to extend our understanding of how learning and the interplay within the teaching of science take place.

Method

The chosen groups of pupils are from seven different schools in three municipalities and represent grades K-6 in the compulsory school. The collection of data for this study has been carried out with the help of observations and video recordings of lessons, interviews with pupils and pupils' notes. Some of the groups have been followed over periods of time, 5-6 weeks. The study contains 32 classroom observations (Table 1).

Table 1. The observations.

Grade	Theme	Number of visits
1	Electric circuits	1
1, 2	Soils	1
2	Solids and liquids	5
2,3 and 4	Soils	1
3	Chemical tests	1
3	Plant Growth and Development	2
3	Electric circuits	1
4	Electric circuits	1
5	Motion and design	4
5	Electric circuits	6
5	Floating and sinking	3
6	Floating and sinking	1
6	Motion and design	5

All the interviews were carried out in school, with an interview-guide, in the form of conversations (Hultman, 2001). The interviews are qualitative in a half-structured format. We have chosen to present our data under certain headings, which have developed during our work. Much of what we present is not specific to the NTA-project but should rather be seen as general issues pertinent to the teaching of science in schools. In the present study we have mainly focused on how pupils are introduced into the "science arena" and how they learn to realise what science is about.

To learn to observe

The excerpt below illustrates how important it is for the pupils to get an opportunity to engage in reflection when they have carried out their tasks. Doing and making notes is not enough. The teacher gave the pupils the following task:

> So the group will look at their vehicles and you'll turn the side like this and then you'll spin the large wheel and all three of you will pay particular attention and see if you notice anything while you're spinning. You are to hold it straight like this and look carefully. Don't say anything until the group has had a chance to talk about what it can see.

The aim of the task was that the pupils were to discover that the wheel stopped spinning after a while and that you could in this way approach the concept of friction. One group of pupils was quickly finished with the task and we had the chance then to discuss with these three boys. (Jan stands for the researcher).

Jan: You were supposed to hold on to the grey rod.

Erik: Yes, that's what we did.
Jan: What did you see?
Erik: That the wheel came loose.
Jan: But was that what you were supposed to be looking at?
Mattias: But that's what we saw.
Jan: That's right.
Magnus: What we're saying must be right.

As can be seen investigative approach does not necessarily lead to scientific insight. For these pupils the experiment did not provide insights into the concept of friction. The job of observing what takes place can often be difficult. The person formulating the task knows what he/she is looking for. A task, which is, formulated in such an open way means that the pupils can see many things, both that which is relevant to the task in hand and that which is not. After such a task it is necessary to have a clear summing up by the teacher where all the results are presented and can be discussed. But summing up as we have noticed in our studies can be tricky and there was not any summing up after that task. During our lesson visits it became apparent how important it is that the pupils will be given opportunities to learn how to define the situation. What are we looking for? What is the focus, what is the background in the task?

The pupils must not be left on their own. If the approach is to have positive effects the teacher must help the pupils so that they understand the purpose and the aim of the task.

This can also be seen from the interview excerpts below. The conversation is about a task where the pupils in grade 4 were to get a chrome-nickel filament to glow by passing a current through it. The pupils were then supposed to draw parallels to how the filament in a light bulb works.

I: What did you learn today?
Frida: I didn't learn anything. I couldn't do it.
I: You couldn't?
Frida: No, we had a filament, which was supposed to glow, or I didn't know if it was supposed to smoke or glow or burn and ours just smoked.
I: Why do you think the filament would burn?
Frida: I don't know. Current came from the battery maybe.
I: That's right. Current came from the battery and you were supposed to see how a light bulb works.
Frida: But I didn't understand anything because it didn't glow. But in this it talks about the aim (points to a notebook) and we're supposed to write up the aim of the task. Then we know what it's all about and what we're to do. Was it you who wrote these books?

From our observations it is possible to draw the conclusion that the teacher must help the pupils to gradually become familiar with the way of working in the science classroom. The first is to learn to observe and the second is to learn to describe.

To learn to describe

Pupils are expected to become more and more familiar with the scientific area of knowledge. They are expected to learn to observe, to describe and document, learn to apply a scientific method to cope with certain concepts and terms. It is in this perspective very important for the pupils to learn to describe what they see. Below there is as we can see a good example where the pupils learn to describe what they see.

T: What happened when you touched the different liquids? What about you, Lisa? Which liquid have you chosen?
Lisa: This one, the soap. It feels smooth.
T: Did everyone think it felt smooth?

Jonas: No.
T: What do you say, Jonas?
Jonas: It felt like slime.
T: Like slime you can play with?
Jonas: Yes, but a little smooth.
T: Mattias?
Mattias: The glue felt smooth.
T: Can you say anything else about the glue?
Eva: Smooth but sticky.
T: Another fluid? Viktor?
Viktor: Corn oil felt a bit thin, weak.
T: Anything else to say about the oil?
Erik: It was slippery.
T: Slippery or slippy, Hanna?
Hanna: Everything except the water was yucky.
T: What do you mean?
Hanna: They were uncomfortable.
T: In what way?
Hanna: They were sticky and smelled nasty.
T: Can you describe how they smelled?
Hanna: It's hard to say. Smell yourself and you'll see.

The final comment is interesting and deserves more consideration. What questions do the teachers ask and why do they ask them? What do the pupils think of the teachers' questions? The questions are not always seen by the pupils as supportive of learning but rather as indicators of learning or as check-questions in order to see if the pupil has carried out the task in a correct way. During their work with this theme the pupils learn to describe the properties of various substances.

Words and terms from science

Learning and progress in science mean that you acquire concepts and knowledge, which have been developed during a long period of time in cultures with specific terms and rules. In this perspective learning can be regarded as the individual increasing his/her familiarity with the words and terms within the area of knowledge.

When some of the pupil groups had finished the main tasks about friction they got an extra task to apply their knowledge of friction. The task was formulated as follows by the pupils' book.

> Select a technical invention where the inventor had to take friction into consideration when he or she constructed a machine. Was the inventor forced to solve the problem of friction or was friction of help to the inventor?

Lina: What?
Jenny: An invention.
Sara: Who invented the car?
Jenny: The fridge, I know.
Lina: Cars, does it have to be cars?
Sara: I don't know. It says a technical invention. So it can't be the fridge.
Lina: We can find out who invented the car in a book. Look for a book.
Jenny: Ann (T), where can you find an invention?
T: You can find that out for yourselves. Select a technical invention where the inventor had to take friction into consideration when he/she constructed the invention. Was the inventor obliged to overcome friction or could he/she use friction? Think about where in everyday life you can find inventions where friction was of use or where it should be as small as possible.
Lina: As we said before, a toothbrush.
Sara: We'll have to get paper and write this down. Should we have a sheet each?

Jenny: Yes.
Lina: So we write down inventions.
Jenny: With friction.
Lina: That sounds better maybe.
Sara: Friction (spells word)
Jenny: Toothbrush.

At an earlier point in a whole class discussion they had mentioned brushing your teeth as an activity where friction is useful. When they were going to solve the extra task they got stuck on the toothbrush once more. It would have been useful here to have time for a discussion with teachers and classmates in other groups in order to progress with the concept of friction. Friction is more than just rubbing. As a student you must get opportunities to "fill" the term friction with more and more experiences. Then it will become a scientific concept. But very often it ends as a word for the pupils. But a discussion was not possible in a class of 30 pupils and with material, which was not functioning, as it should.

Interviewer	**Camilla**
	It's exciting, I don't know why.
Really, is it exciting to work with it?	Yes, you learn new things.
Can you say something you've learned from NTA?	I've learned lots of things.
What?	----
Can you say something?	I've learned that liquids are not all as fast.
Can you say a fluid, which doesn't run fast?	I think it's oil.
That's true. You've learned that. What's the difference between a liquid and a solid?	You can hold a solid in your hand without its running away, but you can't do that with a fluid.
How can you describe a fluid? I see	You can drink it and you can be in it and you can put it in a car rather like petrol. Then things can sink in it or float.

The group summing in the class is important but difficult to carry out in such a way that the teacher gets all the pupils on the same wave length. It is important that the pupils have an opportunity to learn, discover and describe without feeling the pressure to use scientific concepts. Camilla in the excerpts down is a good example of this. The teacher in this instance had devoted time to teaching the pupils to discover and describe. The excerpt from the interview with a pupil called Camilla in grade 2 demonstrates. The interview was carried out some months after they had finished the theme *Solids and liquids*.

Camilla in the interview above shows that she has learned quite a lot about fluids and knows that they have different properties.

The pupils give evidence of fragmentary knowledge. But he needs help to put the pieces together. Each theme must be rounded off with a summary and discussion so that the pupils can get the help they need to process their knowledge. We can see here a great potential for development. How can the interaction between the pupils and between the pupil and the teacher be developed so that relevant learning situations can be created? Language and language use are thus important in science teaching. Many of the pupils' difficulties in the face of science arise because schools have not had an opportunity to use scientific concepts and terms in functional contexts.

To be on the science arena

The next excerpt comes from grade 1 the theme Electric circuits. The pupils had learned a lot about the subject. That gave evidence of knowledge, which greatly exceeds what you could expect from pupils in grade 1. One reason why these pupils had such a good grasp of the subject was that the teacher devoted a lot of time to introducing the theme, the groups worked well together and the teacher was at all times present, although not too present, so that important conversations could be conducted between pupils and between pupils and the teacher. The following interview with Lisa grade 1 illustrates this.

Lisa: I've learned how light bulbs should be connected. I've learned that if you have a light bulb and two batteries the bulb glows very brightly.
I: If you have a bulb and only one battery?
Lisa: It glows weakly.
I: Do you have to think about anything special when you're connecting bulbs and batteries?
Lisa: Yes, you have to do it right.
I: What do you have to keep in mind?
Lisa: You have to think … (draws a diagram) that this is a bulb and this is a battery. A round ring with a cross is a bulb and a line is a wire and you put a wire here and a wire here.
I: If you cut this what happens?
Lisa: Oh, well then the bulb can't glow because the wire to the battery is gone and the current has to go round.

These pupils could draw circuit diagrams with symbols for electrical components. They understood the concept of a complete circuit and in the lesson they easily solved problems with so-called "electrical puzzles".

To learn science is a slow and demanding process for the learner. Many pupils in our study demonstrated that they have learned science and become more familiar with scientific words and terms. On the subject of the theme *Plant Growth and Development* some pupils have the following to say:

I have learned that there are many parts to a flower.
Can you name some parts?
Pistils, stamens, petals
You were talking about bees before, why are you doing that just now?
Because bees can help the flowers to propagate. (Girl grade 3)

I've learned that a flower has to receive pollen to be able to go on.
Do you know anything about the parts of a flower?
Yes, petals, stamens and stigma and pistils, stalk and these, for example, are seedpods.
(The conversation is conducted with the help of a wild turnip in flower, which is on the table.)
Why are you drawing bees today?
I don't know … oh, it was because we were working on pollination. (Boy grade 3)

When teaching concepts meet classroom context

The NTA concept builds on a constructivistic view of learning which is evident in many ways and brainstorming is one way of working. But it can also be seen in the working methods where pupils are to make hypotheses and achieve understanding. Sometimes the hypothesis has no function, however. If the pupil is unfamiliar with the theme or with a concept, the hypothesis or the initial question becomes mere guesswork. Our view is that it would sometimes be better to avoid these questions and hypotheses. When it comes to NTA's application of a constructivist view of learning we feel that time for reflection and language use is not sufficiently emphasised. All student tasks require discussion and reflection.

Practical, experimental work has today an important place in science teaching **as** well **as** in NTA. In our studies we focus on among other things on the experimental task as a possible forum for discussion where concepts and terms are used in a functional way, i.e. in a situation where pupils have an opportunity to use and familiarise themselves with terms and expressions from the sciences. But it is not so often the case that pupils use scientific words and terms and it is perhaps not even possible.

The example down is from the theme *Motion and design.* The teacher first presented the task and then gave the pupil groups the observation card they should follow.

> What is the job of the tan hub connector? Turn the vehicle on its side and hold the grey rod. Spin the large wheel. Time how long it spins. Do this several times. Now remove the large wheel and its tan hub connector. Turn the wheel over. Put it back on the axle so the small hole on the wheel faces out. Put the tan hub connector on the outside of the wheel. (Connect it to the small hole of the wheel.) Now spin the wheel again. Time its spin. What do you observe? How did the wheel spin differently each time? Why do you think this happened? (Remember to return the tan hub connector to the inside of the j wheel when you are finished.).

The excerpt below shows pupils working with that task.

Martin:	First it was 1.60. 1.91, 2.27, 2.46 and lastly 2.30. Maybe we can begin with observation card no. 2 now.
Gustav:	There was something else we were supposed to do here?
Johan:	Take away. Do you understand what we were to do?
Martin:	Take away the big wheel and its tan hub.
Johan:	Were we supposed to take both of them away?
Martin:	Both of them!
Gustav:	Jesus, then the whole thing'll collapse.
Johan:	Doesn't it say somewhere about pulling these things out?
Gustav:	You can't do that.
Johan:	You can't pull them out further.
Martin:	Rubbing friction
Johan:	They have to be warmed up a little.
Martin:	OK; 1.2, start.
Gustav:	Check if it moves a meter.
Johan:	Look, it can't, it can't spin!
Martin:	Have you tried turning over those brown things?
Gustav:	What?
Martin:	But we have to check things to see if we can change it.

The most important thing for the pupils was to understand what to do, how to solve the problem purely practically. There was no room for using scientific words and terms. The prevalent classroom situation can be an obstacle to working with the NTA concept. We elucidate this below with some examples of difficulties, which teachers and pupils can encounter but which could be avoided if the teacher is conversant with the material and is familiar with the framework of the school. There have been difficulties for teachers in carrying out certain tasks during the NTA lessons when pupils, for reasons of space, have to be spread out to various areas in the school. It is difficult to support and help all the pupils in this case. There is also a risk that work in some groups comes to a halt.

Once again the role of the teacher is highlighted. The teacher who helps the pupils to break down the described work-progression into sub-tasks will succeed better. We feel, furthermore, that it is necessary to point out to teachers, among other things on training days, that in certain themes the most important thing is not to understand a certain scientific concept. It is sufficient that the pupils learn to observe and describe what they see. The pupils need to be able to discuss what they've done in order to be able to make a whole unit of knowledge out of the different pieces. If that doesn't happen the pieces remain fragments. Finally let us consider some general conclusions regarding our results.

Conclusions

First we want to emphasise the role of the teacher. During our visits it became obvious how important the teacher is. The slogan in schools has been that the pupil should seek knowledge him/herself and that the teacher is only a tutor. But according to our results there has to be a teacher present who not only provides the pupils with material but also is an important interlocutor who helps the pupil along and who realises what problems the pupils might have in interpreting questions and tasks. We agree with R. Säljö (Säljö, 2000) when he says that it is not reasonable to assume that the activities of pupils will lead to their discovering and acquiring scientific knowledge. Solomon emphasises the teacher factor by writing as follows, "teachers need to help students change what is seen into a vivid illustration of scientific ideas with the capacity for further action" (Solomon, 1999 p. 68). Experimental-material with "hands-on kits" and activity books is no self-sufficient material. It requires a teacher who is active, knowledgeable and sensitive and who will lead the pupil on the path to new knowledge.

Often the pupil tasks in our study were too much about "doing" and left too little time for reflection and discussion. Therefore we conclude that the pupils must be given time to reflect upon what they have done in the science project, to discuss their tasks The teacher must give the pupils opportunities to use scientific words in the science classroom. Vygotsky underlines the teacher's role and the use of language in all learning. What he calls effective instructions (teacher helping pupils with the solution) lead the pupil further. He says that the scientific concepts evolve under conditions of systematic co-operation between the child and the teacher (but systematic corporations in Swedish schools today are unusual). It is in interaction and discussions that we become familiar with the functional characteristics of terms and concepts, i.e. how they are used in order to carry on a conversation in a given discourse (Lemke, 1990; Säljö & Wyndham, 2002). But in our data another picture emerges. In a busy science classroom the pupils or pupil groups are often left on their own and the conversation with the teacher becomes infrequent.

Some teachers testified that they have changed their way of asking questions and talking to the children in the classroom. They now give more open-ended questions and tasks. A question of general importance is whether this method provides a "arena" for the development of concepts. The picture of the pupil as the little researcher who on his/her own finds knowledge through his/her experimentation is not wholly accurate and at variance with our discoveries in the classroom. S.Sjøberg writes "if the goal of teaching is to acquire the concepts and theories of science, it is rather doubtful if practical work is particularly effective" (Sjøberg, 2000, p. 394). It is stimulating to ask pupils questions or to give tasks which the pupil him/herself is to find the answer to. But it is not easy to discover what the teacher wants you to see and discover. It is obvious to the teacher but not to the pupil (Bergquist, 1990). It can even be the case that the teacher wants the pupil to discover something, which the pupil thinks, is obvious. Here we feel we must advise caution. We noticed that too open-ended questions and instructions can be very confusing to the pupils and we find it is essential that the teacher is present and can support and sum up.

Many pupils give evidence of fragmentary knowledge and science for them science seems to be a collection of words and terms which as such have an explanatory value. The pupils need help to put the pieces together. That's way the teacher must be present as a discussion partner with the pupils and supports them in various ways in their work and helps the pupils create a whole from their fragmentary pieces of knowledge. In this perspective the teacher can be seen as a everyday "researcher", trying to understand pupils learning and understanding, which is a much more active role than that of passive tutor. Each theme in the material must be rounded off with a summary and discussion so that the pupils can get the help they need to process their knowledge. We can see here a great potential for development within the NTA project.

When the pupil works on a theme it is important that every task contributes to an understanding of the central content of the theme. Each task should always be related to this central idea. But this doesn't always seem to happen in the concrete school situation. Several of the pupils we talked to have difficulty in understanding why they are supposed to work with a specific task. Nor do they see how the task fits in with the whole.

That's way the introduction of the theme is important. At this stage the pupils learn what the purpose of the work is. The contexts, which the teacher creates for the pupils' learning process, are important. A great deal of the everyday work of the school is about pupils acquiring knowledge they are not especially motivated for. An important part of the teacher's work, then, is to create contexts, which give the pupils motivation and a desire to learn. Meaningfulness lies often in a larger whole than is usually covered in specific teaching situations. For this reason we think it is important to place the theme in a larger context and link it to the community outside school and to organise the teaching situation so that the pupil sees the whole picture and what is meaningful.

Learning and progress in science mean that you acquire concepts and knowledge, which have been developed during a long period of time in cultures with specific terms and rules. In this perspective learning can be regarded as the individual increasing his/her familiarity with the area of knowledge. This is a slow and demanding process for the learner. But in a science classroom with 30 pupils and one teacher this is rather problematic. The teacher has not time to help every student to go further into the science "arena". For many pupils the experimental work ends up with the fact that the pupils learn the method and how to handle the material but get no opportunity learn more science.

In conclusion we must say that the result of the work in the science classroom depends on the combination of pupils, teachers and materials. The pupil, the teacher and the material are not components, which can be described separately. They are variables, which affect each other and at the same time form a whole, which is affected by the surrounding milieu.

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Резюме

ПРЕПОДАВАНИЕ ПРЕДМЕТОВ ЕСТЕСТВЕННОНАУЧНОГО ЦИКЛА В ШКОЛЕ – КОГДА КОНЦЕПЦИИ ОБРЕТАЮТ КОНТЕКСТ

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В данной статье обсуждаются проблемы и возможности тех учеников, которые изучают предметы естественнонаучного цикла. Обобщаются результаты проекта *Естествознание в обязательной школе – содержание и форма обучения*, которые получены на данный момент. Изучена работа студентов и учеников занятых в проекте НТВ (Наука и Технология для Всех). НТВ - совместный образовательный проект Шведской Королевской Академии Естественных Наук и Шведской Королевской Академии Инженерных Наук, который был начат в 1997. Целями проекта являются как повышение общих знаний учеников о естественных науках и технологиях, так и увеличение количества учеников, выбирающих естественные науки и технологии своей профессией, или выбирающих специализированную естественнонаучную пограмму в средней школе.

Целью исследования является лучшее понимание, как происходит процесс обучения естественным наукам и как полученная разрозненная научная информация взаимодействует между собой. Учащиеся 6-ых (К-6) классов обязательной школы из 7 разных школ в 3 разных муниципальных областей Швеции учавствуют в эксперименте. Материалы эксперимента – это видео записи, наблюдения уроков, интервью студентов и их записи.

В течении наблюдения стало очевидно, насколько учитель важен в процессе обучения. Многие школы считают, что ученик сам должен искать и формировать знания, в то время как учитель является лишь консультантом. Но результаты наших исследований показывают, что учитель не только должен присутствовать в классе, но и являтся тем человеком, который помогает ученикам, понимает те проблемы, которые возникают в процессе понимания учениками заданий. Многие ученики обладают фрагментальными знаниями и естествознание кажется собранием терминов, которые сами по себе объясняют феномены. Ученики нуждаются в помощи для объединения этих знаний. Учитель должен присутствовать как партнер в дискуссиях и помогать ученикам объединить полученные знания.

Мы также пришли к заключению, что чрезмерная концентрация на «действии» мешает осмыслению. Вывод заключается в том, что достаточное количество времени должно быть отведено для осмысления того, что было проделано во время научного проекта и обсуждения задач. Учитель должен позволить ученикам пользоваться терминами во время объяснений.

Обучение и прогресс в науке означают освоение терминов и знаний, которые были получены в течении долгого времени. В данном контексте обучение можно рассматривать как индивидуальное увеличение знаний в определенной области. Это сложный процесс, и в больших классах с 30 учащимися и лишь одним учителем такое освоение становится проблематичным. Учитель не имеет достаточно времени, чтобы каждого индивидуально провести на «арену науки».

Для многих учеников ценность эксперимента заключается лишь в том, что они выучивают, как обращаться с материалом и как проводить эксперимент, не давая им шанса узнать побольше о научном понимании феноменов.

В заключении можно отметить, что результат работы зависит от комбинации учителя, учеников и учебных материалов. Эти составляющие не могут рассматриваться отдельно друг от друга. Они вариабельны, и каждая составляющая влияет на все остальные, и являются неотделимым целым зависящим от прочих окружающих условий.

Ключевые слова: естественнонаучное образование, экспериментальная работа, культура школьного естественнонаучного образования, работа с проэктами.

Received 20 May 2004; accepted 18 July 2004.

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