# Examining Changing Attitudes in Secondary School Science

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**Abstract**

This study, carried out in England, examined the variation of attitudes towards science over the first three years of secondary schooling and with gender. The study in question was part of an evaluation of the Lab in a Lorry project, and involved 932 pupils completing a pre-measure questionnaire containing items looking at six separate attitude constructs. From this data, two main patterns emerged; pupils' attitudes towards science declined as they progressed through secondary school, and this decline was more pronounced for female pupils. These conclusions are largely in agreement with previous studies in this field. However, in examining separate attitude constructs, we were also able to identify that the sharpest decline occurred specifically for pupils' attitude towards learning science in school. Furthermore, using linear regression, we identified that as pupils progress through school, this construct becomes a greater influence on attitudes towards future participation in science. Therefore, we also concluded that learning science in school is a particular area that needs to be concentrated upon, if we are to improve children's attitudes towards science. In the final part of the paper, we drew on interview data obtained from 44 pupils involved in the Lab in a Lorry study. Pupils' comments in these interviews provided further insight into why pupils are 'switched off' by school science. We drew out the most prevalent themes that emerged in the interviews, in order to provide further insight into why pupils do not enjoy science in school.

## Introduction

Attitudes towards science and science teaching are issues with long standing attention and interest in science education research. A concern for many countries is the falling numbers of students choosing to pursue the study of science, alongside the increasing recognition of the importance and economic utility of scientific knowledge. In the particular case of England and Wales, we have experienced a 41% fall in numbers going on to study Advanced level physics between 1985 and 2006 (AQA, 2006). This has caused concern for the future supply of qualified persons for UK industry and specialist physics teachers for schools and colleges. The situation calls for researchers to engage with the problem, in order to understand its underlying mechanisms and to find ways to improve it.

The current paper offers a study of attitude development during the first years of secondary schooling in England (Years 7 to 9)[1]. These are crucial years when adolescents form interests and attitudes affecting choices for further education. In order to focus on attitude development, we examine the 'magnitude' of attitude measures and compare them across year groups using the same scales. The study has also made an effort to be precise about the concept of attitudes, which has been much discussed in science education research literature (Bennett, 2001; Francis and Greer, 1999; Gardner, 1996; German, 1988; Osborne *et al*. 2003; Reid, 2006). In a previous paper (Kind *et al.*, 2007), we presented a validation of attitude measures based on six different constructs, developed to evaluate the impact of the 'Lab in a Lorry' initiative developed by the Institute of Physics and the Schlumberger Foundation. In the present paper, we will present findings from the main study of this evaluation using these same measures. The issue we examine here is not how Lab in a Lorry affected students' attitudes but how attitudes change among males and females during the lower secondary years. In particular, the main research questions that we seek to address in the present study are:

- How do attitudes toward science vary as students progress through the lower secondary years in English schools?
- How do attitudes towards science vary with gender in these schools?
- What factors impact on these students' attitudes towards science?

In addition, drawing on our findings from the attitude measures, we wish to put forward suggestions for improvements in secondary school science, in order to try to bring about more positive attitudes. To provide further evidence to support this discussion, we will also draw briefly on findings from interviews carried out with pupils involved in the Lab in a Lorry project. Comments made by pupils referred to their general experience of learning science. Alongside the quantitative attitude measures therefore, we will use this qualitative data to gain insight into problems affecting pupils' attitudes towards science.

## Theoretical framework and literature review

*Defining attitudes*

Attitude can be defined as the feelings that a person has about an object, based on his or her knowledge and belief about that object (Kind *et al*., 2007). This definition is made based on the model that attitudes include the three components of cognition, affect and behaviour (Rajecki, 1990; Bagozzi and Burnkrant, 1979; McGuire, 1985). A person has knowledge and beliefs about objects which give rise to feelings about them, and these two components together may lead the person to take certain actions. The 'objects' can be of any nature and type, and are in this paper restricted to various aspects of experiencing science. It is important to note that attitudes differ from general affects, i.e. moods and emotions. Even if these factors interact with attitudes (Wilson, Lindset and Schooler, 2000), attitudes themselves are best thought of as evaluative judgement formed by the person (Ajzen, 2001; Crano and Prislin, 2006).

[1] These are the first three years of secondary schooling in England, with pupils aged from 11 to 14.

Attitude research in science education has focused on a range of aspects (Osborne *et al.*, 2003). A useful distinction is often made between "attitude towards science" and "scientific attitudes" (Gardner, 1975). The latter involves important attitudes or mindsets for working and thinking in a scientific way, and is not considered in the present paper. The former is often treated as one concept, but includes many dimensions depending on different meanings of "science" and in which contexts these occur. For example, attitudes may be very different towards school science and real science. Such differences indicate that attitude measures should be very explicit about what aspects, or attitude objects, they measure. However, Munby (1982, 1997) and Gardner (1995, 1996) have identified this as a weakness in research on attitudes towards science, and have called for better statistical validation of the attitude constructs. Kind *et al*. (2007) attempted to meet this critique by developing a set of attitude constructs that satisfied basic psychometric criteria for measurements in social research. The study in question developed measures for the following attitude constructs:

- Learning science in school,
- Practical work in science,
- Science outside of school,
- Importance of science,
- Self-concept in science,
- Future participation in science.

*Findings in attitude research*

Findings in attitudes towards science research are difficult to compare across studies, due to the lack of standardised definitions and measurement instruments. Although there are commonly used instruments such as the Test of Science Related Attitudes (TOSRA) questionnaire (Fraser, 1981), problems can be identified with different instruments (Kind *et al*., 2007), and we also have the difficulty that different instrument try and measure different aspects of attitudes towards science. The research may be analogous to the fable about the blind men and the elephant: the picture looks distorted because researchers touch different parts of the phenomenon and nobody holds a view of the whole. To try and take a more broader view, Table 1 summarises some relevant findings from some of the studies that we have examined. The findings are grouped into two main categories: generally on attitude development and more specifically on gender differences. We have not made any attempt to specify how or what aspects of attitudes have been measured, as this information would have made the table too complicated to read. Two contexts, however, are taken into consideration; the country where the research was conducted and what age level (primary or secondary) the research focused on.

[Insert Table 1 about here]

Two patterns stand out as possible conclusions from the research. The first is the steady decline in students' attitude towards science over time. This decline is particularly emphasised for pupils in secondary schooling. The second finding is the differences between boys and girls, with boys generally being more positive and with a less negative trend in their development of attitudes. Both conclusions, however, have to be carefully examined. First of all, studies have found that it is in fact attitudes towards school science that decline, while attitudes towards real science and the usefulness of science remain much more stable (Schibeci, 1984; Osborne *et al.*, 2003). Secondly, it is often very difficult to ascertain from studies whether attitudes towards science differ from other school subjects. Some studies which have investigated this directly have found attitudes relatively similar among different subjects (Hendley, Stables and Stables, 1996) while others report a more rapid decline in science than other subjects (Choppin, 1974). Thirdly, it is also very difficult to tell how negative or positive students are in the various studies. This problem goes back to the measurement problems mentioned earlier, but it also seems that studies are more likely to report negative results. As Osborne *et al.* (2003) ask, should 3.26 on a five-step Likert scale be weighted positively or negatively?

Finally, the attitude research shows contradictory results, as both main trends identified in Table 1 are challenged by some of the studies included in the table. This may be due to the nature of the attitudes themselves (the studies simply have measured different attitudes), the validity of the research instruments (the same attitudes have been measured, but some instruments have poor validity), or the contexts in which attitudes have been measured (attitudes may develop differently in different contexts). The studies reported in Table 1 are, with one exception, taken from the US and UK. This is done on purpose as the picture would have been much more complicated in a wider international scale. Studies in Papua New Guinea (Maddock, 1982, 1983), for example, report a positive trend in students' attitudes toward learning science. However, this result has little meaning without a more in-depth study of the culture in which the study is set. A further demonstration of this is found in the international study TIMSS (Martin *et al*., 2004), in which it was found that the four countries with the lowest percentages of students with high self-confidence in science – Chinese Taipei, Hong SAR, Japan and Korea - are the countries with the highest science achievement scores. Asking these Asian students about how well they think they do in science is obviously very different from asking the corresponding European students. Asking students how well they like school science similarly reveals a clear pattern that students in developing countries are most positive, Western developed countries form a mid-group and the top achieving Asian countries have the least positive students (*Martin et al*., 2004). There are exceptions to this, but both the exceptions and the general pattern illustrate the danger of making simple conclusions on students' attitudes. However, an interesting perspective that has come out of the international comparisons is found in Schreiner and Sjøberg (2006). They focus on students' 'identity construction', which they claim plays a much stronger role in the way young people relate to science in the Western societies today than earlier. Young people today are less focused on 'what do you want to be' and more oriented towards 'who do you want to be' (Schreiner and Sjøberg, 2006). This informs us that attitude research results not only are difficult to transfer from one society to another but also from one time period to another. Students' attitudes must be regarded as a characteristic of the context in which it has been conducted. Attitude research for this reason will be an ongoing issue, where researchers will have to explore students' attitudes towards science in the current social and educational situation.

**Data Collection – attitude measures used**

The data presented in this paper was collected as part of an evaluation of the Lab in a Lorry project, carried out on behalf of the Institute of Physics. Lab in a Lorry is an initiative involving the visit of a mobile laboratory to schools, designed to encourage the participation of pupils aged 11 to 14 in science[2]. As part of the evaluation, pupils' attitudes towards science were measured before the visit of Lab in a Lorry to their schools. For this purpose, a questionnaire was developed incorporating measures for the following areas of pupils' attitudes towards science: Learning science in school, Practical work in science, Science outside of school, Importance of science, Self-concept in science, and Future participation in science.

Following an initial trialling of this questionnaire, it was distributed to five different schools (three located in the North East of England, one in the South East of England and one in the South West) who were being visited by Lab in a Lorry. Pupils from Years 7, 8 and 9 from these schools were asked to complete the questionnaire two weeks before the visit of Lab in a Lorry. In total, 932 pupils completed the questionnaire. Analysing the obtained data, we confirmed through factor analysis that each of the attitude constructs being measured were unidimensional, i.e. one factor was extracted from each measure. The internal reliability of each measure was also found to be greater than the threshold level of Cronbach $\alpha = 0.7$. Details of this data analysis examining the unidimensionality and reliability of these attitude measures are provided in on our previous paper (Kind *et al*., 2007). However, Table 2 below provides a summary of the items comprising each attitude measure and the Cronbach α values obtained from the data. The previous data analysis also found that the Learning science in school, Science outside of school and Future participation in science measures were all highly correlated with each other ($\rho \geq 0.6$). Factor analysis confirmed that items from these three measures also loaded on one single factor. Therefore, these measures could be brought together to provide a Combined interest in science measure. Table 2 also provides the Cronbach α values for this combined measure.

[Insert Table 2 about here]

In this paper, we draw on the data obtained from the questionnaire, in order to examine how the different attitude measures vary over the school years and between boys and girls. In addition to the questionnaires, following the visit of Lab in a Lorry, 44 pupils in the five schools were interviewed about their views on Lab in a Lorry and science generally. We will draw on some of the comments made by pupils, in order to provide some further insight into some of the issues that emerge from the analysis of the questionnaire data.

**Data analysis – average measures**

[2] Further information of Lab in a Lorry can be obtained from the website www.labinalorry.org.uk

Drawing on the data obtained from the questionnaire, we first of all examined how the attitude towards science measures varied across the different school years involved in the study. Figure 1 shows the average Combined interest in science measure for the Years 7, 8 and 9 pupils.

[Insert Figure 1 about here]

This sample of pupils was made up of 272 Year 7 pupils, 432 Year 8 pupils and 228 Year 9 pupils. In finding the average value for a particular attitude measure, the responses given by pupils to the questionnaire items were coded numerically (5 = Strongly agree, 4 = Agree, 3 = Neither agree or disagree, 2 = Disagree and 1 = Strongly disagree; these were reversed for negatively worded items). The average value of a measure for each pupil was found by averaging over the relevant items comprising this measure. The average measure for a particular group of pupils was then found by further averaging these pupil average values over the group. Therefore, the values for any of the attitudes towards science measures for any particular group could vary between 1 (most negative) and 5 (most positive).

As can be seen in Figure 1, we observe a steady decline in the average values of the Combined interest in science measure as pupils progress through secondary school. This is in agreement with one of the main findings that we drew out from the literature summarised in Table 1. Another indication of the extent of this decline can be obtained by looking at the effect size for the difference in the average values between the Year 7 pupils and the Year 9 pupils. For the Combined interest in science measure, this is calculated to be -0.89 standard deviations (the minus indicating a decline in the average measure), a large effect size[3].

Rather than just examining the variation in this Combined interest in science measure, we can look in more detail at the changing attitudes of pupils towards science by looking at each of the separate attitude constructs. Figure 2 below show the variation of each of the attitude towards science measures over the school years.

[Insert Figure 2 about here]

Once again, we can also get an idea of the change in the attitude measures by calculating the effect sizes for the differences between the Year 7 and Year 9 pupils (Table 3). The advantage of examining the individual attitude constructs in this way is that we can see the areas that experience the biggest decline as pupils progress through secondary school. What we see in this case is that the largest decline in pupil attitudes was for their attitude towards learning science in school. In contrast, pupils' attitudes towards practical work and also the importance of science only experienced small reductions as pupils progressed from Year 7 to Year 9.

[3] Cohen (1969) categorises effect sizes of 0.3, 0.5 and 0.7 standard deviations as 'small', 'medium' and 'large'.

[Insert Table 3 around here]

In addition to looking at the variation of the attitude measures over the different school years, we can also examine the differences between boys and girls. Figure 3 below shows the average measure for the Combined interest in science measure, separated for boys and girls as well as for the different school years.

[Insert Figure 3 around here]

It is interesting to note that in the first year of secondary schooling, there is very little difference between boys and girls with regards to this Combined interest in science measure. However, as we move up through the year groups, the differences between boys and girls increase. Looking at the effect sizes for the difference between Year 7 and Year 9 pupils, for the girls, the effect size for the Combined interest in science measure was -1.09, whereas for the boys it was -0.50. Once again, we can gain more detail by looking at the individual attitudes towards science measures. Figure 4 and Figure 5 below show the variation of the average measures over school years, plotted separately for boys and girls.

[Insert Figure 4 around here]
[Insert Figure 5 around here]

It is interesting to note once again that differences between boys and girls for any of the attitudes towards science measures are small for Year 7 pupils, only becoming pronounced later on. To give an idea of the different variations in attitudes for boys and girls as they progress through school, the effect sizes for the differences in the measures are presented separately in Table 4.

[Insert Table 4 around here]

There are a number of issues to note from this table. First of all, for all the attitudes to science measures, girls' attitudes decline more than boys' attitudes as we move from Year 7 to Year 9. This seems to support our second assertion which we drew from the literature in Table 1. Secondly, it is interesting to note the measures for which we see a large difference between the effect size values for boys and girls. In science outside of school, whereas the effect size is very large for girls at over one standard deviation, for boys, the effect size is quite small at around -0.3. For practical work in science, there was a medium-sized fall for girls with an effect size of around -0.4, whereas there was actually a small increase for boys. In Learning science in school, both boys and girls showed large declines in their attitude towards this construct, although this was more pronounced for girls with a fall of around -1.4 standard deviations.

**Data analysis – What affects future participation in science?**

In addition to looking at the variation of the different constructs over school years and between boys and girls, we can also examine the relationships between the constructs themselves. More specifically, we can examine a specific outcome, in this case the measure for pupils' future participation in science, and see how the other constructs affect this outcome. By identifying these relationships, we can also identify possible ways of improving pupils' future participation in science.

In order to examine the relationship between the Future participation in science measure and the other constructs, stepwise linear regression analysis was carried out. Table 5 below shows the standardised regression coefficients for the five attitude constructs in their relationship with the Future participation measure. No regression coefficients are presented for those constructs that were excluded from the regression equation as a result of the stepwise analysis.

[Insert Table 5 around here]

As can be seen, the construct that correlates most highly with the Future participation in science measure was the Science outside of school construct. However, a more interesting set of findings is found if we carry out the linear regression analysis for the three school years separately. Table 6 below shows the results of this analysis.

[Insert Table 6 around here]

Although for each year group the Science outside of school construct is most highly correlated with the Future participation in science measure, there seems to be a pattern in the way that the correlation coefficients vary. As pupils progress through their schooling, the Science outside of school measure becomes a less important factor, and Learning science in school becomes more important. This result seems reasonable in that as pupils progress through school, their experience of science is more and more what they have experienced in school. Therefore, we would expect that their attitude to school science to become a more important factor in whether they would participate in science in the future. It therefore becomes more important that, if we want to encourage pupils to continue with science, they should be enjoying the experience that they are having in the classroom.

**Qualitative data – results of interviews with pupils**

In addition to the quantitative data obtained from pupils in the questionnaire, semi-structured interviews were carried out with groups of pupils from six schools involved in the Lab in a Lorry study. Researchers visited the schools for these interviews approximately two weeks after the visit of Lab in a Lorry to the school. Each school arranged for convenient groups of pupils who had experienced Lab in a Lorry to be interviewed. The sample was therefore neither representative nor random, rather, the interviews allowed the researchers to simply explore issues regarding Lab in a Lorry in more detail.

Altogether, 44 pupils of varying academic ability from Years 7 to 9 were interviewed, separated into 16 groups. In each case, the interview with pupils was recorded at the time and transcribed later. Pupils were asked questions about their experiences of Lab in a Lorry, what they thought the best and worst things were and what they thought of school science in general.

A number of the pupils' comments in response to these questions gave some insight into why pupils are 'switched off' by school science. Analysis of the obtained interview data drew out the following most prevalent themes as reasons why pupils do not enjoy science in school.

*(a) School science is not perceived as practical*

The pupils commented almost unanimously that they enjoyed Lab in a Lorry because of the hands-on/practical nature of the experiments and the fact that everyone could take part. The least popular experiments were ones with the least practical element.

> *"[Lab in a Lorry is] fun and it's what all children want to learn, because it's practical."*

> *"Lab in a Lorry was really, really great. I like science when you do practicals rather than when you're just writing stuff."*

> *"I thought the light (experiment) was the weakest one as well, because there was less practical"*

A large proportion of the pupils went on to say that they found school science "boring" because they rarely did any practical experiments, the element that made school science fun for them.

> *"I like doing experiments but I'm not really enjoying science [in school] that much at the minute because it's board work and I prefer hands-on."*

> *"[Science in school is] alright, it depends what subject you are doing and whether there is any practical involved."*

*(b) School science is not perceived as being well explained*

Whether the pupils enjoyed a particular experiment or not seemed to depend heavily on whether they could understand what was being said and whether or not they thought it had been well explained.

> *[What was the best bit about Lab in a Lorry?] "They explained it really well until you understood it"*

*[What was the worst bit about Lab in a Lorry?] "The sunlight one because there was more going on and you couldn't understand it. The other two were easier to understand, because the people put themselves in our shoes and talked to us as if we were their friends and they were not like teachers."*

On the whole, the pupils were very complimentary about the way that volunteers who working on the Lorry talked to them, saying that they explained things well and that they checked whether they had understood what had been said. (Any negative comments about volunteer explanations seemed to be directed at one particular experiment, which seemed a difficult experiment to understand). The pupils indicated that this was in contrast to their experience of school science, which was perceived as not being well explained.

*"They explained things more than the science teacher would and helped our understanding."*

*"They were different from our normal teachers. They were younger and they explained things in our language."*

*(c) School science is not perceived as relevant*

A common finding was that pupils had not made links between school science and everyday life. A number of pupils said that Lab in a Lorry made them more interested in science because it made them realise that science was important for "everyday life", indicating that a more relevant curriculum may spark more interest.

*[Did Lab in the Lorry make you more interested in science?] "Yes, because it made me realise that science is in everyday life"*

*"I didn't know it could be so exciting and I didn't know that most everyday things had something to do with science."*

**Discussion**

The present study has highlighted a variety of issues concerning secondary students' attitudes towards science. First of all, looking at the variation of the average measures over the different school years, we have observed a steady decline in attitudes towards science as pupils progress through school. This finding has also been highlighted by many other studies, including Yager and Yager (1985), Doherty and Dawe (1985), George (2000 and 2006), and in the review paper by Osborne *et al.* (2003). In addition, the study has highlighted that this decline in attitudes towards science is more pronounced for female pupils. This was in agreement with the previous studies carried out in England (Hadden and Johnstone, 1983, Doherty and Dawe, 1985,), but the more recent work carried out in the United States by George (2006) has found that the opposite to be true, that male pupils' attitudes decline faster.

One of the particular advantages of the present study is that we have defined different aspects of attitudes towards science, and measured these constructs separately with reliable, unidimensional measures. Previous attitude research has been criticised for its lack of clarity in defining what we mean by this particular term, and therefore where the specific problems lie with regards to attitudes towards science. Using the separate measures to look more carefully at secondary students' attitudes, we have highlighted that a particular problem exists with how pupils experience science in school. Not only is this the area within learning science in which we see the steepest decline in attitudes from the start of secondary schooling, but we have also seen that this seems to be a more and more important influence on whether pupils will pursue science in the future. Therefore, the main recommendation that we put forward from this study is the need to concentrate on improving pupils' experience of science in school.

The qualitative data that we gathered from the interviews with a small sample of pupils provides some insight into areas that could be examined in improving this experience of science in school. These were the practical content of science lessons, the way science is taught and explained and the way science is made relevant in lessons. Of course, these are areas which have already been raised in previous studies. With regards to the relevancy of what is being taught, Ramsden (1990) identified the relevance and perceived usefulness of a taught unit in physics as contributing to its success. Likewise, Stokking (2000) identified the perceived relevance of physics for future study or profession as being strongly related to the choice of physics in higher education. Osborne *et al.* (2003) again identified the issue of relevancy and the fact that biology was more likely to be perceived as being relevant for pupils than the physical sciences. Jones and Kirk (1990) identified that if application of physics is relevant to people generally (e.g. health applications), this influences pupils' interest in the application. Reid and Skryabina (2002) found that pupils in Scotland had a more positive view of physics whilst undertaking the 'applications-led' Standard Grade course than when taking the more theoretical Higher Grade course. Therefore, incorporating subject matter that pupils can more easily identify with may therefore be one way of tackling the way that the subject is perceived.

With regards to practical content, Reid and Skryabina (2003), in their survey of Scottish pupils, found that both male and female pupils on the Scottish Higher physics course indicated that they preferred activities such as explaining natural phenomena and doing practical work. With regards to female pupils particularly, Stewart (1998) found that female students at A-level highlighted medical applications, development of oral skills and development of practical skills as features that they would like to see more of in their physics course. Male students preferred more IT and technological applications. On the other hand, looking at how science material is taught, Osborne *et al.* (2003) argued that for science subjects generally, "research evidence shows clearly that it is the teacher variables that are the most significant factor determining attitude, not curriculum variables" (p. 1070). Nielsen and Thomsen (1988) and Woolnough (1994) have also highlighted the importance of the teacher in enthusing pupils in science. Therefore, all these factors, relevancy, practical content and the role of the teacher, need to be examined in order to tackle the perceived decline in pupils' attitudes towards science that we have highlighted in this paper.

Finally, with regards to future research in this area, it also seems important that we look more closely at the combined effects of variables. In most studies, factors involved are studied in isolation without taking into consideration the highly complex situation that occurs when they interacts. Our own study, for example, indicates that learning in science in school and students' self-concept in science both develop with very similar trends with regards to their interaction with future participation in science. To explore such interactions, our research may benefit from more advanced modelling analyses (e.g. structural equation modelling). This is a direction which we will explore in the future.

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Table 1. Overview of relevant literature

| Topic | Result | Author(s) |
|---|---|---|
| Overall development | Students' attitudes towards science decline in primary years | Ayers & Price, 1975 (US)<br>Murphy & Beggs, 2001 (UK)<br>Pell & Jarvis, 2001 (UK)<br>Simpson & Oliver 1985 (US) |
| | Students attitudes towards science **do not** decline in primary years | Harvey & Edwards, 1980 (UK)<br>National Assessment of Educational Progress (NAEP), 1978 (US)<br>Yager & Yager, 1985 (US) |
| | Students' attitudes towards science decline in secondary years (or from primary to secondary level) | Breakwell & Beardsell 1992 (UK)<br>Brown, 1976 (UK)<br>Doherty & Dawe 1988 (UK)<br>Francis & Greer, 1999, (UK)<br>George, 2000 (US)<br>George, 2006 (US)<br>Hadden & Johnstone, 1983 (UK)<br>Johnson, 1987 (UK)<br>NAEP, 1978 (US)<br>Reid & Skryabina, 2002 (UK)<br>Simpson & Oliver 1985 (US)<br>Yager, 1983 (US)<br>Yager *et al.*,1989 (US)<br>Yager & Penick, 1986 (US)<br>Yager and Yager, 1985 (US) |
| | Students attitudes towards science **do not** decline from primary to secondary level | Hobbs and Erickson, 1980 (Ca) |
| | Students who start of with more positive attitudes drop slower over time | George, 2000 (US)<br>George, 2006 (US) |
| | Attitudes towards chemistry and physics decline more than towards other subjects | Hadden & Johnstone, 1984 (UK)<br>Whitfield, 1979 (UK) |
| | Attitudes towards the usefulness of science is relatively stable (and positive) | George, 2006 (US)<br>NAEP, 1985 (US)<br>Yager and Yager, 1985 (US) |
| Gender issues | Boys are more positive towards science than girls | Cannon & Simpson, 1985 (US)<br>Simpson & Oliver, 1985 (US)<br>Weinburg, 1995<br>Francis & Greer, 1999 (UK)<br>Harvey & Edwards, 1980 (UK) |
| | Boys start off with more positive attitudes than girls, but boys' attitudes decline faster | George, 2006 (US)<br>Simpson & Oliver, 1985 (US) |
| | Girls' attitudes decline faster | Hadden & Johnstone 1983 (UK)<br>Doherty & Dawe, 1985 (UK) |

Table 2. Summary of the attitude towards science measures

| Attitude measure | Items comprising the measure | Cronbach α |
|---|---|---|
| Learning science in school | We learn interesting things in science lessons.<br>I look forward to my science lessons.<br>Science lessons are exciting.<br>I would like to do more science at school.<br>I like Science better than most other subjects at school.<br>Science is boring. | 0.89 |
| Self-concept in science | I find science difficult.<br>I am just not good at Science.<br>I get good marks in Science.<br>I learn Science quickly.<br>Science is one of my best subjects.<br>I feel helpless when doing Science.<br>In my Science class, I understand everything. | 0.85 |
| Practical work in science | Practical work in science is exciting.<br>I like science practical work because you don't know what will happen.<br>Practical work in science is good because I can work with my friends.<br>I like practical work in science because I can decide what to do myself.<br>I would like more practical work in my science lessons.<br>We learn science better when we do practical work.<br>I look forward to doing science practicals.<br>Practical work in science is boring. | 0.85 |
| Science outside of school | I would like to join a science club.<br>I like watching science programmes on TV.<br>I like to visit science museums.<br>I would like to do more science activities outside school.<br>I like reading science magazines and books.<br>It is exciting to learn about new things happening in science. | 0.88 |
| Future participation in science | I would like to study more science in the future.<br>I would like to study science at university.<br>I would like to have a job working with science.<br>I would like to become a science teacher.<br>I would like to become a scientist. | 0.86 |
| Importance of science | Science and technology is important for society.<br>Science and technology makes our lives easier and more comfortable.<br>The benefits of science are greater than the harmful effects.<br>Science and technology are helping the poor.<br>There are many exciting things happening in science and technology. | 0.77 |
| Combined interest in science | (Items from Learning Science in school, Science outside of school and Future participation in science combined) | 0.93 |

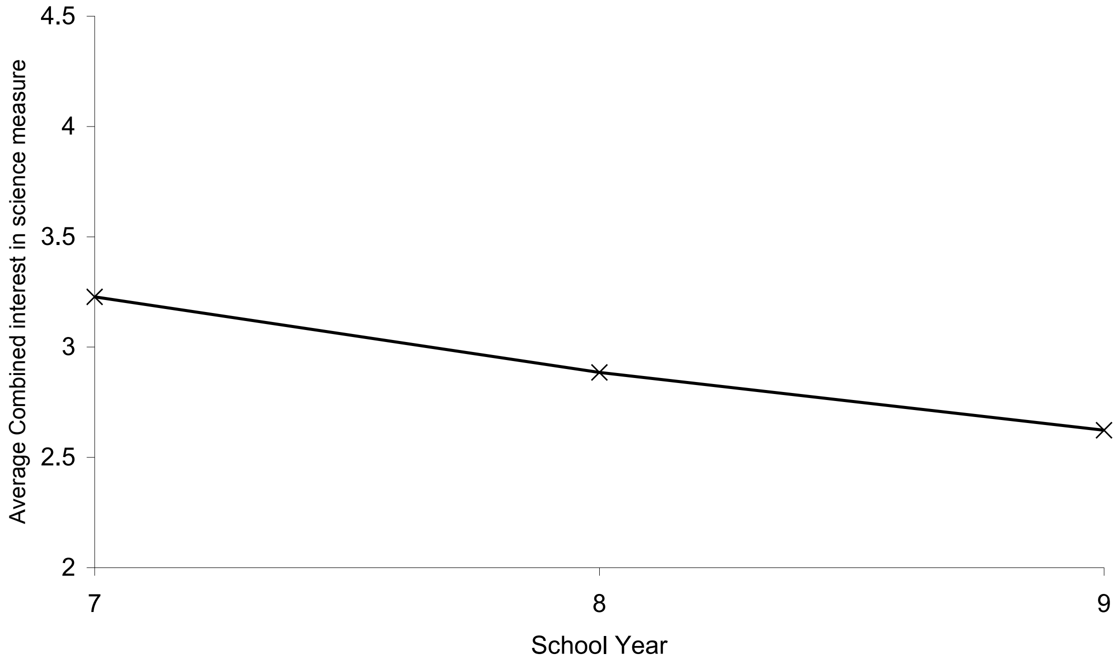


Figure 1. Combined interest in science measure against school years

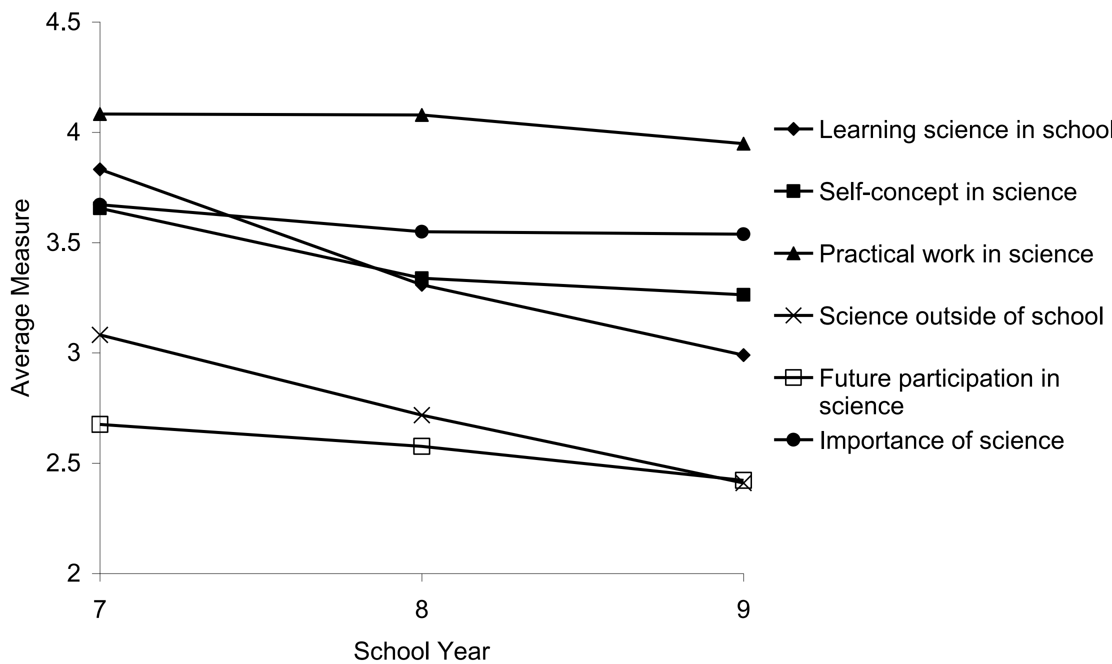


Figure 2. Variation of the attitudes to science measures over school years

Table 3. Effect sizes for differences between Year 7 and Year 9 pupils

| Measure | Effect size |
|---|---|
| Learning science in school | -1.19 |
| Self-concept in science | -0.58 |
| Practical work in science | -0.21 |
| Science outside of school | -0.81 |
| Future participation in science | -0.31 |
| Importance of science | -0.21 |

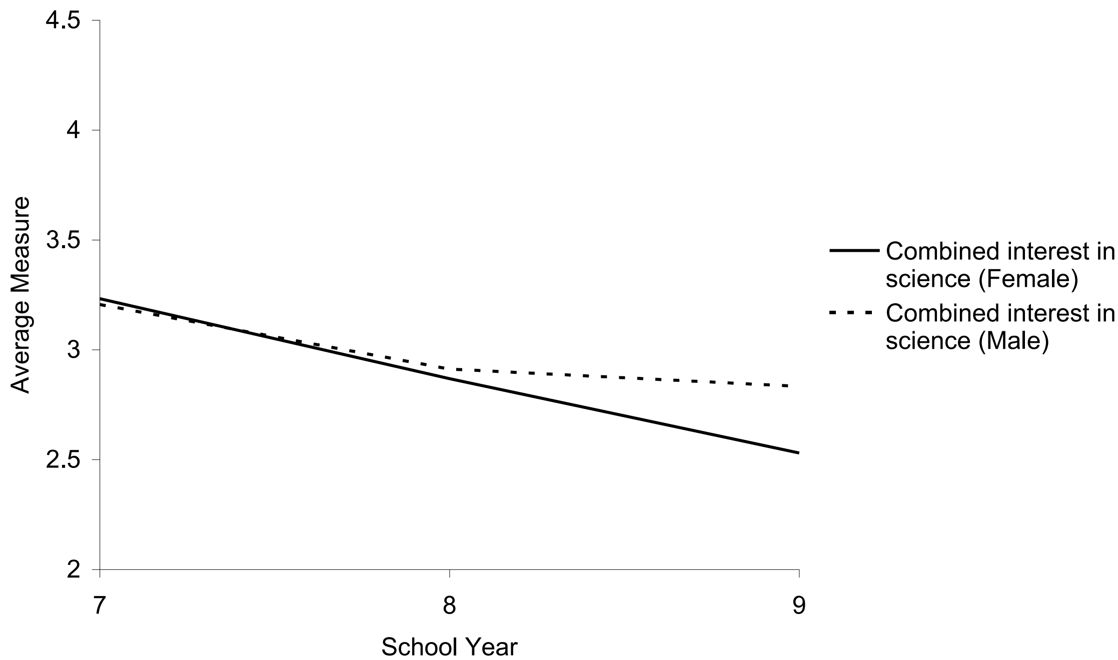


Figure 3. Combined interest in science measure against school years and gender

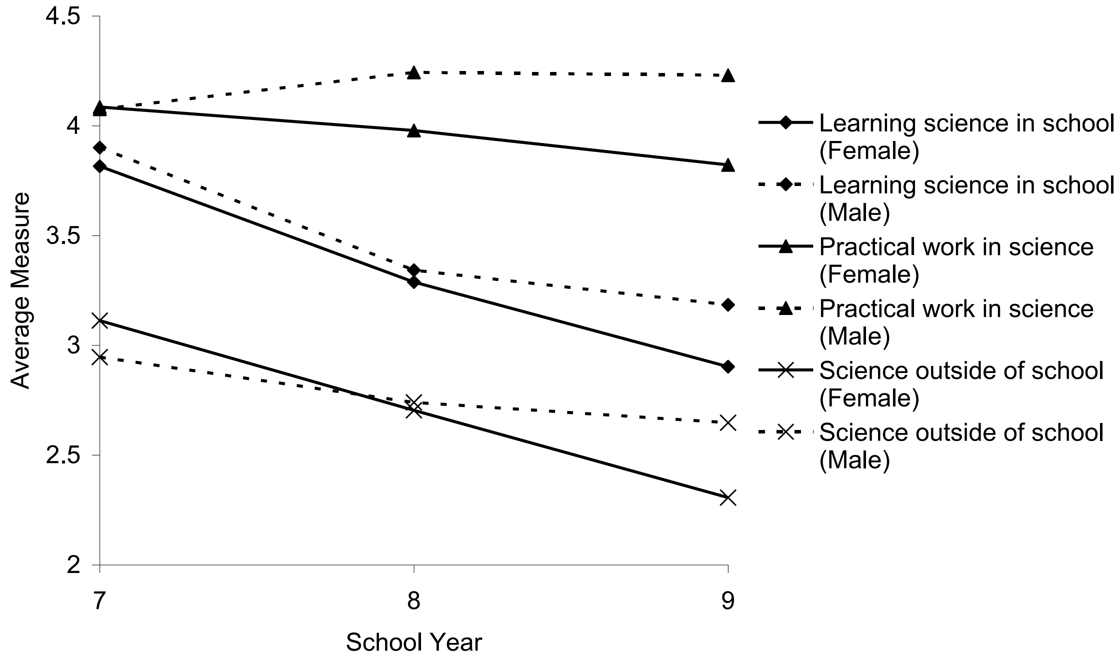


Figure 4. Average measures against school years and gender

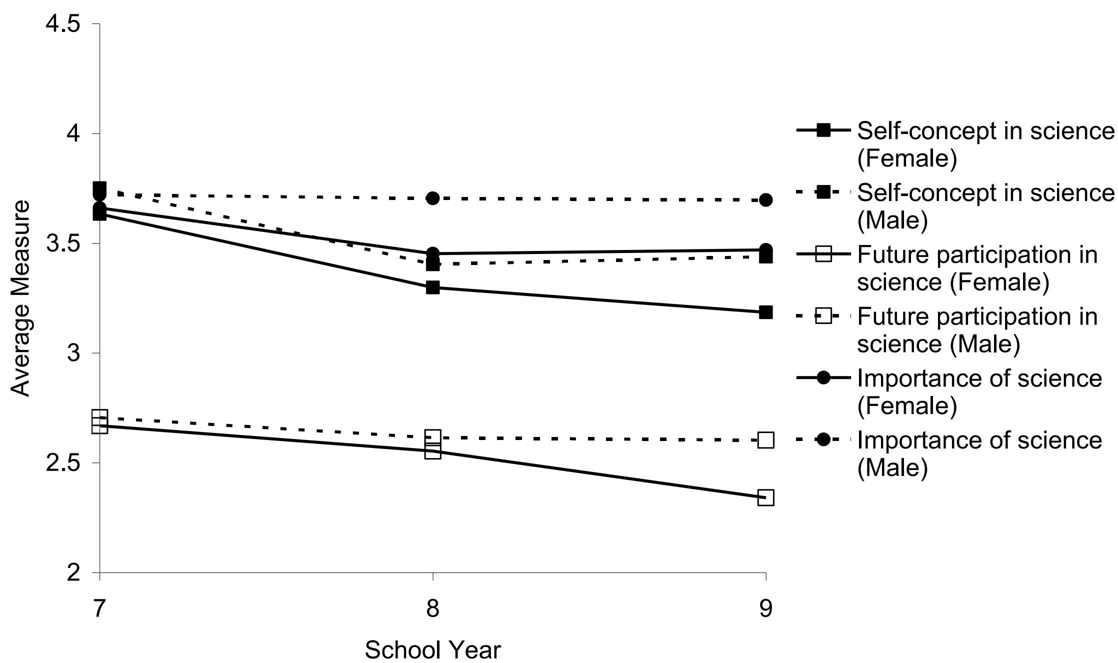


Figure 5. Average measures against school years and gender

Table 4. Effect sizes for differences between Year 7 and Year 9 pupils, presented separately for boys and girls

| | Effect size | |
|---|---|---|
| Measure | Girls | Boys |
| Learning science in school | -1.37 | -0.90 |
| Self-concept in science | -0.68 | -0.45 |
| Practical work in science | -0.42 | 0.26 |
| Science outside of school | -1.02 | -0.33 |
| Future participation in science | -0.41 | -0.12 |
| Importance of science | -0.33 | -0.03 |

Table 5. Linear regression coefficients of attitude constructs with Future participation in science measure – all pupils

| Measure | β |
|---|---|
| Learning science in school | 0.146 |
| Self-concept in science | 0.153 |
| Practical work in science | - |
| Science outside of school | 0.416 |
| Importance of science | 0.154 |

Table 6. Linear regression coefficients of attitude constructs with Future participation in science measure – different school years

| | β | | |
|---|---|---|---|
| Measure | Year 7 | Year 8 | Year 9 |
| Learning science in school | - | 0.198 | 0.290 |
| Self-concept in science | 0.150 | 0.151 | 0.227 |
| Practical work in science | - | - | - |
| Science outside of school | 0.552 | 0.404 | 0.302 |
| Importance of science | 0.142 | 0.161 | - |