Rapporter i didaktik
Nummer 4/Oktober 2007
English version

An Evaluation of How NTA is Helping Schools to Attain the Science Studies Syllabus Goals at the Grade 5 Level

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Summary

This evaluation is based on interviews with 80 students attending Grade 6 in school. The analyses have been conducted quantitatively and processed statistically with regard to how students satisfy the goals of the Science Studies syllabus depending on whether or not teachers have participated in the *Naturvetenskap och teknik för alla* ("Science and Technology for All") program, hereby referred to as NTA. The results show that students who have been attending NTA classes register better results in the interviews than those students who have not experienced NTA. However, some of the results vary in terms of gender.

With regard to the goals concerning the *Scientific Activity*, both girls and boys in NTA classes register results that are at least 50 percent better than those of students who had not participated in NTA. In relation to the goals concerning *Nature and Man*, boys taking part in NTA demonstrate results that are between 60-70 percent higher than those of boys who have not participated in NTA. NTA classes appear to have fewer under-achievers and more over-achievers in comparison with non-NTA classes. However, there do not appear to be any differences between treatments among girls with regard to their knowledge concerning *Nature and Man*.

When it comes to the *Use of Scientific Knowledge* in a non-scientific context, the available data from both sample groups is too limited to permit any acceptable statistical treatment.

There are no significant differences between NTA classes and non-NTA classes with regard to which subject areas are being taught. However, boys in NTA classes appear to remember a significantly higher number of areas than boys in non-NTA classes.

Taken as a whole, the results suggest that although the same subject areas have been studied in both groups, they have been treated with greater depth in NTA classes than in non-NTA classes. The conclusion is that NTA have a significant positive effect on the results of both low- and high achievers. Students' knowledge is significantly higher with NTA. But there are areas where schools would benefit from further help in developing science-based education. Such help relates on the one hand to improving girls' results with regard to goals concerning *Nature and Man*, and, on the other hand, to helping teachers realizing the syllabus goals concerning the *Use of Scientific Knowledge*.

Aims and Background

This evaluation has been made on commission by the board of NTA Development, with the aim of assessing how NTA supports schools in realizing the goals of the Science Studies (biology, physics and chemistry) syllabus at the Grade 5 level. In order to create a reference for the results attained with NTA in the subject Science Studies, a comparison has been made with results in schools where the NTA program has not been used. The evaluation is based on interviews with a total of 80 students in Grade 6. The interviews have been analyzed quantitatively with regard to the students' knowledge in Science Studies. The evaluation has thus been leveled at how much students remember from their education in this subject after their first five years of compulsory nine-year schooling, i.e. the actual curriculum. However, it does not indicate what the teachers have actually taught, i.e. the implemented curriculum. There may be a number of areas in which the students remember very little or nothing at all, even though they have received instruction in these very areas. Of course the specific design of an evaluation affects what the students do remember. Meeting a well-informed adult in an interview context represents a much more common situation when it comes to the use of scientific knowledge in both school and society at large than a paper and pencil test.

Since 1997 the Royal Swedish Academy of Sciences and the Royal Swedish Academy of Engineering Sciences have been collaborating with Swedish municipalities' in the school development program *Naturvetenskap och teknik för alla* (NTA) – Science and Technology for All. Today more than seventy municipalities, a dozen or so independent schools and the Schools for the Deaf and Hard of Hearing participate in the program.

The aim of NTA is to support municipalities in their provision of in-service training for teachers of science and technology related subjects. In the main the program has been concerned with the early years of compulsory schooling (Grades K-6), although in recent years it has begun to expand to higher grades. NTA-based teaching makes use of different thematic units adopting an inquiry based learning approach. At present 15 units are in use for years K-7, e.g. "Floating or Sinking", "The Chemistry of Food" and "The Life Cycle of a Butterfly". One Science Study unit takes up approximately ten weeks of Science Study lessons. Teachers involved in the NTA program have to undergo special training in the unit before they are allowed to use it. In addition, guides for the teacher and for the students and a complete set of materials are available for each unit. The thematic units and the training that NTA offers make it possible for teachers to teach Science Studies even if they have not specialized in the subject or the school is not equipped with necessary Science Studies resources. NTA therefore facilitates the continued education of teachers in Science Studies as part of their everyday teaching in the classroom. Using NTA thus constitutes a development process allowing not only students to learn science, but also allowing teachers to learn and teach the subject on a continuous basis in their day-to-day work. Studying how NTA actually helps teachers to provide students with an improved knowledge of science is therefore of considerable interest. The aim of this evaluation is thus– for the first time – to quantitatively measure what students learn in NTA and compare this with how students otherwise succeed in Science Studies.

The syllabus goals for Grade 5 are written in general terms and they mention a number of areas that students should be acquainted with rather than details of knowledge that students are expected to acquire. Furthermore, a significant number of the goals for Grade 5 consist of so-called “goals to aim for”, which are formulated for use in nine-year compulsory schooling as a whole. In planning this evaluation, the problem of the Science Studies subject being established to such various degrees in schools was discussed, and that this means that schools cover the different subject areas with different emphases. An evaluation based on pre-formulated questions, to be answered with pen and paper, thus risks the introduction of a number of biases, where a comparison between NTA schools and non-NTA schools easily becomes misleading in terms of the choice of subject areas and the problems addressed by the questions. In particular there was a danger that the evaluation would only highlight the areas and problems dealt with in NTA, and that its very formulation would give NTA students an advantage. We have therefore chosen to conduct the assessment by means of interviews, which makes it possible for students to respond in relation to how local schools in various ways have worked with the goals laid down in the syllabus.

The national syllabus for the subject Science Studies contains three categories of goals: 1) concerning *Nature and Man*; 2) concerning the *Scientific Activity*, and 3) concerning the *Use of Scientific Knowledge* (see www.skolverket.se). Knowledge concerning Nature and Man is primarily concerned with the learning of scientific concepts, i.e. what science presently knows about humans, nature and the material world. Knowledge concerning the Scientific Activity mainly deals with knowledge in scientific inquiry and about the nature of science. Knowledge concerning the Use of Scientific Knowledge is mainly related to how science can be used in for example socio-economic and technical issues, or those concerning sustainable development. In this evaluation we mainly study the first two categories of goals, i.e. knowledge concerning Nature and Man and that concerned with Scientific Activity. The reason as to why the goals concerning the Use of Scientific Knowledge have been excluded from further analysis is that during the interviews it became clear that, to all intents and purposes, neither NTA-students nor non-NTA students made significant reference to using scientific knowledge in contexts other than those which were directly scientific. A quantitative comparison is thus not possible, and in this instance we merely note that regardless of whether NTA is used or not, Grade K-5 students learn little concerning the third type of goals.

Methodology

Data Collection and Sampling

The collected data is based on interviews with a total of 80 students from Grade 6 educated in Sweden's nine-year compulsory school system. The students are all around 12 years of age and are divided equally between 20 school classes from five Swedish municipalities. In order to create as broad a representation as possible of the students' socio-economic backgrounds, the choice of municipalities consists of a metropolitan area (Stockholm), a city suburb municipality (Haninge), together with three more sparsely populated municipalities spread over Sweden (Gotland, Falun and Östersund). The municipalities were also selected because they included classes that worked with NTA and those that did not. In each municipality two classes were chosen where students had worked with at least 3 NTA themes and two classes where students had never worked with NTA. These classes were chosen with the aid of the local coordinators in the different municipalities. Only those teachers who gave their consent participated in the evaluation. Four students from every class were interviewed – two boys and two girls. The students were selected alphabetically in that the two girls and two boys whose names came first in the alphabet were interviewed. Both the students and their parents gave their written permission. We were at great pains to ensure that the students as a sample had a broad and varied background and that they constituted as representative a selection as possible of the spread of backgrounds and circumstances for learning Science Studies in Sweden. Careful attention has also been paid to ensuring that there were no systematic differences between the classes – apart from whether they were taught with or without NTA. The interviews were conducted during the academic year 2006/2007 and interviews with NTA classes and non-NTA classes were equally divided during this period of time. All the interview conversations were recorded digitally for later analysis.

All the interviews were conducted by the same person (Per Anderhag) and lasted between 20-60 minutes, depending on how much the students had to say. Each interview was carried out in the same way and consisted of two parts: an introductory and open section and a closing structured section. The introductory part of the interview consisted of questions where the students were asked to talk about the Science Studies teaching they had received. What did they do? What had they learned? The discussion was conducted in narrative form, where the interviewer helped the student in different ways, e.g. by rewording a question if the student had difficulty in remembering something. It is important to note that Science Studies sometimes has to be reformulated to "Biology", "Chemistry", ”Physics", "Nature", or "experiments" in order to fit the different content taught as well as the students' ability to remember at the time of the interview. A typical start to each interview was that the interviewer and the student concerned introduced themselves to each other and the interviewer then asked the student a little about whether (s)he enjoyed school. The first formal interview questions might then be: "Good, now let's talk about Science Studies. Does anything in particular come to mind when you hear the expression Science Studies? What is Science Studies anyway?" and continue with questions like: "Can you tell me a little about what you did in Science Studies in Grade 5? Do you remember?"

The closing part of the interview consisted of a systematic run-through of the 24 areas included in Science Studies teaching in the nine year compulsory school context (see, for example, Figure 2). These areas are of such breadth that they do not only include the attainable objectives for Grade 5, but also the aspiration objectives for nine year compulsory schooling as a whole. In the interviews these areas were described in the kind of language normally used in the teaching of students in the grades K-6. Questions relating to work undertaken in the area *The History of Life* included things like "Dinosaurs – is that something that you've talked about?" Follow-up questions for every area that the students recalled were again related to what they had done and what they had learned, and could be formulated as "What did you find out then?" or "Why do you think that?" It is important to note here that this way of interviewing students does not imply or presuppose that there is only one particular way in which schools can realize the curriculum objectives.

Analysis

All the interviews were analyzed with regard to how many and which of the 24 areas the students had studied. In addition, the students' understanding of the content in the different areas was analyzed in accordance with five variables. These five variables are:

Terms Phenomena: Words that the students use and that represent scientific phenomena, e.g. *friction*, *larva*, *sound waves*, *diet*, *decomposed*, *sodium*.

Terms Artifacts: Words that denote different artifacts, objects, instruments or aids that the students have used in connection with Science Studies classes, e.g. *magnifying glass*, *bug keys*, *glass jar*, *test tube*.

Terms Activities: Words that students use and that describe activities or concepts associated with the conducting of science, e.g. *experiment*, *testing*, *report*, *cross-section*.

Relations Nature and Man: A proposition that relates a scientific phenomenon to something else and thereby gives it scientific continuity, e.g. “the *larva* had turned into a *pupa*”, “a *mountain* and then it falls down and becomes *gravel*”, “there was a *northern pole* on the *magnet*”.

Relations Activities: A proposition that relates a scientific activity to something else and thereby gives it scientific continuity, e.g. ”We *reported* quite a lot, we *wrote down and things like that*” or ”Then we had to *compare* it *by using an insect key like this*”.

These variables reflect the syllabus goal categories *Nature and Man* and *Scientific Activity*. *Relations Nature and Man* and *Relations Activities* directly reflect these categories. We chose three variables for terms. *Terms Artifacts* and *Terms Activities* are directly related to the goals concerning *Scientific Activity*. The former relates more to the actual equipment used and the latter more to the activities directly associated with scientific work. *Terms Phenomena* deal with and are directly related to the goals concerning *Nature and Man*.

Only those terms and relations that the students themselves mentioned were counted. Counting the number of terms and relations provides a statistically comparable measurement between students who have worked with NTA and those who have not, and is a way of measuring what the students have learned in Science Studies. We have not formed any judgments as to whether the relations are correct or incorrect. In actual fact very few of the relations named by the students were apparently incorrect; they instead represented the students attempts to reason with the interviewer about a certain relationship, often by making use of various everyday terms. There is no distinct line between what is correct or incorrect here; it is rather to do with the students’ initial attempts to argue in a scientific manner. In the context of this evaluation we consider that such arguments ought not to be depreciated. On the contrary, our view is that such learning should be encouraged. One example is:

> So we talked about hearing coming in through the ear, then passing to the eardrum which was vibrating in there and how then converted by the nerves, I think it was, to the brain which then understands it as hearing.

In such a case questioning whether the student has understood hearing according to established physiological knowledge, i.e. whether hearing actually comes in through the ear, and whether the nerves are directly connected to the eardrum, etc., seems rather pointless.

Here we see a student trying to explain hearing's basic scientific principles and who has a good foundation from which to build further.

The analysis is thus based on what the students actually remember from the teaching they have received (the actual curriculum). This takes its departure in a quantification of the number of terms and relations that they are able to communicate to the interviewer. It is also important to remember that this evaluation is based on research on students' learning processes (Wickman & Östman, 2002; Wickman, 2002) rather than on a set of predetermined assumptions as to which test questions the students should be able to answer at a certain age. Neither does it take it for granted that students ought to have learned certain specific relationships when entering Grade 6; something that does not have any support in the flexibly formulated steering documents. The method makes it possible to quantitatively measure what can be statistically established with regard to what the students have actually learned in Science Studies by the time they reach Grade 6. This knowledge is not only a response to pre-formulated questions, but a measurement of the knowledge that the students can communicate in a discussion with a well-informed adult; an objective that aligns with the continued use of such knowledge both in school and in society at large. In this way the evaluation has validity when it comes to the students' communicative ability in Science Studies that goes beyond responding to a set of pre-prepared questions. Studies have also shown that the students' ability to answer test questions increases considerably if they have an opportunity to discuss the content and context of the questions with the person constructing the questions (Schoultz, 2002; Säljö, 2005). Particular care was given to this during the interviews in that the students were given ample opportunity to talk about what they had experienced in the classroom and what that meant to them. Similarly, the interviewer could reformulate the questions if the students didn't understand (Kvale, 1997).

Differences in the outcome of the variables have been calculated by means of t-tests in the program *Statistical Package for the Social Sciences* (*SPSS Base 15.0*) and account has been taken of those cases where the variances differ. A significance level of 5 percent was used in all the cases, and all the tests were two-tailed. Those distributions that differed significantly from normal were tested by using the Mann-Whitney U-test. The significance level didn't change in any of the cases, which is why – for the sake of simplicity – only the significance values from the t-tests are presented. We have thus chosen to regard students from the same class as independent observations in order to simplify the analysis.[1]

[1] It should be pointed out that even though the students are now in the same class it may be the case that they changed classes at an earlier grade.

Results

The Significance of NTA Independent of Gender

Both Table 1 and Figure 1 are compilations of the interview results of students who have been taught Science Studies with the NTA program and those who have not. Significant differences can be noted with regard to the number of *Terms Artifacts*, the number of *Terms Activities*

Table 1. *Comparison of the number of terms, relations and subject areas that students (both boys and girls) who have experienced NTA and those who have not experienced NTA mentioned during the interviews.*

Variable	NTA/Non-NTA	Mean	Significance
Terms Phenomena	NTA	41.6	^{NS}0.057
	Non-NTA	32.0	
Terms Artifacts	NTA	29.8	*0.019
	Non-NTA	23.5	
Terms Activities	NTA	7.4	***0.000
	Non-NTA	4.7	
Relations Nature and Man	NTA	40.4	^{NS}0.057
	Non-NTA	32.6	
Relations Activities	NTA	18.8	***0.000
	Non-NTA	11.1	
Subject Areas	NTA	14.9	^{NS}0.120
	Non-NTA	13.5	

The figures in the right-hand column indicate the probability (P-value) of the observed difference between means with the hypothesis that the two means are equal. ^{NS}Not statistically significant difference with $P>0.05$; *statistically significant difference with $0.01<P\leq0.05$; **statistically significant difference with $0.001<P\leq0.01$; *** statistically significant difference with $P\leq0.001$

and the number of *Relations Activities.* Students who have experienced NTA have statistically significantly better results concerning these variables. Differences are considerable and are particular high when it comes to *Terms Activities* and *Relations Activities*. On average NTA students use 57 percent more *Terms Activities* and 69 percent more *Relations Activities* than students who have not experienced NTA. When it comes to *Terms Artifacts* the result is 27 percent higher for those with NTA than for those without. With regard to the other variables, the tendency is towards better results for NTA students, although here the differences are not statistically significant. In terms of all the variables, the tendency is that the number of students with very low results diminishes, while the number of students with very high results increases with NTA. This suggests that NTA has the potential to raise the results in Science Studies teaching for both high- and low achievers.

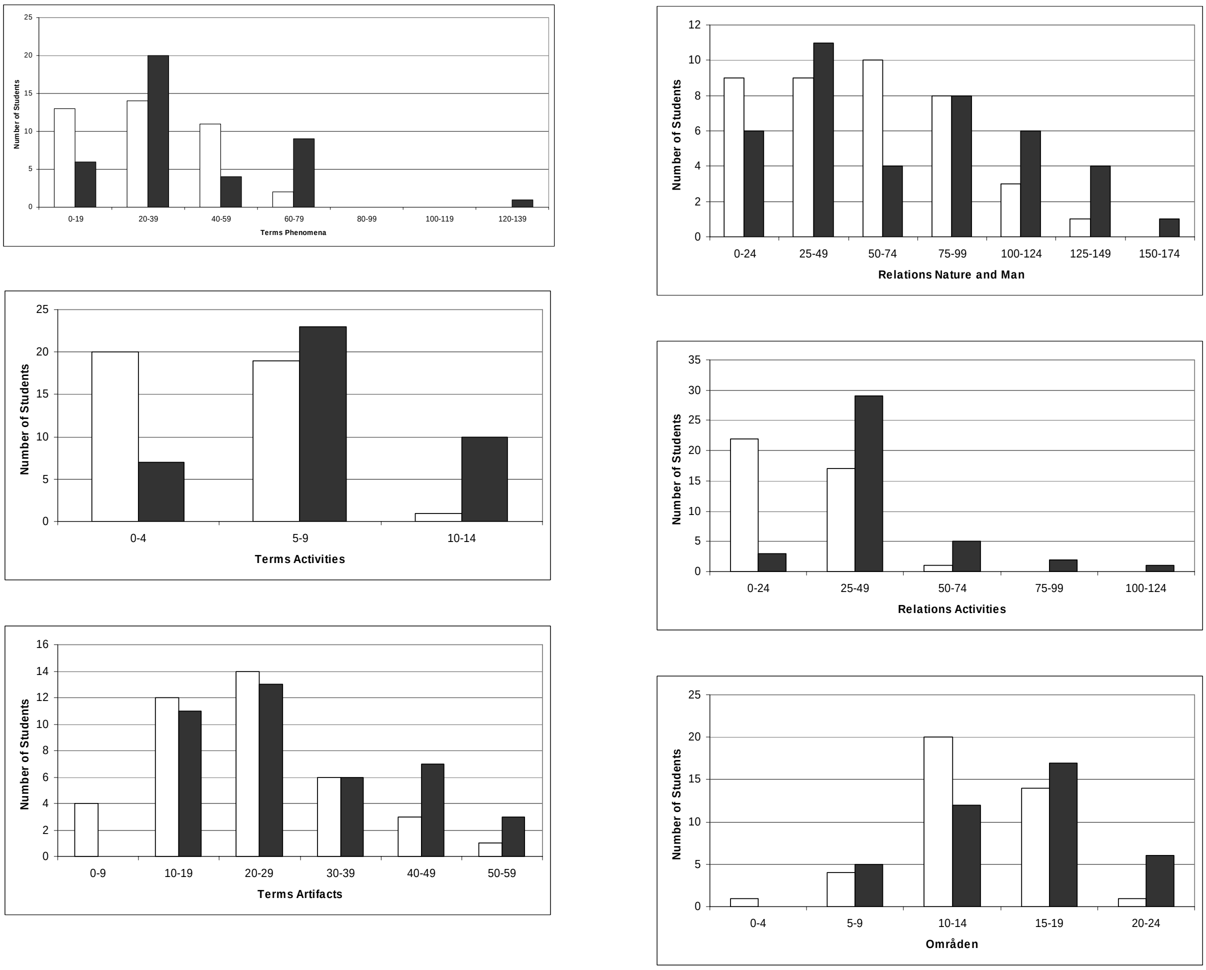

Figure 1. *The number of terms, relations and subject areas that non-NTA (white columns) and NTA (black columns) students mentioned during the interviews. The material takes account of* all students, *irrespective of gender.*

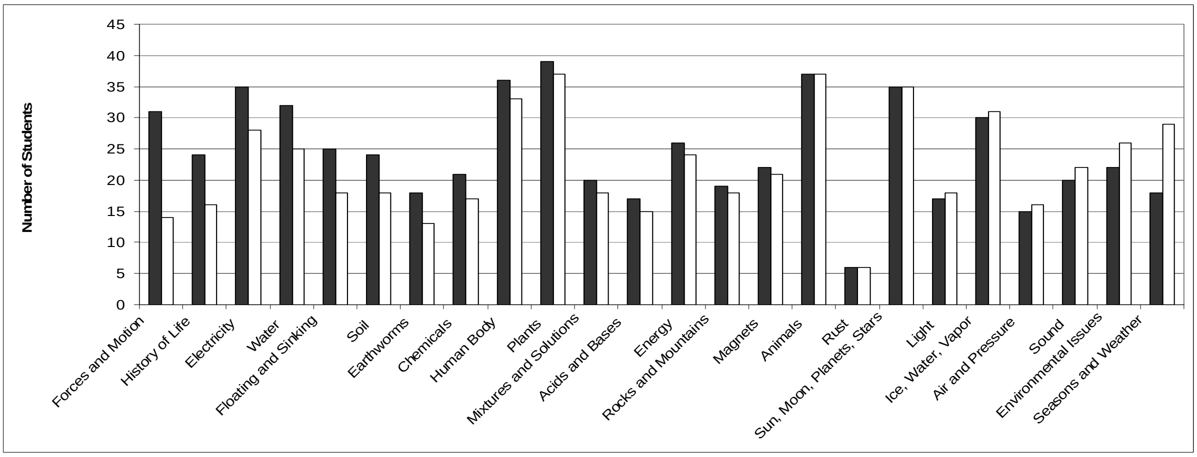

Figure 2. *Comparison of the subject areas that students from non-NTA classes (white columns) and students from NTA classes (black columns) remembered from what they had been taught. The material takes account of* all students *irrespective of gender. The subject areas are ranked from left to right according to the differences between NTA students and non-NTA students (the number of NTA students minus the number of non-NTA students who remember having been taught in that subject area).*

Figure 2 is a compilation of the subject areas that the students remembered having been taught in. It is clear that there are few systematic differences in the areas dealt with in an NTA context in comparison with those dealt with in non-NTA contexts. It is not possible to statistically demonstrate that certain areas are dealt with more often with NTA than without NTA and vice versa (χ^2=6.64, d.f. 23, P>0.05). The tendency is that NTA to a greater extent make use of areas within physics than without NTA – primarily the area *Forces and Motion* but also the areas *Electricity*, *Water* and *Float and Sink.* Surprisingly, students who had participated in NTA mentioned *History of Life* more often, despite this not being specifically dealt with as an NTA unit. The area more often dealt with in classes where NTA is not used is *Seasons and Weather*. However, as has already been mentioned, none of these differences can be supported statistically.

Differences between Girls and Boys

Table 2, Figure 3 and Figure 4 show the number of terms, relations and subject areas that girls and boys mentioned during the interviews according to whether they had experienced NTA or not. Concerning two of the variables there are statistically significant differences between girls and boys who have participated in NTA (Table 2). The boys have a significantly higher mean concerning the two variables that are related to a conceptual understanding of scientific results. The boys' mean values are approximately 50–60 percent higher for the variables *Terms Phenomena* and *Relations Nature and Man*.

Table 2. *Comparison of the number of terms, relations and subject areas that girls and boys mentioned during the interviews. Comparisons of NTA students and non-NTA students have been conducted separately.*

Variable	NTA/Non-NTA	Mean Girls	Mean Boys	Significance
Terms Phenomena	NTA	32.5	50.8	*0.027
	Non-NTA	34.4	29.5	^{NS}0.372
Terms Artifacts	NTA	26.2	33.4	^{NS}0.108
	Non-NTA	25.2	21,8	^{NS}0.325
Terms Activities	NTA	7.2	7.6	^{NS}0.332
	Non-NTA	4.8	4.6	^{NS}0.776
Relations Nature and Man	NTA	57.0	86.8	*0.05
	Non-NTA	59.3	52.8	^{NS}0.532
Relations Activities	NTA	44.6	39.0	^{NS}0.501
	Non-NTA	27.7	22.4	^{NS}0.137
Subject Areas	NTA	13.7	16.0	^{NS}0.314
	Non-NTA	13.8	13.2	^{NS}0.643

See Table 1 for an explanation of the right-hand column.

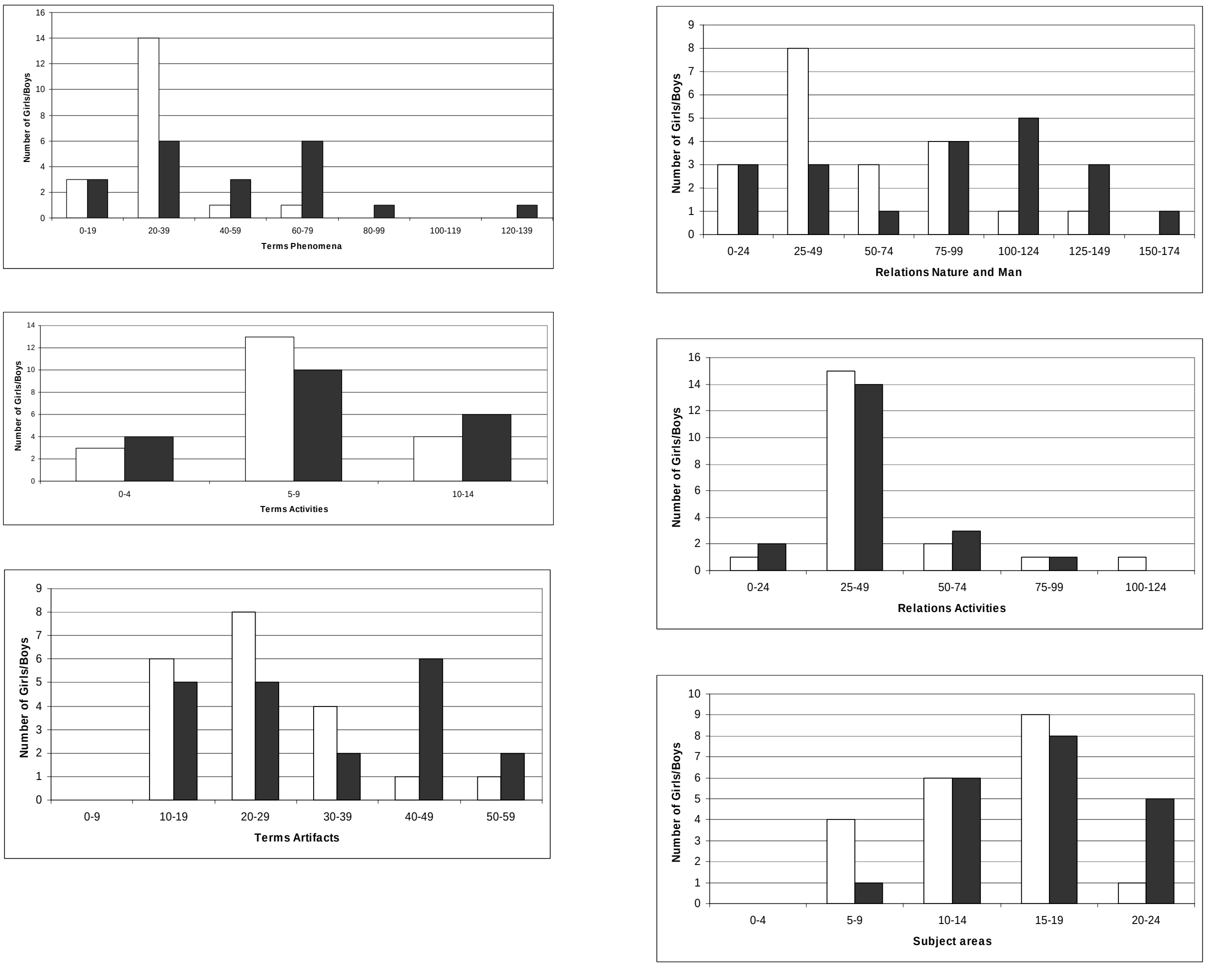

Figure 3. *The number of terms, relations and subject areas that girls (white columns) and boys (black columns) who participated in NTA mentioned during the interviews.*

There are no significant differences in any of the variables between girls and boys in classes where NTA has not been used. In terms of gender, the results are more equal in those classes that have not participated in NTA than in those that have participated in NTA. This difference is primarily due to the fact that in NTA the boys score much higher than the girls when it comes to the variables *Terms Phenomena* and *Relations Nature and Man*.

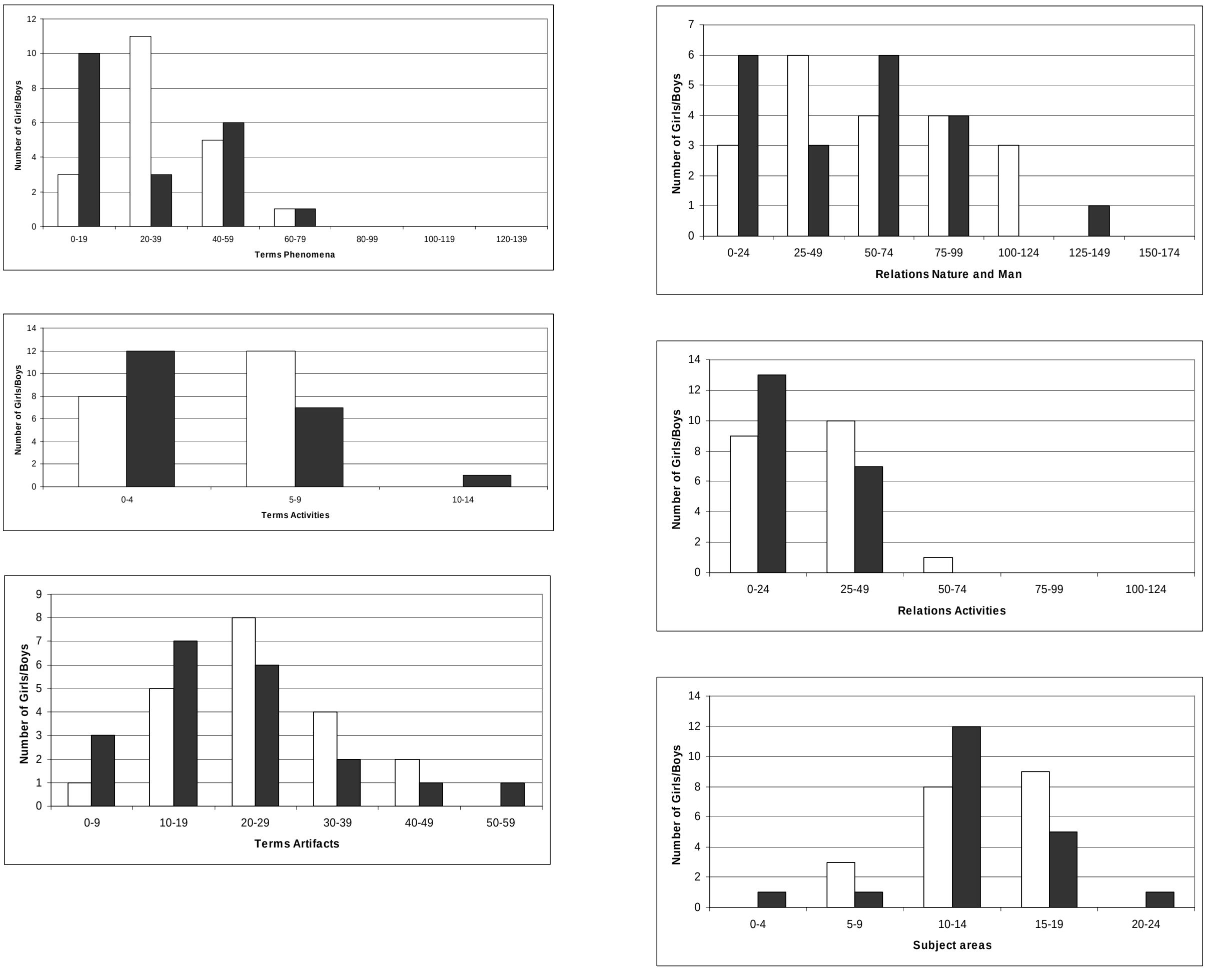

Figure 4. *The number of terms, relations and subject areas that girls (white columns) and boys (black columns)* who have not participated *in NTA mentioned during the interviews.*

Figures 5 and 6 are compilations of the areas that girls and boys, respectively, remember having been taught in, depending on whether or not they had been taught with or without NTA. Even though the tendency is that certain areas are more common in NTA, and especially among boys who have been taught with NTA, there are no statistically significant differences between the genders for those students taught with NTA (χ^2=7.58, d.f. 23, P>0.05) or without NTA (χ^2=3.72, d.f. 23, P>0.05).

In view of the fact that there are differences between girls and boys when they have been taught with NTA, and especially with regard to *Terms Phenomena* and *Relations Nature and Man*, there is reason to look more closely at the separate effects NTA has on boys and on girls.

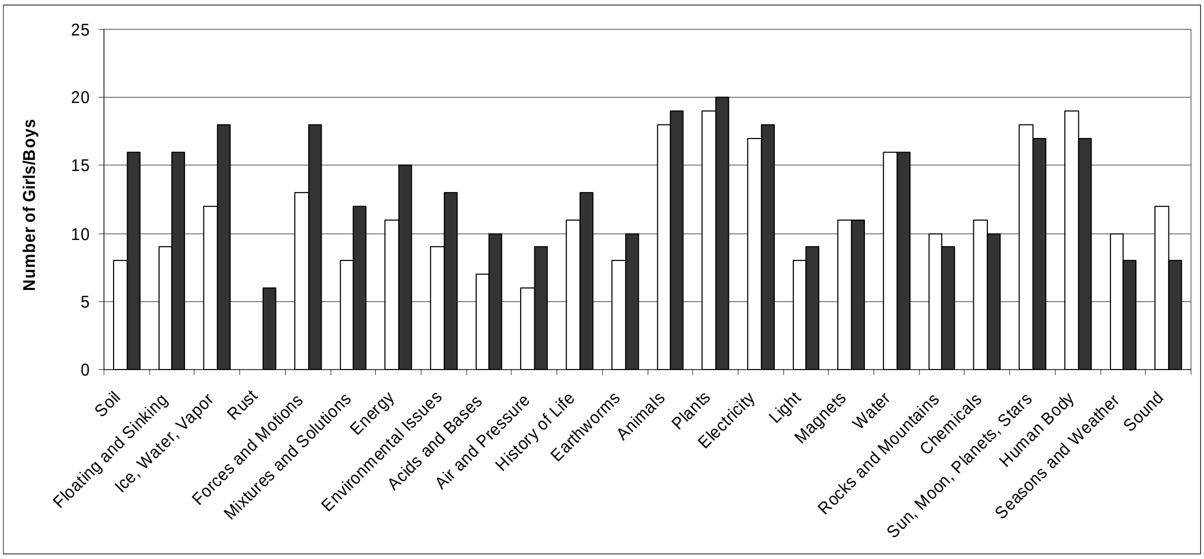

Figure 5. *Comparison of the subject areas that girls (white columns) and boys (black columns) remember having been taught in. The material only includes those students who* took part *in NTA. The subject areas are ranked from left to right according to the differences between girls and boys (the number of subject areas girls minus the number of subject areas boys).*

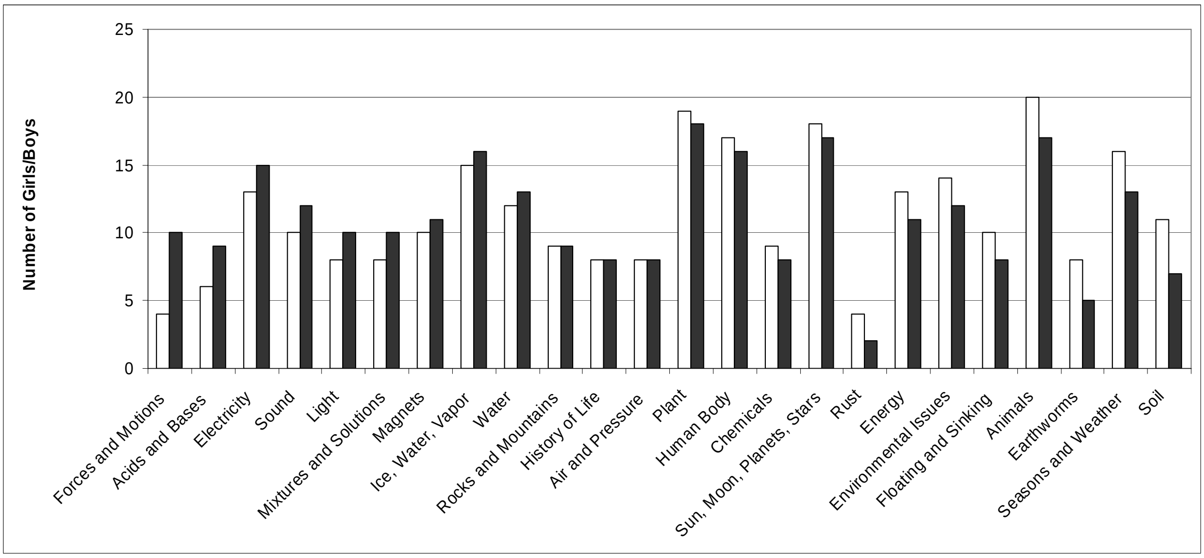

Figure 6. *Comparison of the subject areas that girls (white columns) and boys (black columns) remember having been taught in. The material only includes those students who have* not participated *in NTA. The subject areas are ranked from left to right according to the differences between girls and boys (the number of subject areas girls minus the number of subject areas boys).*

The Importance of NTA for Girls

A comparison of the number of terms, relations and subject areas mentioned by girls who have been taught or have not been taught with NTA, respectively, can be found in Table 3 and Figure 7. There are statistically significant differences with regard to the number of *Terms Activities* and the number of *Relations Activities.* The differences are considerable. On average, girls who have been taught with NTA use 50 percent more *Terms Activities* and 61 percent more *Relations Activities* than girls who have not been taught with NTA. There is a clear shift here in that when NTA is used the number of low-achieving girls diminishes and the number of high-achieving girls increases quite dramatically. In the other variables the differences are non-significant statistically, and there are no significant differences between girls taught with NTA and those who have not been taught with NTA.

Figure 8 illustrates the subject areas that girls who have participated in NTA and those who haven't taken part in NTA remember that they have been taught in. There are no statistically significant differences between the groups (χ^2=7.44, d.f. 23, P>0.05). There is a possible tendency for girls who have participated in NTA to mention certain physics-related subject areas more often, while girls who have not taken part in NTA discuss *Environmental Issues* and *Seasons and Weather* more often. But the differences are small, apart from when it comes to *Forces and Movements*. However, it has not been possible to establish these tendencies statistically.

Table 3. *Comparison of the number of terms, relations and subject areas that girls who were taught with NTA and those not taught with NTA mentioned during the interviews.*

Variable	NTA/Non-NTA	Mean	Significance
Terms Phenomena	NTA	32,5	^{NS}0.726
	Non-NTA	34,5	
Terms Artifacts	NTA	26,2	^{NS}0.753
	Non-NTA	25,2	
Terms Activities	NTA	7,2	***0.000
	Non-NTA	4,8	
Relations Nature and Man	NTA	57,0	^{NS}0.815
	Non-NTA	59,3	
Relations Activities	NTA	44,6	**0.004
	Non-NTA	27,7	
Subject Areas	NTA	13,7	^{NS}0.931
	Non-NTA	13,8	

See Table 1 for an explanation of the right-hand column.

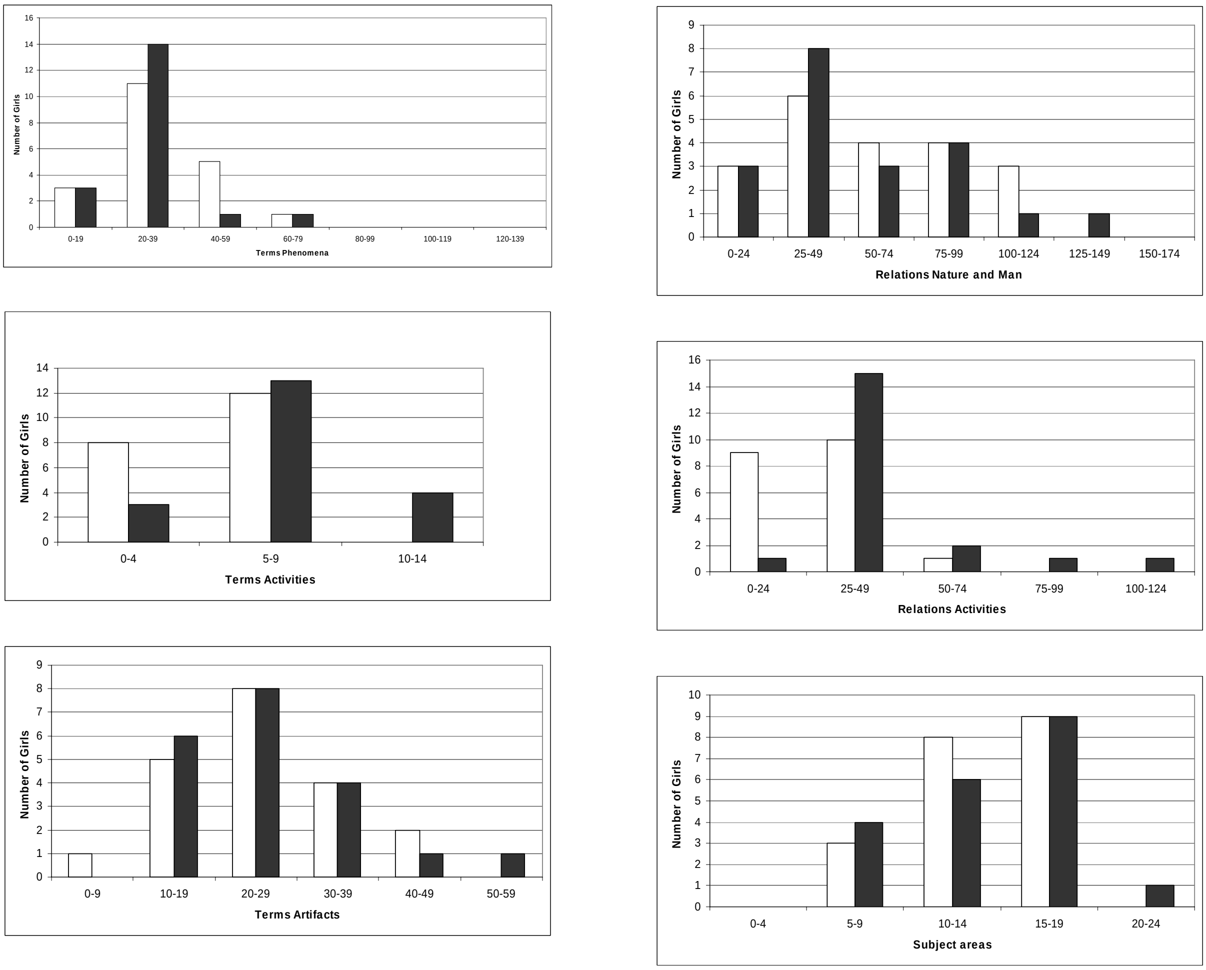

Figure 7. *The number of terms, relations and subject areas that non-NTA students (white columns) and NTA students (black columns) mentioned during the interviews. The material only relates to* girls.

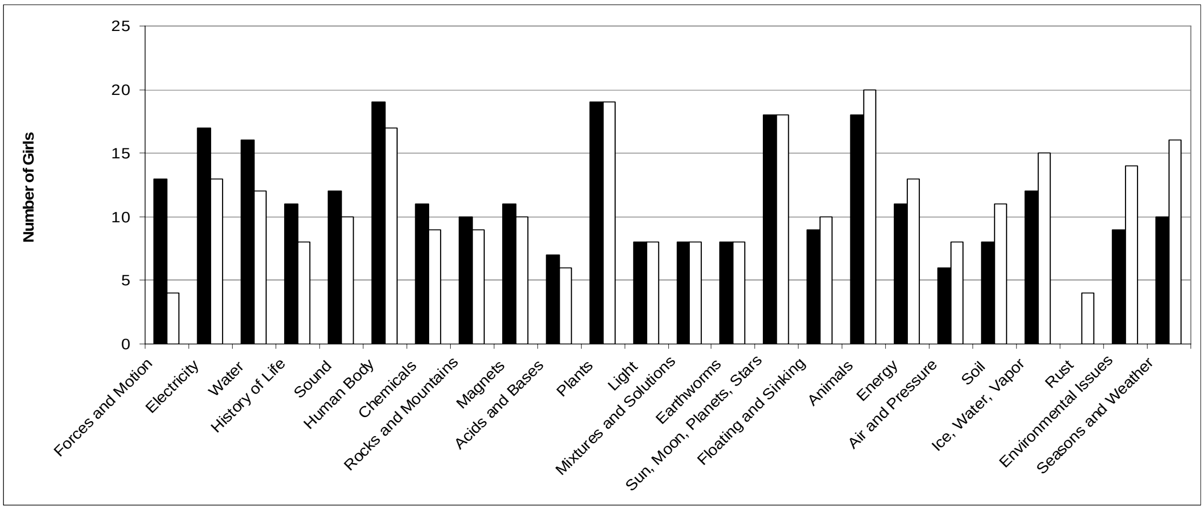

Figure 8. *Comparison of the subject areas that* girls *from non-NTA classes (white columns) and* girls *from NTA classes (black columns) remember that they have been taught in. The subject areas are ranked from left to right according to differences between NTA students and non-NTA students (the number of girls NTA minus the number of girls non-NTA who remember that they were taught in the subject area).*

The Importance of NTA for Boys

Table 4 and Figure 9 compare the number of terms, relations and subject areas mentioned by boys who have been taught with NTA and without NTA, respectively. Statistically speaking, boys who have participated in NTA perform significantly better for all the variables in comparison with the boys who have not taken part in NTA. With regard to those variables that are more conceptually oriented towards scientific results, i.e. *Terms Phenomena* and *Relations Nature and Man*, the differences are considerable. On average, boys who have participated in NTA make 70 percent more use of *Terms Phenomena* and approximately 60 percent more use of *Relations Nature and Man* than those boys who have not taken part in NTA. When it comes to *Terms Artifacts*, *Terms Activities* and *Relations Activities,* NTA participation indicates a similar increased weighting, namely, 53 percent, 65 percent and 74 percent respectively.

The number of subject areas is also significantly higher in NTA. While the difference with regard to this variable is lower, on average boys who have participated in NTA remember 21 percent more areas than boys who have not taken part in NTA. Figure 10 indicates those areas that boys who have participated in NTA or alternatively not participated in NTA remember having been taught in. There are no significant differences between the groups (χ^2=5.81, d.f. 23, P>0.05). It is thus difficult to discern any tendency with regard to which specific subject areas that boys who have participated in NTA remember better.

Table 4. *Comparison of the number of terms, relations and subject areas that boys who have been taught with NTA or without NTA mentioned during the interviews.*

Variable	NTA/Non-NTA	Mean	Significance
Terms Phenomena	NTA	50.8	*0.012
	Non-NTA	29.5	
Terms Artifacts	NTA	33.4	**0.006
	Non-NTA	21.8	
Terms Activities	NTA	7.6	***0.001
	Non-NTA	4.6	
Relations Nature and Man	NTA	86.8	**0.009
	Non-NTA	52.8	
Relations Activities	NTA	39.0	***0.000
	Non-NTA	22.4	
Subject Areas	NTA	16.0	*0.032
	Non-NTA	13.2	

See Table 1 for an explanation of the right-hand column.

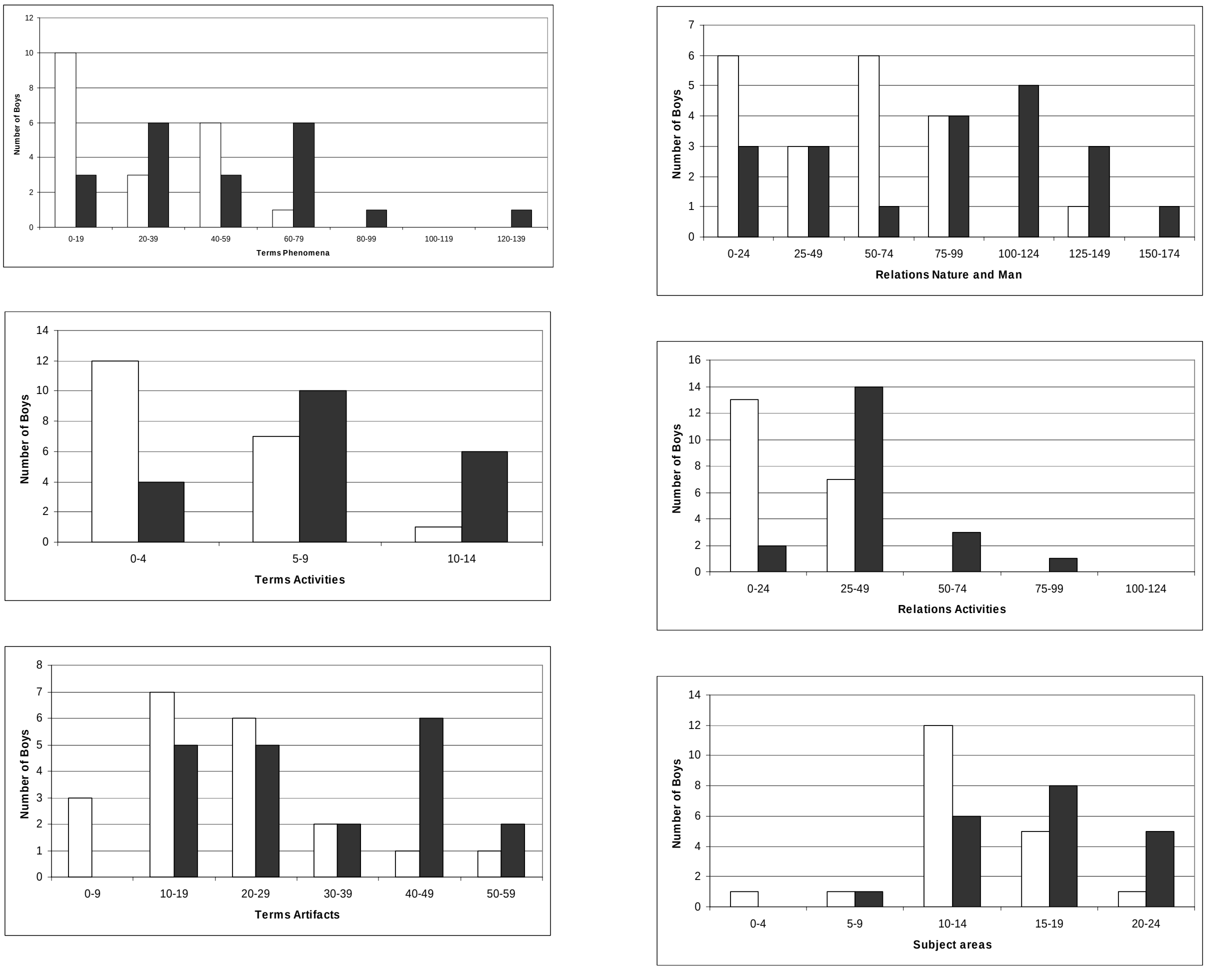

Figure 9. *The number of terms, relations and subject areas that non-NTA students (white columns) and NTA students (black columns) mentioned during the interviews. The material only relates to* boys.

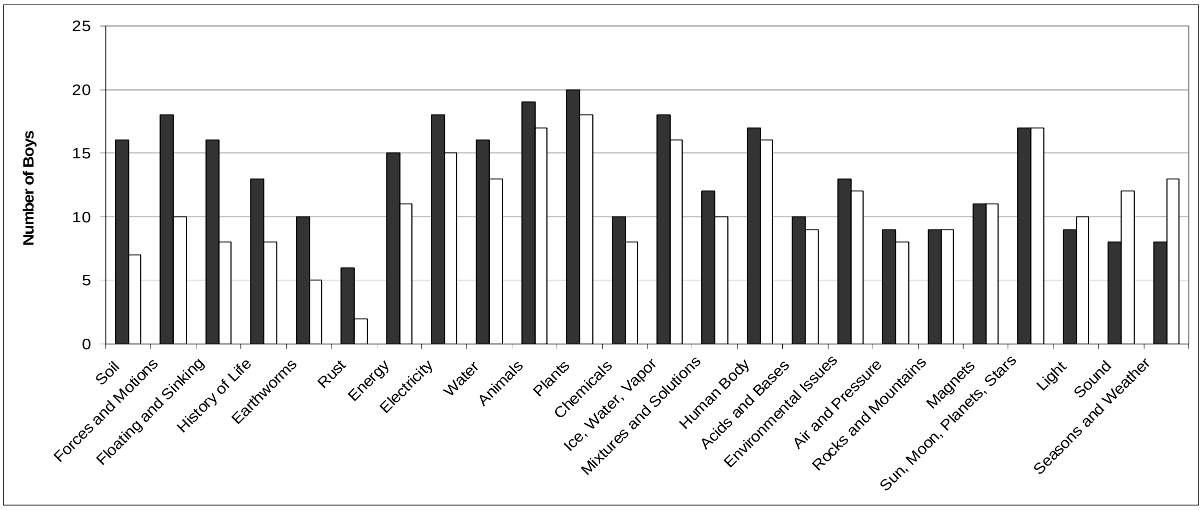

Figure 10. *Comparison of the subject areas that* boys *from non-NTA classes (white columns) and* boys *from NTA classes (black columns) remember that they have been taught in. The subject areas are ranked from left to right according to the differences between NTA students and non-NTA students (the number of boys NTA minus the number of boys non-NTA who remember that they have been taught in the subject area).*

Summary

There are certain differences between students who have been taught with NTA in comparison to those without NTA when it comes to the number of subject areas they remember. There is a slight increase for the boys in NTA, but no difference in the case of the girls. However, there are significant differences in what the students learn with and without NTA. As the subject areas covered are not markedly different, the higher values for NTA in terms of what the students learn must be primarily explained by the fact that NTA deals with certain areas in greater depth.

The most obviously positive effect with NTA is to be found in what the students learn about scientific activities. Significantly higher values for NTA are to be found for girls as well as boys. On average the results are 50–74 percent higher with NTA; something that must be regarded as decisive in comparison with the relatively minor differences that are usually noted between countries in studies like TIMSS or PISA. For example, Singapore, which performed best in TIMSS in 2003 (http://timss.bc.edu/timss2003.html), had only a 10 percent higher "Science Achievement Average Scale Score" when compared with Sweden.

With regard to learning that is more oriented towards a conceptual understanding of the results of science, i.e. syllabus goals concerning *Nature and Man*, there are considerable differences between girls and boys. In the case of the boys, participation in NTA leads to a considerably better average result than if they hadn't taken part in NTA. The difference of 60–70 percent is just as dramatic when it comes to scientific activities. In the case of the girls, there is little difference between NTA participation and non-NTA participation in the results concerning *Nature and Man*. The differences are insignificant. The differences in the results regarding NTA between girls and boys are statistically significant for these variables. Similarly, the better result for boys is also considerable in *Terms Artifacts*, while no effect can be determined for the girls.

The significant differences found do not only imply that the number of students who perform less well during the interviews is lower with NTA than without. The number of high-achievers is also greater with NTA.

Conclusions

The main conclusion of this evaluation is that, on average, those students taught with NTA learn more than those who have not taken part in NTA. This is the case for both girls and boys. Students in classes that have not been taught with NTA did not perform significantly better in any of the measured variables. Considering the extent of the differences and the fact that the result was higher for both low-achievers and high-achievers, there is reason to conclude that in general NTA helps teachers to teach Science Studies with a view to realizing the syllabus goals set for nine-year compulsory schooling. The overall improvement in the results suggests that this not only relates to all the basic goals for all students at the grade 5 level, but also to the goals to aim for nine-year compulsory schooling as a whole.

In the case of boys the results in NTA are better concerning all the variables, which suggest that in this case NTA helps teachers in their work with two of the three goal categories for nine-year compulsory schooling. Girls in NTA have significantly better results only when it comes to knowledge relating to scientific activities, whereas there is no difference at all for knowledge relating to scientific results. Thus, even though NTA has a positive effect on girls, the gaps between girls' and boys' learning are more marked with NTA than without.

This evaluation is summative and does not set out to study the reasons for the resulting differences between students who have participated in NTA and those who have not. However, it is clear that teachers in NTA do not have the same opportunities to teach girls about scientific results as they have with boys. The reason for this could be that while teachers using NTA learn a teaching method that deals with Science Studies, they are not afforded to learn the conceptual content to the same degree. One reason for the existence of NTA is that many teachers' have themselves received limited education in science and how to teach Science Studies. Although in many respects NTA helps to overcome the latter problem, the former problem remains. Earlier studies have shown that to a great extent teachers discuss what *happens* with children, but do not spend much time discussing what happens might mean in terms of how one conceptually *understands* nature. One hypothesis is that girls – to a lesser extent than boys – talk about scientific interpretations with each other based on different practices and interests at home. Similar differences in interests between girls and boys have been demonstrated in extensive studies (Schreiner, 2006). Girls thus ought to find it more difficult to relate what happens to scientific concepts. In this case girls would appear to have a greater need than boys to have such a discussion at school, with other students and above all with the teacher (cf. Brickhouse, 2001). This is something that needs to be studied in more depth and, in accordance with the National steering documents, NTA ought to aim towards giving girls the same opportunities as boys to learn Science Studies. This has to be one of the important challenges facing NTA in the future. A previous evaluation has shown that girls as well as boys enjoy working with NTA (Anderhag & Wickman, 2006). Hence, t is difficult to imagine that a difference in attitude to NTA is the reason for the difference between girls and boys. Another important challenge should also be to put more emphasis on helping teachers to deal with issues relating to the use of scientific knowledge in contexts other than just the subject of science, particularly in relation to societal issues and decision making.

Considering that there are few systematic differences between NTA classes and non-NTA classes with regard to which subject areas are dealt with, and that boys remember somewhat more areas with NTA, the conclusion must be that NTA does not squeeze other areas out. In general, classes that use NTA deal with the same subject areas, although in many cases they do so in more depth and with better results.

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