Göteborg: Acta Universitatis Gothoburgensis, 2003

# Pupils' responses to school science and technology? A longitudinal study of pathways to upper secondary school.

A summary of my thesis
Britt Lindahl, Kristianstad University, Sweden
Britt.Lindahl@mna.hkr.se

## Background and aims

School in Sweden is compulsory between the ages of 7 and 16. During these years about 10 % of the teaching time is for science, in the beginning as an integrated subject and later on as a set of distinct subjects. Once a term the pupils and their parents get oral progress reports but it is in Grade 8 (15 years) that they first get written marks in each subject. At the age of 16 nearly all pupils continue onto upper secondary school and they can then choose between 16 different programmes. If they later on want to study science or technology at the university, they have to choose a programme with all the subjects, mathematics, biology, chemistry and physics, and less than 20 % of the pupils do so.

The new Swedish Education Act<sup>1</sup> (1998) emphasizes democratic values and in the syllabus of science<sup>2</sup> (2000) there are objectives for the pupils as members in a democratic society. Using Roberts' (1988) curriculum emphases to analyze science teaching, this means a change from "Correct explanations" and "Solid foundation" to "Science, technology and society". Sjøberg (2000a) and Miller (1996) also discuss different arguments for teaching science in school. One of them is an economic argument and this is more commonly used in the debate in Sweden as statistics show that Sweden educates too few scientists/engineers. However it seems that this is not a good argument for young people. A Swedish study (NOT, 1997) shows that young people think that science is important but also that they would not choose it for their own career.

There are few studies about interest and attitude toward science among young children in Sweden. In the "Second International Science Study" (Riis, 1988) Swedish pupils at the age of ten think that science is both fun and interesting. Amongst older pupils the boys still think it is interesting but not so much fun and the girls definitely do not think it is fun and their interest varies. The result for the oldest pupils corresponds with later results in the "Third International Mathematics and Science Study" in both Sweden and other European countries (Beaton et al., 1996). In the article "Mission impossible? Can anything be done about attitudes to science?" Ramsden (1998) summarizes some general conclusions in earlier research:

..... the widely held perception of science being difficult and not relevant to the lives of most people, of science causing social and environmental problems; that science is more attractive to males than females; that interest in science &creases over the years of secondary schooling; that these more negative views are associated with the physical sciences rather than the biological sciences (Ramsden, 1998 s 125).

According to Ramsden (1998) interest in questions of attitudes towards science has decreased since each study gives the same results and nobody knows what to do to change the students' attitudes. On the other hand this is the most important research question according to teachers in schools and therefore she encourages us to continue with research in this field, so that

<sup>1</sup> Available on http://www.skolverket.se/pdf/lpoe.pdf. (Ministry of Education and Science in Sweden, 1998)

<sup>&</sup>lt;sup>2</sup> Available on http://www.skolverket.se/pdf/english/compsyll.pdf. (National Agency for Education, 2000)

young people in the future can really feel that science offers them something of use and interest.

The aim of the study is to follow a group of pupils from the age of twelve until they leave lower secondary school at the age of sixteen to describe and analyse how their attitudes towards and interest in science and technology develop and change but also how this and other factors influence their choice for upper secondary school. From my perspective as a science teacher it is important that our teaching stimulates young people's interest in science, not at first-hand because of an economic argument but for the pupils' own sake. I want them to feel joy and excitement for science and therefore another aim is to discuss teaching implications of the result.

#### Framework

#### Previous research on attitudes and interest

My review of earlier research follows the same structure as the articles of Gardner (1975) and Schibeci (1984) in which they discuss relationships between attitudes and three groups of variables. They are *individual variables* such as cognitive factors, personality and sex, *school variables* as interaction, instruction and teachers and *structural variables* as social and cultural background and factors in society. One of the greatest difficulties of summarising research on the affective dimension of science learning is the lack of mutual theoretical frameworks, concepts and instruments (Gardner, 1985; Ramsden, 1998; Schibeci, 1985; Schiefele, Krapp, & Winteler, 1992; Simpson, Koballa Jr., Oliver, & Crawley III, 1994). Many studies on attitudes towards and interest in science and technology have been completed but it is difficult to extract a coherent view from them as the question is very complex. In the study I summarise my review of earlier research in four points:

- Attitude or interest is judged in the literature by a range of quite different measures, from whether the pupils (students) "like" such things as the teaching, the teachers, the content, and the different subjects to their choice or intention to choose a course or an education in science.
- There are relationships between attitudes/interest and cognitive variables such as ability, achievement and marks but not as strong as might be expected.
- Sex and personality are important for attitudes/interest as well as social and cultural background.
- "Everything" in school may influence attitudes/interest but it is difficult to assess the relative strengths of different factors.

On the other hand it is difficult to find any study about either the relationships between the many different variables, or reasons for individual pupils' change of attitudes. Nor have I found any studies about the relationship between scientific concept understanding and attitudes towards science.

## My model

Keeves' (1998) discusses three systems of influence that can be identified in the field of science education, which affect stability and change in human development and learning.

These systems have their origin in biological factors, environmental factors and planned learning experiences or interventions. These factors interact with each other in significant ways and it is therefore impossible to conduct experimental studies, which consider only one of them.

#### Action and intention

In an analysis of action von Wright (1971) distinguishes between causal and intentional explanations. In order to understand a sequence of behaviour as an action, and not merely as a reflex, we have to ascribe meaning to the behaviour. The intention gives meaning to the behaviour. When we look upon a person's actions and try to understand them, we can distinguish different determinants. von Wright differentiates between *internal determinants*, such as wants, beliefs and abilities, and *external determinants* that constitute duties, norms and opportunities. Both internal and external determinants refer to the person's contextualization and make a certain behaviour possible and other impossible in the situation. The external determinants are external in the sense that they depend on the situation. (Halldén, 1999, 2002)

According to the theory of reasoned action (Ajzen & Fishbein, 1980) and planned behaviour (Ajzen, 1985) a person's intention to perform a behaviour also depends on different determinants which are *attitudes toward the behaviour*, *subjective norm* and *perceived behavioural control*. The third determinant is very close to Bandura's (1997) concept *self-efficacy*. The strength of the determinants is different from one person to another but also from one action to another. The determinants are in turn built up as the sum of different variables with different strength. These variables can be age, sex, values, and so on. The theory says that the intention to behave in a certain way is strengthened if the person

- has a positive attitude towards the behaviour
- believes near people have a favourable attitude towards the behaviour
- believes she has the resources and opportunity to engage in the behaviour

I understand the action to choose for upper secondary school as being influenced by many different factors or determinants which also affect each other. This system is very complicated and therefore difficult to explore. From the theory of Ajzen and Fishbein I have outlined a model of how I understand the action of choosing for upper secondary school.

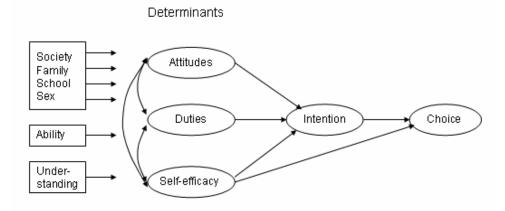


Figure 1. My model of the action of choosing for upper secondary school based on the theory of planned behavior.

In my perspective the choice for upper secondary school is a well-considered decision. The pupil has an intention to become "something" in the future. This "something" can be very distinct already or a choice with many opportunities later on. The decision depends on three determinants, *attitudes* of all kinds, *duties* or experienced demands from the neighbourhood and *self-efficacy* which means the conviction to be able to succeed with the action. Behind these determinants there are many different variables which influence them all. From my perspective as a science teacher I have also decided to look at some structural variables together with the influence of understanding of scientific concepts and ability.

#### Attitudes and interest

An analysis of studies in the affective domain of learning reveals a complex picture of the way in which the terms are used. Most common are attitude and interest. Sometimes they are used interchangeably, sometimes as synonyms to motivation, opinion, views, and belief and so on. Attitude is a common term in social psychology and many psychologists believe that attitudes have three different components: affect, behavioural intention and cognition. Others use the affective and cognitive components or only the affective (Atkinson, Atkinson, Smith, & Bem, 1993; Carlson, Buskist, & Martin, 2000). Interest can also be conceptualized in a variety of ways, each of which reflects the theoretical orientation of the research questions being asked and methods being used. In spite of their differences, common to most of this work is the assumption that interest is a phenomenon that emerges from an individual's interaction with the environment (Krapp, Hidi, & Renninger, 1992). In my study I will use attitude and interest as synonyms for the affective components in these concepts. In my view, they are the product of many events both in and outside school.

#### **Duties**

From their home the pupils have more or less conscious demands for their future. They also belong to many other cultures which contribute to their picture of their possibilities and the future. It is not possible for me to study all the cultures and subcultures to which they belong but I will carefully listen to what they have to tell me about their backgrounds.

## Self-efficacy

Perceived self-efficacy is the pupils' own judgements of their capabilities to organize and execute courses of action required to attain designated types of performances. Their beliefs depend upon the context and environment. It is not the same as self-esteem which mean the pupils' judgements of their self-worth (Bandura, 1997). They can have a high self-esteem even if the self-efficacy for science is low. During the years in school the pupils have got an idea of their own capabilities and what it means to choose a certain programme. Out of this they decide what is possible or impossible to choose for upper secondary school.

#### Ability

The pupils' judgement of their own capability does not necessary corresponds with their real capability. Ability in this study means the pupil's possibility to succeed in science and technology at upper secondary school. Svensson (Härnqvist, 1998) has shown that there are twice as many who could be successful in science according to their mathematical ability, as actually choose science. As ability measure he used an inductive-logical test which in several studies has shown high correlation with high achievement both in mathematics and in general.

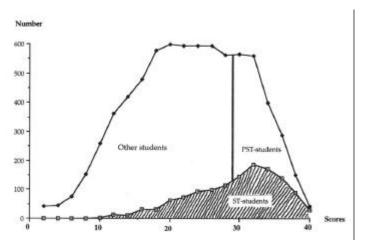


Figure 2. Score distribution of science and technology students (ST), potential science and technology students (PST) and other students in the inductive-logical test in Grade 6.

Figure 2 shows his sample score distribution of this logical test at the age of twelve. The students who have completed an upper secondary education in science and technology are marked as ST-students. According to Svensson, students above the average scores of this ST-group are a group of potential science and technology students (here called PST-students). In this group most students are girls from all social classes and boys from the working class. In my study I will discuss ability in a wider perspective and use this test together with their marks.

## **Understanding**

From research we also know that pupils have problems to understand everything taught in science lessons. They have 'misconceptions' or 'alternative conceptions' of different kinds described in many studies (Driver, Guesne, & Tiberghien, 1985; Driver, Squires, Rushworth, & Wood-Robinsson, 1994; Duit, 2002). According to Andersson (1994) secondary science teaching only succeeds in stimulating about 20% of the pupils to leave their everyday thinking for a more scientific one. To construct another measure of the level of understandings of my sample, I will ask some questions about everyday phenomena and analyse them according to the qualitative differences found in research on conceptual understanding. I will pose the questions during interviews as Säljö (1995) has criticized this research from a social cultural perspective meaning that the poor performance is related to the fact that the questions are asked in a everyday context and we expect a scientific answer. Out of this criticism Schoultz (2000) built his study on Vygotsky's (1986) "zone of proximal development" and found that the pupils showed a better understanding in a conversation than in written tests.

# Research questions

Earlier research shows a complex picture. We know that the pupils' attitudes are influenced by cognitive and structural factors and what happens in school but we know little about their relative importance and about the individuals who choose or do not choose science for different reasons. In the study I will describe and analyse both the group results and individuals out of these questions:

➤ How do pupils' attitudes towards and interest in science change during the five last years in compulsory school? What in school affects them?

➤ What decides the choice for upper secondary school? What significance has attitude/interest, ability, understanding but also such factors as sex, social and cultural background?

The perspective on the individuals requires a longitudinal study and I follow a group of 80 pupils from Grade 5 (12 years) to Grade 9 (16 years).

## Methods and samples

The basis of my study is how the pupils experience school, and science teaching, and the feelings that will influence them when choosing a programme for upper secondary school. The data is collected using observations, interviews and questionnaires, as by combining different methods and contrasting them the understanding of a complex situation can be deeper (Cohen, Manion, & Morrison, 2000). The study is carried out in a school with pupils from different home backgrounds. About 25 % are from immigrant families. Up to Grade 6 class teachers taught them integrated social and natural science but from Grade 7 the pupils have biology, chemistry, physics and technology taught by subject teachers. The sample consists of 80 pupils, the whole age group in this school. The group changes over time as pupils move out and in, some pupils do not want to be interviewed and so on but more than 50 pupils have complete all the questionnaires and interviews during the five years. When referring to the group it means at least 80 pupils, as many girls as boys, who have answered the questionnaires.

#### Data collection

#### **Observations**

To understand and interpret data it is important to know the background and context and the best way is to take part and to observe. Patton (1990) discusses the possibility to be both inside and outside the process by changing the role from participating to observing. For me it is a question of finding the most appropriate way to get good data during the week preceding the interviews. I have chosen to be an observer in the classroom, to see the pupils in their natural settings, and to see them as pupils. While observing I sit in one corner of the classroom and take notes of what is happening and later on I use these notes at the interviews. In other lessons, when the pupils are working on their own, I change to the role of participant observer. By helping them and asking questions I increase my knowledge about them.

#### **Questionnaires**

To gain a different perspective I also use questionnaires. I have chosen to use already published instruments to be able to compare my group with larger groups. The instruments are "Science and Scientists (SAS)" (Sjøberg, 2000b) and "Evaluation Through Follow-up (UGU-95)" (Reuterberg, Svensson, Giota, & Stahl, 1996). The first one (SAS) is about pupils' experiences outside school, what they want to learn more about in science and their view of science and scientists. It is a synthesis of different studies done in different countries. In this design it has been used among 13-year-old pupils all over the world. The second (UGU-95) is a Swedish study with questions about attitudes about both school and spare-time, how interested they think they are to learn more in different school subject and how good they think they are in these subjects. There are also tests of verbal, spatial and logical-inductive ability.

#### **Interviews**

In interviews with open-ended questions you must be able to interpret what is said and to do so you must have a deep knowledge about the setting and the question area. The interview can then take different forms from a conversation to formal deep interview (Kvale, 1997). When I interview or talk with the pupils I have a number of questions about spare time, school, and teaching but also about their future. I do not follow a strict list with questions but try instead to follow up each pupil's answer. In that way the interview is more like a chat than an inquiry and the pupils feel freer to talk. The other part of the interview is about some everyday phenomena. From analysis of aims in the syllabus and research on children's ideas in science I have selected questions about the earth in space, electrical circles, and why they can see me, can smell food, and perspire when they do exercise.

## Design

- Grade 5 I began the study by administering both questionnaires to gather data about the pupil's interests and attitudes. After that I talked with each pupil about their answers and asked them about their thoughts concerning school, science and the future. At the end of the interview I asked them to explain day and night, the year, seasons, rain and light.
- Grade 6 This year I began with observations in each class for one week to build up a picture of the pupil as a pupil. After that they completed the questionnaires and tests from UGU-95. Then we talked about their encounters with a new school, subjects, teachers and teaching.
- Grade 7 I observed lessons for one week in each class and repeated the attitude questionnaire. The interviews were about their meeting with biology, chemistry, physics and technology. We talked about gravity and I repeated the questions about time, seasons, rain and light.
- Grade 8 I repeated the observations and attitude questionnaire. The interviews were about feelings for science and science teaching compared with other subjects. At the end of the interview they were asked to light a lamp with a battery and then we discussed different electric circuits.
- Grade 9 Once more I repeated the observations and attitude questionnaire. The interviews were about their choice for upper secondary school and their thoughts about their future. I repeated the questions about seasons, rain and light and to see if they could use their knowledge about molecules and change of state I also asked them to explain why they can sense the smell of food and why they perspire when they do exercise.

## Analysis

Interviews are transcribed word for word and I have also NUD\*IST for the analysis. All quantitative data are recorded in SPSS. From this material I construct descriptions of the group but also a personal description of some pupils. Which data I use and how I do the analysis are described below together with the results.

## Results on group level

When I leave them in Grade 9 they have just chosen for upper secondary school. Perhaps they will be accepted to study in the chosen programme, perhaps not. Some will have to choose a new programme before autumn; others will perhaps change their choice after some weeks if they do not find the programme suitable for them. But many of them will follow their intentions and realise their dreams. Perhaps their dreams would have been different if school and teaching had been different. It is difficult to speculate but I am sure that their view of science could have been more positive. It is not easy to summarise all these pupils' experiences and feelings as they are so different but from each research question I will discuss some aspects repeated by many of them.

How do pupils' attitudes towards and interest in science change during the five last years in compulsory school?

A sententious answer would be "it was mucked up" at least for physics and chemistry but I shall try to give a more balanced answer. In the attitude questionnaire the pupils have answered the questions: "How good do you think you are at the following subjects?" and "How interested are you to learn more in the following subjects?" in grades 5, 6, 7, 8 and 9. They did this for all their school subjects. The alternatives for the first question were "good, quite good, neither good nor bad, quite bad and bad" and for the second "very interested, interested, not particular interested and not interested at all". I have coded the alternative and calculated the mean for how good and interested they think they are. On average they feel most interested and best in Grade 5. During the following years their mean rating falls but rises again in Grade 9 but not to the same level as in Grade 5. Looking at the sexes I can see that the girls think they are nearly as good in Grade 9 as in Grade 5 but not as interested to learn any more. The boys on the other hand think they are as interested in Grade 9 as in Grade 5 but not as good as before.

Looking at different subjects I can see that interest in learning more in the social sciences is increasing for both girls and boys as well as their feeling of success. The same applies to biology. The initial experience of the girls with physics, chemistry and technology in Grade 7 makes them feel uninterested to learn more but also that they are not so good either in these subjects. During the years their interests stay on a very low level but also they feel a little more competent. That girls are uninterested in physics, chemistry and technology is nothing new but what is more interesting is that the boys are also negative. Compared with the girls they are more positive but compared with other subjects, physics and chemistry are at the bottom.

So my conclusion will be that pupils' interest in physics and chemistry is low and decreases during the years. It has little to do with age as interest in other subjects is higher and increases. It has little to do with sexes as both girls and boys put these subjects at the bottom of their ranking lists.

#### What in school affects attitudes and interest?

A short answer is "everything" but a real answer; the situation is complicated. Some pupils can say that they love to do labwork in science but not calculating and others say the reverse. It is the same with most activities. The following summary of about 60 interviews every year is a description of the most important factors to quite a lot of the pupils.

The pupils have very little experience of science from upper primary school. The one they have is mostly from some "days with experiments" and therefore they expect science to be like that. They are very disappointed the first year at lower secondary when they meet science teaching where they are supposed to sit still and listen, copy the blackboard and fill in stencils. When they start with labwork in the next grade they really like it but probably it was too late to change their image of science. As they have little experiences of physics and chemistry from lower grades they say they perceive it is so new, so strange, so difficult and so serious all at once. They compare with other subjects such as English and geography which started like a game and the difficulties have come gradually. As they experience science as difficult, they also think they are not good in the subject, and then it becomes much more difficult and so on. This can be the beginning of a negative spiral between attitudes and behaviour which can be difficult to break (Shrigley, 1990).

They perceive both physics and chemistry as authoritarian subjects with the message "it is like this, learn it because it is right, here is nothing to discuss". They also perceive all lessons are so predictable; first the teacher talks, then the pupils work. When analysing all the interviews it is so obvious to me that science teaching has to be more varied. Some pupils like one way of working, others like other ways, but all dislike doing it the same way all the time. Sometimes they all want to discuss, work together in groups, and to pose and work with questions from their own area of interest. In other words, they want to have more influence on their learning like they have in other subjects.

Another important thing is what is taught in science. Not even biology is interesting if it is about algae and mosses. Much rather they want to learn about human beings precisely like the pupils in Reiss' (2000) study. Answers in the SAS-study also show that they are interested in everything that is odd, fantastic and spectacular for instance dinosaurs and life in space. It is like Egan (1995) says that upper primary is the age of the extreme. I can understand one girl's frustration if she had expected such content and had to learn about how a hammer works. I can hear the same disappointment from many pupils who like to watch TV-programmes about science and read such magazines. Some pupils who during lessons and interviews showed "scientific attitudes" also choose a non-science programme for upper secondary school saying they are not interested in "school science".

The last area, which can be more important than I would ever have thought, is the "hidden messages" in science or its semiotics (Shapiro & Kirby, 1998). Many pupils have told me, it is so depressing to go to the classrooms with black desks, black blackboard, curtains cocked to one side, dirty walls with old pictures and worst of all bad smelling. Together with this they meet textbooks with only facts and facts, terrible to read, and very serious teachers. There are pupils who ask "Is it not allowed for science teacher to laugh?"

## What decides the choice for upper secondary school?

As early as in Grade 5 we talk about their dreams for the future and quite a lot of the pupils have ideas about their working life. Many have predictable dreams such as being a police officer, hairdresser, lawyer, vocalist and doctor. Other pupils are not so precise but could imagine working with computers or the economy. There are of course quite a lot who have no idea yet. I posed this question every year. Before the interviews in Grade 9, I read all

\_

<sup>&</sup>lt;sup>3</sup> Scientific attitudes means good characteristics for scientific work such as logic, open-mindedness, honesty, scepticism, curiosity and consideration of consequences (Gardner, 1975; Simpson et al., 1994).

transcriptions and the pupils were also allowed listen to this part of earlier interviews. Both I and also the pupils were very astonished that their dreams from Grade 5 or 6 have been more or less repeated every year. If so many decide their future so early and science is so unfamiliar to them, perhaps it is not strange that they do not choose science. Another problem is that they do not know very much about different professions within science. When talking about chemistry most of pupils can only give me two reasons for learning it. The first is to get good marks and the second is to become a chemistry teacher. The last one is none of their future dreams and as they cannot image any more professions for which chemistry is relevant, they cannot see the meaning with learning chemistry.

## What significance has attitude/interest?

According to the pupils interest is the most important factor for their choice for upper secondary school. Nearly all pupils who have not chosen science explain their choice with the subjects in the programme had to be interesting. If I look at the attitude questionnaires there are only 6 of the 80 pupils who say they are more interested in natural science than social science. 44 say the contrary. When I ask the pupils who have chosen science, why they have done so, the most common answer is that they have to because of their future careers. If I look at the attitude questionnaires they are not more interested in science than their schoolmates. There are also pupils who have dreams for their future which involves choosing science for upper secondary but as they think that science is so boring they have given it up. Already in the SAS-questionnaire in Grade 5 they answered a question about important factors for their future career and the most important was to get an interesting work. Every year I have also asked about important factors for their future career and the answer had been the same all the time. In the SAS-study pupils all over the world say exactly the same (Sjøberg, 2002).

#### What significance has ability?

Of course, ability and achievement are important but not as important as expected, just as Gardner (1975) concluded. The pupils who choose science have high marks or high scores on the logical-inductive test, often on both. On the other hand only one quarter of the gifted pupils with high marks choose science for upper secondary school. As there is much more mathematics in the science programme you could expect pupils with the highest mark in mathematics to choose it but not even half of the pupils do so. On the other hand one third of the pupils who have chosen science have barely passed in mathematics. Many gifted pupils' reason for not choosing science is their sense of self-efficacy (Bandura, 1997). According to their own opinion they are not good in science and mathematics even if their marks are good. It is especially the girls who do not trust their marks and say that they must be wrong as they do not understand. They seem to feel that to be good they also have to be interested and get encouragement from the teacher. According to Aikenhead's (1996) terminology, they have not got enough help to cross the borders into the subculture of science.

## What significance has understanding?

In nearly all grades I have asked the pupils to explain some everyday phenomena and categorised their answers according to research on conceptual understanding. In year 9 there are a small group (about 30 % of the pupils) who are categorised to have good understanding across a range of conceptual areas. In this group it is only 25 % who choose science. In the interviews it was obvious that the pupils are not used to discussing and answering questions like this. For example when I ask them about the seasons, many answer, it is because the inclination of the earth. When I continue with questions about how that can explain why it is colder and darker in winter, they look very surprised as they feel they have already given me the "correct", complete answer. They seem to have a view that the task is simple, and a

superficial answer is sufficient. They are not interested in pursuing such ideas to any depth. I conclude that they do not understand that they have not understood the whole range of the question. If this is the case they cannot improve their understanding.

There is another aspect of not understanding. Often teachers do not make clear to the pupils what they are supposed to learn from the labwork or what is said in the textbook. When they do not understand such things they doubt their own capability and lose interest.

#### What significance has sex, social and cultural background?

In this group there are as many girls as boys who choose science. Compared with the nation it is the boys in this group who do not choose. The most important reason for those who choose science is that they already have decided on their future career. The reasons for gifted pupils not to choose differ between the sexes. More girls say they do not think they are able but more boys say that it because they find science boring. The pupils who choose science tend to be immigrants or have well educated parents. In the interviews these pupils say that they can choose what they want to but I can also hear between the lines that many parents think that they shall choose a programme preparing for further education. But if it is an education within natural or social sciences does not seem to matter.

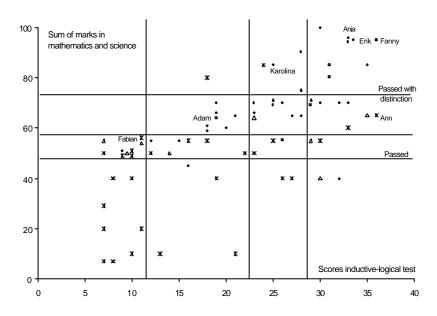
#### **Summary**

If I interpret the pupils' choice for upper secondary school from my model in figure 1, I can see that many pupils have a positive attitude to science but often a more positive attitude to other subjects. They have duties to their parents but these are not strongly expressed. There are parents who wish their children to choose a theoretical programme but only one of the 80 subjects "have to" take science. The last determinant, self-efficacy, follows the same pattern as the attitude. Many pupils think they are good in science but not as good as in other subjects. For most pupils it seems as if attitude is the strongest determinant for the choice. The determinants are influenced by different factors. Girls and boys perceive science teaching differently but it seems as if the boys are on their way to developing the same critical attitude as the girls have had since long ago. The social background is important as many of the pupils who choose science are from well educated homes but even this group is loosing interest. There are many pupils from cultures with a strong patriarchal tradition who choose science; perhaps it is easier for them to accept the authoritarian nature of the science teaching. Good ability is a necessary factor but does not guarantee science will be chosen. Neither has good conceptual understanding a crucial importance but on the other hand there are many pupils who say that they would not choose science as they do not understand science in the way it is taught. So my conclusion is that to most pupils, attitude is the most important determinant but also self-efficacy as they influence each other.

#### Case studies

In this section I will discuss determinants and factors affecting individual pupils. I will frame the cases to represent different ability levels, shown in figure 3. In the group half of the pupils chose a programme preparing for further studies but most of these chose the social science programme rather than the science. I have used the inductive-logical test, to identify potential science pupils but, as I am thinking of ability in a wider way, I have also represented their ability by calculating the sum score of their marks in mathematics and sciences in the final year. Figure 3 shows pupils on a scatter plot of these ability measures. If the pupil has passed in all subjects the sum will be 50 and if s/he has passed with distinction it will be 75. The

maximum is 100. I have also marked the quartiles on the test. The third quartile is the same as the line for potential scientists identified by Svensson (Härnqvist, 1998).



<sup>&</sup>lt;sup>®</sup> Natural science programme <sup>◆</sup> Social science programme <sup>▲</sup> Aesthetic programme <sup>★</sup> Other programmes

Figure 3. Pupils' choice of programme for upper secondary school from their ability measured with a logical-inductive test and their marks in mathematics and science. Pupils who have chosen the science programme are marked with filled squares and those who have chosen the social science programme with filled diamonds. The triangles have chosen an aesthetic programme and the stars a programme preparing for a working life.

The following case descriptions give more details about individual pupils, selected to represent a range of ability and attitudes. In the upper corner on the plot there are three very able and diligent girls who have chosen science. They are all from well educated homes and have an ambition to be a physician or an engineer. None of them like science as they think it is boring. They have very high marks in all subjects but are not so good at answering my questions about everyday phenomena. One of these girls, **Fanny**, is a very silent girl, always working in the classroom. She seldom puts up her hand to ask and answer questions. When I first met her five years ago, she told me that she liked mathematics, but she thought that the tasks were too easy for her. She has repeated this in every interview. When I ask her in Grade 8 about science, she says, it is boring but you have to learn it. She was also very surprised when she got her first marks as she had not understand that she was among the best in science. On the other hand she is not so good in answering the questions concerning everyday phenomena. Her way of answering tells me she learns by heart and tries to remember and is not used to discussing ideas to come to an answer. In my view she is a girl who has not had the opportunity to develop her skills in school and her reason for choosing science is that she had to, for her chosen career.

In the same corner there is a quite different girl, **Anja** who is very socially competent, always discussing ideas. Her parents are scientists and brother and sister too. She has from the beginning told me that her dream is to be a doctor, and therefore she will choose science for upper secondary school. But when I met her in Grade 8, she told me she had changed her mind. Her dream was still to be a doctor but she could not think of taking science so it would be impossible. She hates science and the way it is taught. She said she likes to discuss and she wants to learn more about human beings, not about dead things. Anja tells me that she often

reads her book in civics before going to sleep. She would not dream of doing the same with her book in physics. When talking about her marks she tells me that her best marks are in science but that must be wrong as she does not understand anything in science. But when I ask about everyday phenomena she is not that bad.

Erik is a calm and confident boy. At school he does what he has to do but not more. He finishes his tasks very fast and then he has lot of time to talk with but also to help his schoolmates. I think school is not so demanding for him even if his marks are amongst the best. First time I met his class in Grade 5, his teacher told me that this boy was one of the most brilliant pupils in mathematics he ever had met. His next teacher in mathematics told me the same. But Erik's favorite subjects are history, English and sports. He thinks science in school is boring but he likes to watch scientific programmes on TV and is also one of the best in answering my questions about everyday phenomena. He says he has chosen the social science programme for upper secondary school as there is too much mathematics in the natural science programme. When I asked him if anyone has tried to convince him to choose science instead his answer is no.

A boy who has chosen science is **Adam**. He works well in the classroom but cannot sit still. He thinks he is doing well in school and says that he is interested in all school subjects, especially science. He reads both books and newspapers. He has a strong ambition to be a doctor like his parents and works therefore very hard with his homework and succeeds quit well in school. He has lot of problems with mathematics in school and is not amongst the best in answering the questions about everyday phenomena. But perhaps it will be enough with a high ambition and good support from home to succeed?

**Fabian** is the philosopher in the group and one of the best in explaining everyday phenomena. He is very interested in nature and would prefer to be in the forest instead of the school. He thinks a lot about the humans' and animals' rights and knows very much about nature but hates mathematics. When he watches TV or reads magazines it is always about science or technology, never soaps or comics. He is bored with school but his parents have expectations for his future. His choice for upper secondary is an aesthetic programme.

There is also another group of very diligent pupils at the top of the figure, mostly girls. They have a very clear idea of their future and it is not within science. They work very hard to become something within media or the caring sector. One example is **Karolina**, a very thoughtful and mature girl. You do not notice her in classroom but she is very diligent and helps anybody who asks her. Her self-confidence is not so good. She reads a lot, plays the flute but does not like computers and is interested in people and the world around her. Every morning she watches the news on TV and in the evening many different programmes. Her favorite subject in Grade 6 was Physics since the teacher was brilliant. She described how much fun it was when she succeeded in solving the problems. She is also one of the pupils who has developed her understanding of everyday phenomena more than others. Her choice is social science and her dream is to work with social welfare.

In the group of high scoring logical-inductive pupils to the right in the figure, there is also a group of pupils who are not so diligent. Some of them are in conflict with both home and school and some come from the working class, just thinking of getting a job like their parents as soon as possible. Many of these pupils think that school is boring and their teachers describe them as lazy troublemakers. One of them is **Ann**. When I first met her in Grade 5 and 6, she was a good and diligent girl. It seemed that she worked hard to be among the best

in the classroom. When I came back in Grade 7, I could not recognize her. She was seldom in the classroom and when she was there, she had a disturbing influence on lessons. Her appearance is conspicuous with blue hair and provocative clothes. Her teacher told me that her parents had divorced. In Grade 8 she was still disruptive but perhaps on her way back. When listening to lessons in mathematics she seems to be quite competent. She thinks science is awful when they have to sit still and listen to the teacher but a little better the few times they are allowed to work with their own projects. Her understanding of the everyday phenomena was quite good in Grade 5 but in Grade 9 she could not or was not interested in answering my questions. Her choice for upper secondary is within the caring sector.

#### Discussion

## What is new in the study and which new questions are posed?

It is not easy to summarise a study like this as young people today are a heterogeneous group with many subcultures and ways of living. There is no majority to refer to (Regeringens proposition, 2002:120). On the other hand there are some findings which are new and worth paying attention to.

The first finding is that pupils are interested in science but not as much as in other subjects. In the lower grades they want to learn more about fantastic and spectacular things and about human beings. But it is not the content that is the major problem; it is more the way it is presented in school. Pupils feel it is never made clear why they need to learn particular content, do labwork, or the wider purposes of science as it is meaningful in their lives. Even more important is the way we teach. They want to have more variation in the teaching and the opportunity to influence their own learning.

The next finding is that many pupils even at Grade 5 have an idea of their future career which later on is the same as their choice for upper secondary. If science shall have a chance in their lives the pupils must have a positive experience of science from the beginning of primary school through all years. Once they have lost their interest it is very difficult to get them back. The competition for their attention is intensive and the older they get the more difficult it will be to catch their interest and allegiance. As young people today are engaged in different questions in society another direction of teaching may make them realise that social sciences give them tools to act but natural sciences give them the important knowledge?

The third finding is that even the "safe bets" fail. For a long time we have known that the girls are critical of science teaching but what is clear in this study is that the boys are as critical as the girls. The same thing is true of the well educated parents' children. It is not so that able pupils with high marks will choose science, not even if they have the "right" background and a natural interest in science. Is it possible to change teaching in a way that both girls and boys no matter their background will be interested?

The final finding is about the importance of understanding. The pupils complain about not understanding but they are referring to another type of understanding than the one of formal concepts. On the other hand good understanding of concepts is not rewarded in their marks. Would teaching built upon insight gained from conceptions research help the pupils to understand and make them more interested in science?

#### What can school do to make them feel for science?

The second aim of the study is to discuss implications for teaching. I have earlier concluded that attitudes are the most important determinant together with self-efficacy for the choice of programme in upper secondary school. Of course we can not ignore structural factors such as sex and background but instead of blaming them it is our duty to accommodate them.

The first thing I will suggest is that we have to start with science much earlier. One reason for this is, when the pupils encounter science they have already started to form their thoughts about their future and as they have little experience of science this does not exist in their mind. To give them a chance we have to build up their knowledge during a long time as we do in other subjects. Let science start as a game in primary school and let the difficulties come gradually. I think that Egan (1995) makes a point that if the young pupils are interested in fantastic and spectacular things let them work with that. As I have asked the same questions about rain, seasons and light many times, I can see that many of the pupils who had attempted some explanation in Grade 5, no matter how naive, have a better understanding in Grade 9 than those who answered "don't know" in Grade 5.

Millar (1996) agues that first we have to decide why we want to teach science to all young people; from that we can work out what we want to teach them; then find the best way to do this. It seems to be a consensus over the world that the answer to why, must be scientific literacy in a school for all children (AAAS, 1994; Millar & Osborne, 1998). Many pupils in the study say that they do not understand why they are learning science. Perhaps they will feel a better need for science knowledge if they are encouraged to use it to read and discuss scientific articles and controversies. As language and argumentation is important in science it also had to be important in school (Driver, Newton, & Osborne, 2000; Kolstø, 2001; Lemke, 1990). Another consensus is the overloaded curriculum and instead of increasing we must decrease it and give space for other aspects then facts. If the teenagers like to read science magazines and look at TV-programmes about science, let us start from this. In the SAS-study (Sjøberg, 2002) as well in my study the pupils show a greater interest for science content as optics if it was presented in another context as the rainbow. Let us learn from the teachers in mother tongue that it is better that the children read, than what they read. This is also a way to give them more influence on their schoolwork as many of them ask for. There would seem to be no problem in changing the teaching from its current concept focus as the Swedish syllabus for compulsory school gives aims for science concerning nature and Man, scientific activity and use of knowledge (National Agency for Education, 2000).

The last thing I will draw attention to is all the hidden messages from the classroom but also from the teacher and textbooks. Some of the messages ought to be easy to put right if we are aware of them. But I think that the most serious message is that we make them feel incapable and lacking in understanding. In the questionnaires I can see that the pupils think that they are not as good in physics and chemistry as in other subjects. From the interviews I know that they have problems understanding the formal concepts but also the meaning from their classroom learning and from labwork. This means that we must give more encouragement to pupils as not even the "best" feel that they are doing well, but also teach for understanding.

#### References

- AAAS. (1994). Science for All Americans. Project 2061. New York: Oxford University Press, Inc.
- Aikenhead, Glen S. (1996). Science Education: Border Crossing into the Subculture of Science. *Studies in Science Education*, 27, 1-52.
- Ajzen, Icek. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.), *Action control: From cognition to behavior*. New York: Springer-Verlag.
- Ajzen, Icek, & Fishbein, Martin. (1980). *Understanding Attitudes and Predicting Social Behavior*. Englewood Cliffs, N.J.: Prentice-Hall Inc.
- Andersson, Björn. (1994). Om utvecklingen av en Na-didaktisk forskarmiljö i Göteborg. In H. Strömdahl (Ed.), *Aktuell NO-didaktisk forskning i Sverige* (pp. 7-16). Stockholm: Skolverket.
- Atkinson, Rita L.; Atkinson, Richard C.; Smith, Edward E., & Bem, Daryl J. (1993). Introduction to psychology (11 ed.). Fort Worth: Harcourt Brace Jovanovich College Publishers.
- Bandura, Albert. (1997). *Self-efficacy. The exercise of control*. New York: W. H. Freeman and Company.
- Beaton, Albert E.; Martin, Michael O.; Mullis, Ina V. S.; Gonzalez, Eugenio J.; Smith, Teresa A., & Kelly, Dana L. (1996). Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study: Boston College.
- Carlson, Neil R.; Buskist, William, & Martin, G. Neil. (2000). *Psychology. The science of behaviour* (europeisk ed.). Essex: Pearson Education Limitid.
- Cohen, Louis; Manion, Lawrence, & Morrison, Keith. (2000). *Research Methods in Education* (5 ed.). London: RoutledgeFalmer.
- Driver, Rosalind; Guesne, Edith, & Tiberghien, Andrée (Eds.). (1985). *Children's Ideas In Science*. Milton Keynes: Open University Press.
- Driver, Rosalind; Newton, Paul, & Osborne, Jonathan. (2000). Establishing the Norms of Scientific Argumentation in Classrooms. *Science Education*, 84(287-312).
- Driver, Rosalind; Squires, Ann; Rushworth, Peter, & Wood-Robinsson, Valerie. (1994). *Making Sense of Secondary Science*. London: Routledge.
- Duit, Reinders. (2002). *Students' and Teachers' Conceptions and Science Education* [www]. IPN. Retrieved 2002-12-20, from the World Wide Web: http://www.ipn.uni-kiel.de/aktuell/stcse/stcse.html
- Egan, Kieran. (1995). Berätta som en saga. Stockholm: Runa Förlag AB.
- Gardner, Paul L. (1975). Attitudes to Science: A Review. *Studies in Science Education*, 2, 1-41.
- Gardner, Paul L. (1985). Students' interest in science and technology: An international overview. In M. Lehrke & L. Hoffmann & P. L. Gardner (Eds.), *Interests in Science and Technology Education* (pp. 15-34). Kiel: Institute for Science Education (IPN).
- Halldén, Ola. (1999). Conceptual Change and Contextualization. In W. Schnotz & S. Vosniadou & M. Carreteo (Eds.), *New Perspectives on Conceptual Change*. Oxford: Pergamon (Elsevier Science Ltd).
- Halldén, Ola. (2002). Om att förstå, missförstå och inte förstå. Ett intentionellt perspektiv på inlärningssituationen. In H. Strömdahl (Ed.), *Kommunicera naturvetenskap i skolan*. Lund: Studentlitteratur.

- Härnqvist, Kjell. (1998). A longitudinal program for studying education and career development (Report 1998:01). Göteborg University: Department of Education and Educational Research.
- Keeves, John P. (1998). Methods and Processes in Research in Science Education. In B. J. Fraser & K. Tobin (Eds.), *International Handbook of Science Education* (Vol. 2, pp. 1127-1153). London: Kluwer Academic Publishers.
- Kolstø, Stein Dankert. (2001). Science Education for Citizenship. Thoughtful Decision-Making About Science -Related Social Issues. Diss., Faculty of Mathematics and Natural Science, University of Oslo.
- Krapp, Andreas; Hidi, Suzanne, & Renninger, K. Ann. (1992). Interest, Learning and Development. In K. A. Renninger & S. Hidi & A. Krapp (Eds.), *The Role of Interest in Learning and Development* (pp. 3-25). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.
- Kvale, Steinar. (1997). Den kvalitativa forskningsintervjun. Lund: Studentlitteratur.
- Lemke, Jay L. (1990). Talking Science. Norwood, NJ: Ablex Publishing Coperation.
- Millar, Robin. (1996). Towards a science curriculum for public understanding. *School Science Review*, 77(280), 7-18.
- Millar, Robin, & Osborne, Jonathan. (1998). *Beyond 2000: Science education for the future* [www]. King's College London, School of Education. Retrieved, 2002-08-31, from the World Wide Web: http://www.kcl.ac.uk/depsta/education/be2000/be2000.pdf
- Ministry of Education and Science in Sweden. (1998). *Curriculum for the compulsory school, the pre-school class and the after school centre, Lpo 94* [www]. Retrieved 2003-03-01, from the World Wide Web: http://www.skolverket.se/pdf/lpoe.pdf
- National Agency for Education. (2000). *Syllabuses 2000, Compulsory school* [www]. Retrieved 2003-03-01, from the World Wide Web: http://www.skolverket.se/pdf/english/compsyll.pdf
- NOT. (1997). *Ungdomars attityder till naturvetenskap och teknik. (NOT-häfte nr 9)*. Stockholm: Skolverket och Högskoleverket.
- Patton, Michael Q. (1990). *Qualitatve Evaluation and Research Methods*. London: Sage Publications.
- Ramsden, Judith M. (1998). Mission impossible?: Can anything be done about attitudes to science? *International Journal of Science Education*, 20(2), 125-137.
- Regeringens proposition. (2002:120). Åtta vägar till kunskap- en ny struktur för gymnasieskolan [www]. Regeringen. Retrieved 2003-03-10, from the World Wide Web: http://www.regeringen.se/propositioner/sou/sou2002.htm
- Reiss, Michael. (2000). *Understanding Science Lessons Five years of science teaching*. Buckingham: Open University Press.
- Reuterberg, Sven-Eric; Svensson, Allan; Giota, Joanna, & Stahl, Per-Arne. (1996). *UGU-projektets datainsamling i årskurs 6 våren 1995.* (*Rapport 1996:18*). Göteborgs universitet: Institutionen för pedagogik.
- Riis, Ulla. (1988). *Naturvetenskaplig undervisning i svensk skola huvudresultat från en IEA-undersökning*. Stockholm: Skolöverstyrelsen.
- Roberts, Douglas A. (1988). What Counts as Science Education? In P. Fensham (Ed.), *Development and Dilemmas in Science Education*. London: The Falmer Press.
- Schibeci, Renato A. (1984). Attitudes to Science: an update. *Studies in Science Education*, 11, 26-59.
- Schibeci, Renato A. (1985). Students' attitudes to science: What influences them, and how these influences are investigated. In M. Lehrke & L. Hoffmann & P. L. Gardner (Eds.), *Interests in Science and Technology Education* (pp. 35-48). Kiel: Institute for Science Education (IPN).

- Schiefele, Ulrich; Krapp, Andreas, & Winteler, Adolf. (1992). Interest as a Predictor of Academic Achievment: A Meta-Analysis of Research. In K. A. Renninger & S. Hidi & A. Krapp (Eds.), *The Role of Interest in Learning and Development*. Hillsdale, NJ: Lawrence Erlbaum Assosiates, Publishers.
- Schoultz, Jan. (2000). *Att samtala om/i naturvetenskap. Kommunikation, kontext och artefakt.* Diss., Linköping Studies in Education and Psychology No 67, Institutionen för pedagogik och psykologi, Linköpings universitet.
- Shapiro, Bonnie, & Kirby, David. (1998). An Approach to Consider the Semiotic Messeges of School Science Learning Culture. *Journal of Science Teacher Education*, 9(3), 221-240.
- Shrigley, Robert L. (1990). Attitude and behavior are correlates. *Journal of Research in Science Education*, 27(2), 97-113.
- Simpson, Ronald D.; Koballa Jr., Thomas R.; Oliver, J. Steve, & Crawley III, Frank E. (1994). Research on the Affective Dimension of Science Learning. In D. L. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning* (Vol. 1, pp. 211-234). New York: Macmillan Publishing Company.
- Sjøberg, Svein. (2000a). *Naturvetenskap som allmänbildning en kritisk ämnesdidaktik*. Lund: Studentlitteratur.
- Sjøberg, Svein. (2000b). Science And Scientists: The SAS-study. Cross-cultural evidence and perspective on pupil's interests, experiences and perceptions. Oslo: University of Oslo.
- Sjøberg, Svein. (2002). Science for the children? Report from the Science and Scientists-project. Oslo: University of Oslo.
- Säljö, Roger. (1995). Begreppsbildning som pedagogisk drog. *Utbildning och demokrati*, 1995(2), 21-36.
- von Wright, Georg Henrik. (1971). *Explanation and understanding*. Itaca: Cornell University Press
- Vygotsky, Lev S. (1986). *Thought and Language*. Cambridge, MA: MIT Press (Original publicerat 1934).