Comparison of Pupils' Interest and Performance in School Science Lessons

Some suggestions to improve the number of girls choosing physical sciences at A-level.

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Abstract

The study aimed to discover whether the correlation commonly assumed between interest and performance, that is that the greater the interest the higher the performance, holds true. It was found that it did, albeit weakly with only 6.05% more of the correlations being positive than negative. It was also found that pupils' opinions of their own ability matched their results pretty closely, with 34.46% more positive matches than negative ones. Personal opinion of ability also closely matched interest, with 18.18% more positive than negative correlations.
Particular focus was given to gender differences in achievement in science. This confirmed earlier work that interest, perceived ability and test results were more closely linked for girls than boys. Many girls said they found physics boring, yet expressed interest in several applications of it. Both boys and girls found chemistry to be uninteresting, the applications in the National Curriculum not being seen as relevant to real life.

The information was gathered by questionnaires given to pupils and examination of past test scores. A representative group was selected for further study, including observation of questions answered and asked in lessons and informal interviews.

Previous Research

It is widely taken that there is a link between interest and performance in a subject. A person who is interested in something is more likely to work at understanding it than someone who is not. Conversely, a person who does well in something is likely to cultivate an interest in it.

There is a tendency for pupils to value science education as a help to them in a career "rather than as a subject of intrinsic interest" [2]. Having said that, they rate english and maths as more important for a future job [1]. Despite finding practicals interesting [2], science lessons on the whole are regarded as boring. Particularly worrying is the decrease in interest with age [1], when one would hope that they would be finding more and more things of interest in the subject.
Several reasons have been given for this dislike. Pupils referred to "being frog-marched across the scientific landscape" with no time to look at anything for long [2]. The use of a spiral curriculum lead to complaints of repetition without significant progression [2]. Another common complaint was lack of relevance to real life [1,2]. This could be to do with pupils' ideas of real life and how these are arrived at. A positive relationship has been found between watching current affairs programmes and finding science interesting, and a negative one between soaps and interest in science [5].

A pupil's perception of their own ability is likely to be influenced by their interest in the subject concerned. External information, including teacher and peer group feedback and more particularly exam results, contribute to self-perception. 15% of teachers asked to comment on the KS3 SATs felt that the results of the tests demotivated the pupils as they couldn't demonstrate what they were able to do and they "now perceive science as something too difficult for them" [6].

It has been found in many pieces of research that boys find science more interesting than girls [1,2,3]. If interest does influence performance this could account for the underachievement of girls in KS3+4 science. A few more boys than girls say they find science easy and a larger number often answer questions in class [1,3]. Slightly more boys decide to do A-level science than girls [1]. Only 16% of scientists are women [4]. It might be thought that this is due to lack of involvement in science lessons, but girls tend to handle apparatus and initiate discussions as often as boys [3].

Looking at the sciences separately some surprising facts emerged. As would be expected from stereotype, girls are less interested in physics than boys, and more interested in biology [2]. However it has been seen that girls are not avoiding traditionally masculine disciplines as much as boys are avoiding traditionally feminine ones [10]. Despite its frequent and dramatic experiments, chemistry was regarded by both sexes as the least interesting due to lack of apparent relevance [2]. It has been suggested that girls are more receptive to context-based learning than boys, who prefer abstract thought [10,11]. It has also been found that girls' choices of subjects at A-level are more closely related to how hard they perceive the subject to be [10]. This probably explains why those that do go on to do A-level physics are more able than their male colleagues [10].
If we assume that natural ability in science is not gender specific then something is happening in secondary schools that leads to the present gender difference. At the end of KS2 more girls enjoy science than boys [3] but this has reversed by the end of KS4 [1,3]. In Year 7 an equal percentage (60%) of boys and girls believe they will make use of their science knowledge after leaving school [1]. By Year 11 this has dropped to 44% for boys and only 32% for girls [1].

Research Methods

Questionnaires

A lot of the information was gathered from questionnaires (**Appendix A**). These were given to 85 KS3+4 pupils and completed as part of a lesson.

The major part of the questionnaire was based on a 5-point Likert-type scale [8]. Although this is capable of giving some indication of degree of opinion, it must be borne in mind that more-able people tend to avoid extreme replies [9]. This type of scale does however allow respondents to indicate their likes and dislikes without using the extremes of 'yes' and 'no' which they might fear to be prejudicial to their futures.

The second part of the questionnaire aimed to see what areas of scientific application were found interesting. A list of applications that had recently been in the news and related directly to the KS3+4 National Curriculum was given. Respondents were asked to tick any that sounded interesting. Not only did these topic votes help to decide how interested each pupil was in science, it showed the differences between physics, biology and chemistry.

Pupils' Questions

In order to further assess pupils' interest they were asked to write down any questions about science that they wanted answering. The assumption was that those who were more interested in the subject would ask more questions, either through ability or inclination. It was hoped that the areas the questions covered could also provide useful information about discipline preferences and reasons for not liking science lessons.

Test records

The existing records of the pupils' achievement in end-of-topic tests were correlated with their questionnaire answers. A selection of results from biology, chemistry and physics topics were averaged to give a fair representation across science. Although test scores are not a full measure of ability, they do indicate the performance seen by the public and the pupils themselves.

Observation + Discussion

A selected group of pupils were observed in their science lessons. The number of times they volunteered to answer a question and the number of non-operational questions they asked were recorded.
It was thought important that pupils were not formally interviewed, to avoid political responses. Questions about their intended profession, opinions of science lessons, and opinions of themselves were asked in general conversation. Information provided without the need to ask the questions was simply noted.

Data Analysis

The raw data was converted into digital form for ease of analysis. A result more than 0.435[†] times the standard deviation above the mean was assigned a 1, a result more than 0.435 times the standard deviation below the mean was assigned a –1, a result between these limits was given a 0. This yielded a table of positive, neutral, and negative score compared to the mean for each factor (interest, perceived ability, performance, and topic votes). For example a test score much higher than average would give a positive score in the performance table. A completely uninterested response would produce a negative score in the interest table.

These tables were then compared to reveal any positive or negative correlations between the scores for each respondent. A positive correlation was recorded if both scores were positive or both negative. A negative correlation was recorded if one score was positive and the other was negative. The significance of a correlation (positive or negative) was at the 3% level[‡].

In order to determine whether the sample contained more positive or more negative correlations the λ-weighting was defined. This was the percentage of the sample displaying a positive correlation minus the percentage showing a negative one. As the creation of a random sample has no bias towards positive or negative it would be most likely to produce a λ-weighting of 0%.

Results

Interest vs Performance

There was a small positive connection between interest and test results. This was shown by a λ-weighting of 6.05%.

Graph 1 appears to show the 'W pattern' found previously [1]. The graph dips in Yr8 and Yr10. If this is in line with the previous research the results for Yr11 would rise again. No explanation for this pattern has been forthcoming.

There was a stronger correlation between interest and performance in boys than girls. Girls had a λ-weighting of 2.68%, compared to 6.46% for boys. However this is mostly caused by a large difference in Yr7 - in all other year groups in the sample girls had a higher or equal weighting to boys (Graph 1).

Interest vs Perceived Ability

The connection between a pupil's interest in science and their perception of their own ability appears to be a reasonable one. A λ-weighting of 18.18% was found.

This relationship is particularly strong in Yr9 and Yr10 for girls, and much weaker for boys (Graph 2). Perhaps this is connected to having to choose GCSE options clarifying pupils' thoughts about subject preferences and interests. This would tie in with previous work which showed that girls are more sensitive to these factors than boys [10,11].

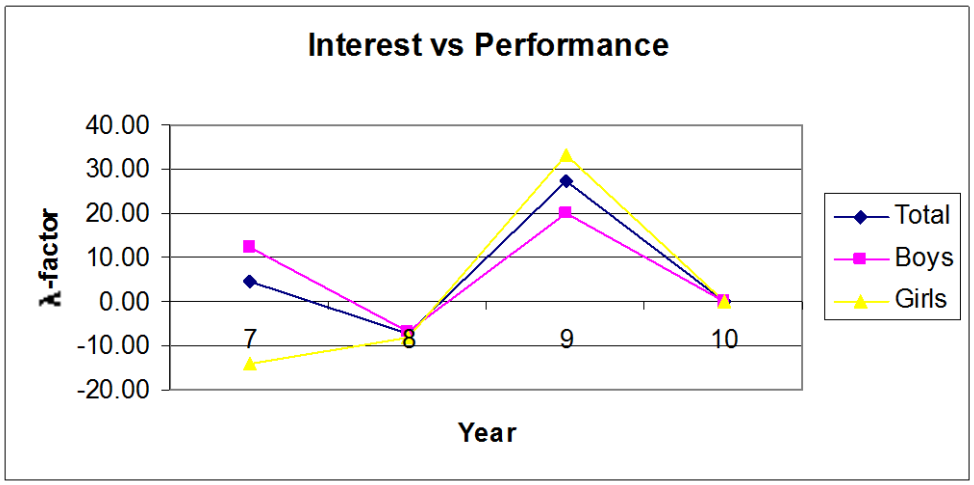
Perceived Ability vs Performance

As would be expected, pupils' perception of their own ability is heavily linked to their performance in tests. A significant 34.46% λ-weighting was found.

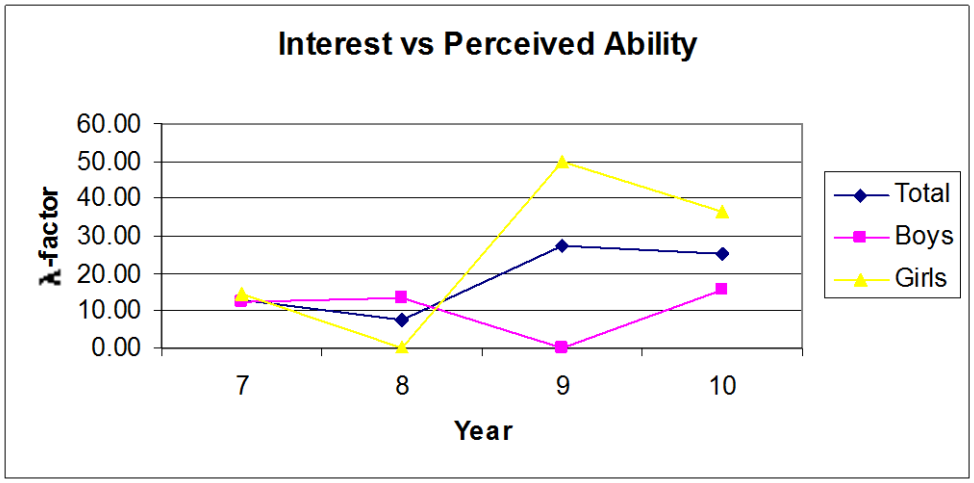
Graph 3 shows how the λ-weighting changed with year group. This is very low for Yr7 and increases steeply to Yr8 and beyond. Such a rise could be explained by pupils doing more tests and getting more feedback, thus indicating that the perception of ability is fed by the test scores.

Examination of the development with time of pupils' test scores showed that they generally moved away from the mean, allowing for fluctuations caused by subject preferences. This supports the suggestion that perceived ability affects the test score – those who are above average get above average test scores, which boosts their confidence, which improves their score next time.

[†] Chosen to give a 3% significance in the final result.
[‡] 3% of a random sample would show a correlation calculated in the same manner.



Graph 1



Graph 2

Graph 3

The results indicate that girls' perception of their ability has a closer connection to their test results than for boys. This was shown by a λ-weighting of 39.15% for girls, as opposed to 29.66% for boys. This difference was most marked in Yr9 (Graph 3). This coincides with the run up to the KS3 SATs and possibly has some connection with them.
Possibly the emphasis placed on the SATs exaggerates the existing tendency for girls to judge their ability by test results. Whether this is the case or not, the results of the SATs must have a dramatic effect on girls' perception of their ability.

Interest in Topics

The average percentage of topics in which an interest was expressed was 39.59% for biology, 23.81% for chemistry and 35.56% for physics. It was to be expected that biology topics would score highly. It was less expected that physics would almost equal biology, as it had been declared 'not interesting' by many pupils. This might be because the scope of the subject is not understood and the topics were not seen to be physics.
The positive correlation between topic votes and performance increases with age (Graph 4). This could indicate that pupils are concentrating more and more on the things that they find interesting. Those who find a lot of things of interest are more likely to find questions about these interests in tests.

The questions written by pupils responding to the questionnaires were mostly in three well-defined areas. A large number (9/36) were about space and planets. Many others (7/36) were to do with medicine. The third large group was related to the operation of science lessons. The remainder of questions asked were about healthy eating, weaponry and explosives.

Both these results support previous studies which found that chemistry was uninteresting and irrelevant to pupils [2] (apart from bomb-making).

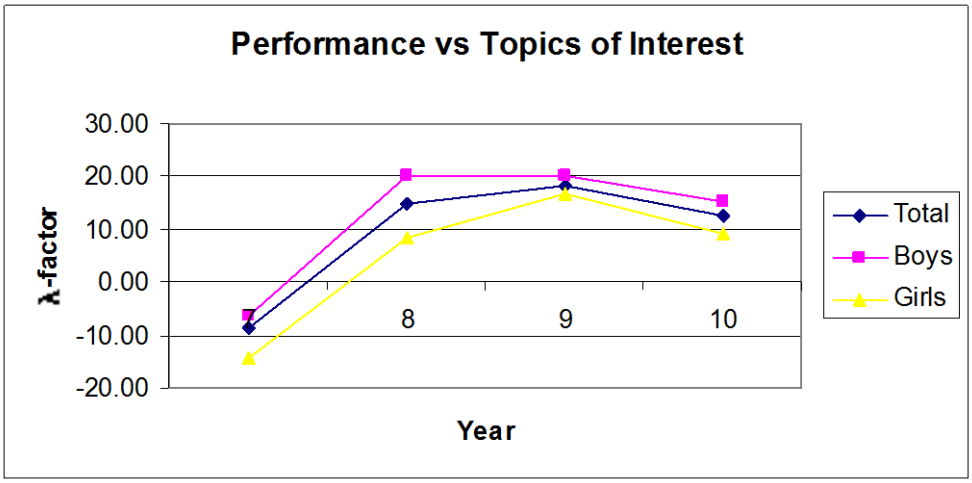
Girls showed much less interest than boys in current applications of science. On average they expressed an interest in 20% less topics in biology and 15% less in chemistry and physics. This comparative drop in interest in biology goes against stereotype.

Opinions of Science Lessons

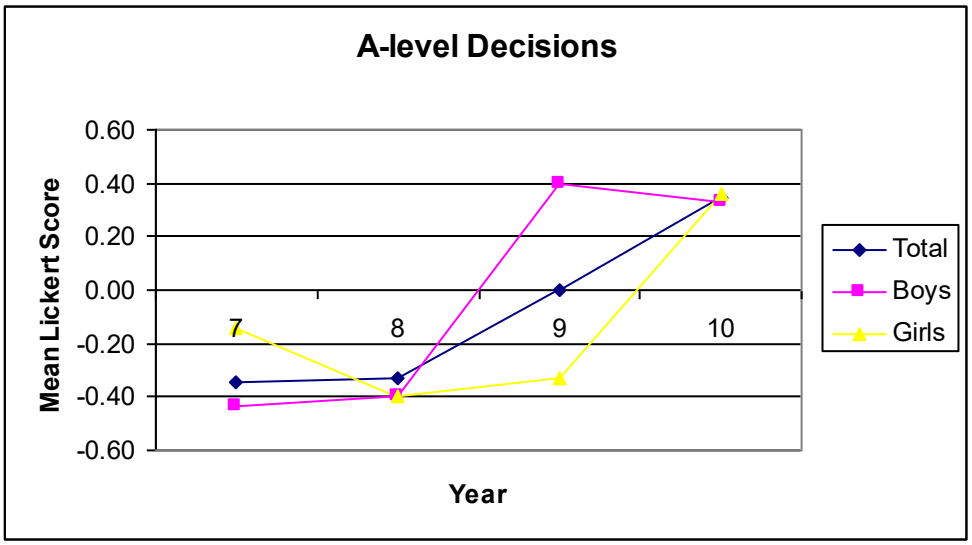
Many pupils commented in the questionnaires and orally that they disliked having to study all sciences up to the end of GCSE. Physics and chemistry were the most common ones people wanted to drop, which mirrors the lack of interest in those areas shown in the questionnaires and previous studies [2]. In all cases this was said to be because they were uninteresting, not because they were hard. It was also noted that the most boring topics lasted the longest.
The foundation tier Yr10 group made the most comments about how to improve science lessons, more practicals being mentioned frequently (as with other classes). A couple of pupils complained that the end-of-topic tests were not differentiated. This meant they knew they couldn't show what they were able to do as there would be too many parts of the questions on which they couldn't get started. This affected their self-confidence badly, as was found in research into KS3 SATs [6]. Several also pointed out that they couldn't remember physical formulae, and wouldn't know what to do with them anyway – a problem they didn't encounter in biology.

A-level Decisions

In Yr7 and Yr8 there are more pupils who think they will not do A-level science than think they will. The ratio improves over the next few years, jumping up in Yr9 for boys and Yr10 for girls (Graph 5).
This corresponds roughly to the increases in interest and perceived ability, seeming to indicate that these are crucial factors in deciding whether to do a subject beyond GCSE. However, it also coincides with the increased awareness of the usefulness of science for jobs and university gained from careers work.



Graph 4



Graph 5

Individual Cases

Thus far the methodology has been largely one of counting, eg. the number perceiving science as interesting and demonstrating ability in science. The advantage of this is that it is in the public domain, is clearly communicable, can be defined with little ambiguity and checked by other researchers. However, this kind of research can be criticised for making bare quantitative statements and for reporting on the general without regard to the effects on the individual.

It has been pointed out that applying a single methodology will compound weakness and that methods used within a piece of educational research should cover each other [13]. This research is investigating attitudes and this responds better to the interpretative and the qualitative rather than the quantitative. It has also been demonstrated that it is not enough to look at the outcomes, it is illuminating to examine the process as well [14]. The following case studies (with false names) describe pupils in the process of addressing themselves to individual subjects and to their understanding of their interests and abilities in those subjects. They help to illustrate the general points disclosed by the statistical findings.

Joanne is in a Yr10 foundation set. She dislikes having to use formulae, saying they 'are pointless and it is hard to remember them'. Her results in physics are accordingly low. However she does understand the science a lot of the time. She believes she is reasonably good at science but that she fails in tests. Like most of the class, and possibly because of that, she is reluctant to answer questions, even if addressed directly.

She has not decided what she wants to do in the future, except that it would not have anything to do with science. She voted for two biology (cancer research, healthy eating), one chemistry (making medicines) and two physics topics (nuclear weapons, predicting earthquakes).

Morgan is an excellent Yr10 pupil in terms of performance. He frequently scores full marks in physics tests. He finds science lessons boring and would rather be doing a different subject, which leads to him being disruptive in lessons. He dislikes normal practicals but showed great enthusiasm working on a three-lesson project requiring groups to design and test an electronic system to solve a given problem.

Morgan wants to be a technical designer, hence wanting to do a science at A-level despite his stated dislike of the subjects. He voted for five biology topics (life on other planets, police forensics, cancer research, reproduction, healthy eating), two chemistry (making fireworks, making medicines) and two physics (lasers, nuclear weapons).

Jennifer is a very bright girl in Yr9. She does not take anything as given, rather she has to understand the reasons behind it. This means she often takes a lot longer than other pupils before she is happy with an idea. In turn this leads her to describe herself as "thick" and "slow". This view of herself is not affected by her good test results (she is one of only three in the class being entered for the 5-7 tier SATs).

She does not like physics, complaining that the topics are boring and difficult. She does enjoy biology and chemistry and sees them as more important to becoming a doctor. In her questionnaire she voted for three biology topics (genetic modification, police forensics, reproduction), one chemistry topic (making medicines) and one physics topic (black holes). It is noteworthy that despite her stated interest in chemistry, she only found one of the chemistry applications interesting (and that was one which fitted her intended profession).

Matthew is an able boy in Yr9. He is determined to sit the 5-7 tier SATs papers in science, but he is unwilling to work for this. He doesn't do homework, hates answering questions in class and spends most of the lesson chatting. Despite this he takes pride in being able to understand hard concepts before

the rest of the class. His test scores fluctuate by subject – low marks for chemistry, moderate ones for biology, and good ones for physics.
He finds physics the most interesting and is prepared to work a bit harder to do well in those topics. He voted for three biology topics physics (life on other planets, police forensics, reproduction), one chemistry (making fireworks) and five physics (black holes, robots, lasers, nuclear weapons, predicting earthquakes). These interests match with his performance in tests.

Laura is one of the highest performers in Yr7 science. Her test results are excellent across all topics but she rarely answers questions in class. She says she finds the tests hard and that she isn't very good. She dislikes science lessons and would rather be doing a different subject.
Her interests are strongly physical, voting for three physics topics (robots, nuclear weapons, lasers), three chemistry topics (making fireworks, making petrol, making medicines) and no biology ones.

Steven is a strong science pupil in Yr7, but his test results are not as good as Laura's. He really enjoys science lessons and loves answering questions in class. He thinks he is very good at the subject and finds tests and practicals easy.
His preference is for biology and he wants to become a doctor. He voted for one topic in each subject (lasers, cancer research, making medicines), all connected to treating disease.

These cases highlight the problem that able girls lack confidence in their ability. They also indicate that chemistry is found interesting where it overlaps with biology. The dislike of certain aspects of science lessons is voiced by strong and weak performers alike.

Conclusions

Positive connections between interest, perceived ability and performance were found, as expected. These were all particularly strong for girls in Yr9.
Biology was the most popular discipline within science. Physics applications were a very close second to biology but opinion was against the lessons. Chemistry was shown to be uninteresting in both opinions of lessons and applications.
Pupils generally decide to take A-level science quite late, particularly so for girls. This is linked to a sudden increase in pupils' perception of their own ability, or to the realisation of career requirements.

Suggestions for Improvement

The findings of this research, admittedly limited by sample size, indicate the following.

General Ideas

A significant boost in the performance of girls might be seen if science topics were linked closely with current issues. Such demonstration of relevance is usually regarded as good practice anyway, but it would appear that the effects are greater for girls than boys.
Pupils' perception of their own ability is closely linked to their performance in tests. This is particularly so for girls. Improving pupils' perception of their ability will help improve their self-confidence. Placing less emphasis on SATs would help in this respect.
As girls choose A-levels with more regard for how difficult they see each subject than boys, increasing their performance in science at GCSE should increase the number that choose to continue.

Yr9 and Yr10 are in need of special attention. They are highly important years influencing pupils' A-level choices, crystallising ideas about interest and ability. They are where the numbers wanting to carry on with the subject overtake those not wanting to.

Schemes of Work

Physics could benefit by placing greater emphasis on learning through application. It has been seen that many topics mentioned in the National Curriculum are found interesting

by pupils. However there are many areas that are seen to be very boring. These could be incorporated into the interesting areas as ways to help understand them. For instance, fusion, electro-magnetic waves, magnetism and optics could be taught in connection with astronomy. A scheme of work of this kind has already been produced by the Open University [12]. However this is a post-16 syllabus, what is needed is a GCSE or even KS3 applied syllabus.

The way chemistry is taught needs to be reviewed. Despite the attention-grabbing experiments most pupils find the subject to be very dull. An applied syllabus, as suggested for physics, is needed, though it must be pointed out that the applications mentioned in the National Curriculum are seen as irrelevant by the pupils.

Most current work in chemistry is on the boundaries with physics and biology. Many A-level syllabuses reflect this by including significant amounts for biochemistry and physical chemistry, but the KS3+4 schemes of work are still stuck in the days of heavy industry in this country. Pupils most often express interest in chemistry topics to do with health care. Perhaps teaching should concentrate on these new fields or should admit it is dealing with the history of chemistry and address the subject appropriately. Whichever way is chosen should increase the interest to pupils and so convince more of them to carry on with the subject after GCSE.

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Number of words: 4,294

Appendix A

The following 85 double pages contain the raw questionnaire data.

The annotations at the bottom left of each sheet refer to the number of topics in each discipline (biology, chemistry, physics) voted for by the respondent.
The annotations at centre bottom are test scores for that individual.
Where applicable, the annotations on the bottom right refer to the number of questions asked relating to each discipline.