Factors working towards and against constancy in the language of science

Last updated 14 May 2009

There is a certain amount of constancy in the language of science - at least between French and English. Other essays on this site have presented some of the details. This essay considers some of the factors encouraging this constancy, and some of the factors against. The essay is focussed on the secondary school curriculum and differences between the French and English systems - which contribute to the differences - will be explained.

This essay is adapted from my unpublished Ph.D thesis, Lowe 1992 chapter 27. Some of the information and examples are dated, but they are indicative. The work of updating would make a nice piece of coursework, in whole or in part, to give to out to trainee ESP teachers.

Factors favouring an international language of science

1. **Language dominance of English**
   This needs only noting, not explaining.

2. **International Commissions**
   There have been and are various international commissions, which in various areas have sought to standardise nomenclature across several languages. This information is now dated, there have been more since it was written. Those working in ESP need to be aware that there are a whole range of international commissions seeking to standardise language within a subject, and, in the case of Canada, to standardise nomenclature between French and English. Maillot (1981 p221) mentions for instance the Conférence Générale et du Comité International des Poids et Mesures (CGPM) which started work in 1889 and (page 179ff) devotes a whole chapter to the normalisation internationale. In his special area of interest he mentions the Commission Internationale de Règlementation en vue de l'Approbation de l'Equipement Electrique (CEE) and the Commission Electrotechnique Internationale (CEI) the latter representing forty three countries. (Maillot 1981 p180). He especially mentions, for subjects other than electronics, the ISO (Organisation Internationale de normalisation) and the CEN (Comité Européen de Normalisation. (p181), then lists four others saying the list is still incomplete and on page 194-6 discusses several other organisations of standardisation. In Britain, the work of the ISO is represented by the British Standards organisation. [A misleading name, as the term 'British' here means 'applicable in Britain', not that the origin is necessarily from Britain.] The ISO is only one of the organisations responsible for implementing international norms. In the domain of medicine for instance there is the work of the BNA (Basel Nomina Anatomica) (Maher 1986b p114).

   The pressures of various international committees to standardise language exist.

Presumably such pressures come from a desire on the part of scientists speaking different languages to communicate clearly with each other and not be misled by differences.

3. **National Commissions**
Working in the same direction, but on a different track are the efforts of various groups within English and other languages to standardise usage within a language. Translation and mutual comprehension between languages is greatly enhanced if the number of synonyms and variants is reduced. The efforts towards standardisation of medical terminology have to face for instance the fact that,

> The medical language register in European languages is a jungle of synonyms. (Brucellosis has for instance, at least 25 linguistic synonyms in English). (Maher 1986 p132).

At school level in England the Association for Science Education, in association with bodies such as the Royal Society and the Institute of Biology has made attempts in recent years to standardise terminology, for units, words and other conventions, and to make clear what is acceptable for younger secondary school children and what is needed for students at baccalaureate level. Here there is an instance of two national bodies working separately who may well give differing importance to conforming to international standards. In Britain the wide acceptance by examining boards and publishers of the reports has contributed towards the recommendations as a whole being implemented, even if there are still some details still disputed, or to be agreed.

4. **Examinations and textbooks**
In England the examination bodies and the textbooks have a large influence on what is acceptable language. As the examination boards themselves are made up of experienced teachers as well as full time paid officials and university staff, examinations cannot be viewed solely as the universities imposing standards on the school system. The ASE as a specialist teachers organisation amongst others, has influence on the examinations which, until recently with the implementation of a national curriculum up to the age of sixteen, were independent of direct ministerial control. It remains to be seen how the national curriculum will influence the standardisation in England.

Efforts at standardisation are highly likely to take into account pressures for internationalisation. For instance the reversal of recommendations made by the ASE, as discussed in Section 3j below, shows how the ASE felt obliged to follow changes made at the international level.

5. **Computerisation**
In the domain of organic chemistry, the development of chemical indexing has resulted in considerable systemisation and simplification. Even here though, trivial names such as formic, acetic, benzoic, acetylene and phenol will continue to be used, therefore despite the pressure of computerisation for systemisation, not all trivial names are to be abandoned. The result then is the phenomena of 'dual naming'. In the long term therefore computerisation is a pressure increasing the internationalness of science, but while dual

naming exists, there is likely to be differences between languages.

Similarly, to turn to a modern area of research, the proposed mapping of the human genome. The sheer mass of data that will be collected, forced molecular biologists at the end of 1989, to store their information for the map in the same way, and to use a system of labelling known as sequence tagged sites which are a form of genetic shorthand. The necessity to computerise data will force standards of labelling on the whole scientific community involved. In the interests of communication between scientists working within English, let alone working in other languages, it is to be hoped that these standardisation efforts succeed. (Watts 1990 p37).

The reasons why constancy tends to break down

1. **No agreed convention**
There are some areas where, even at school level, there is no international convention, therefore there cannot be constancy of scientific language for this has yet to be agreed. Examples are oxidation number (ASE 1985 p95) and osmoregulation in animals (IOB 1989 p24).

2. **Several choices in a language**
Whenever the terminology is not clearly defined and agreed in one or more languages, it is not possible for the language to be fully international.

   Similarly, as already noted, whenever there are synonyms in a language, it is unlikely that there will be a completely similar set of synonyms in another language, and that there will always be a one to one correspondence between each synonym in each language. When synonyms exist, it is often custom and style that dictates which one is chosen in a given sentence, and it is possible that nuances of meaning exist between the synonyms.

3. **More than one international standard exists**
Even when an international committee has attempted to standardise nomenclature, it does not follow that variants have been eliminated. For instance, in the domain of chemistry, the ASE report on nomenclature has: It has to be noted that the IUPAC Rules (rules of the Commissions of the International Union of Pure and Applied Chemistry) permit the use of more than one name in a number of cases. (ASE 1985 page vi).

   > . . . the I.U.P.A.C. Rules are, for the most part, drawn up to enable research workers to name new and complicated compounds systematically, and so the I.U.P.A.C. Rules permit the use of both systematic and non-systematic names for a very large number of fairly simple compounds, including most of the organic compounds met in schools, and permit the use of at least two systems for naming inorganic ions. (ASE 1972 p1).

   The report therefore in many cases had to make a choice as to which name to recommend. The issue was complicated by the fact that so called 'trivial' names exist for many substances, and again, IUPAC is in a sense of little help in that non-systematic names are allowed.

At school level there is the question of simplifying names down to the level of comprehension of the pupils. The ASE report (1985 p2-3) states emphatically on this point that "Naturally, the name chosen should be appropriate to the level of understanding of the student".

Organic chemistry is also a special case with an "illogical morass of trivial names" (ASE 1985 p3) in which case:

> It is believed that it would be far easier to associate trivial names with a logical nomenclature if that were learned first. (ASE 1985 p3).

These trivial names are often sanctioned by IUPAC and are not necessarily as fully international as the systematic names. (ASE 1985 p3).

Also, it is possible that different languages will make different choices within those internationally permitted. This means CSL can fail at school level, even if at the researcher level there is agreement, for instance if the school system in one country takes one option and the schools in another country take another option.

4. Different science disciplines operate different standards

Biologists sometimes, use words, units and names from other subjects, including inorganic chemistry. It is quite possible for new terminology to be agreed and widely used in for instance chemistry, and for biologists to be still using the old terminology. If this can happen within a language, the situation can get more complicated between languages. The classic example of this is of course the use of the calorie as the unit of energy, a use maintained by biologists long after physics and chemistry have converted to the joule. In Tunisia in 1988 both units were in use. The fifth year biology text also used the old terminology for the copper oxides whereas in the same year, the newer system was used. [This biology text though was long overdue for revision, unlike the more recently produced chemistry text]. It is quite possible that both languages will have this kind of confusion, but this possibility ought not to be assumed: languages change, and at rates that are not necessarily the same, as discussed in Section 3e. below.

The fact that there are possible disagreements between subjects is recognised by the reports of the Institute of Biology and the Association for Science Education. At one point they give conflicting advice:

> Where the chemistry of the material is not under discussion it may well be preferable to use a trivial name for relatively complex materials. . . . Biochemistry in particular has a need for a wide range of complex materials. . . . there can be no objection to the use of approved abbreviations such as Lys, Val, for amino acids. However, when teachers discuss the structures of relatively simple substances for which systematic names can conveniently be constructed, the Sub-committee hopes that the names will be those used in the corresponding chemistry courses. (ASE 1985 p64).

> Acetic acid and acetyle (particularly in acetyle coenzyme A) are in general use by biochemists but students taking Chemistry will be used to 'ethanoic acid' and 'ethanoyl'. Acetic acid should be used in preference to ethanoic acid and acetyl should continue to be used in preference to ethanoyl because of the widespread use of acetyl in biochemistry. (IOB 1989 p11).

In all the examples given above, it is not new areas of science which are being discussed, the areas where the terminology is being developed. The examples are all from areas where the subject content is quite stable. It is the language itself which is changing, and changing at different rates and under different constraints between the disciplines in science.

e. Times of language change

Though I have not investigated this opinion, it seems to be widely held that science is a fixed body of knowledge that simply has to be learnt. Science is seen as a body of facts, theories, and practical methods, that have to be taught in watered down form to each generation. This view I suspect is held by students in Tunisia, is re-inforced by textbooks and teaching styles, and may have been a contributing factor to the assumption that scientific language is a constant.

While one might expect an emerging subject such as bio-technology to be involved in a period of language development, in order to cope with the new discoveries, presumably by the time a topic in science is taught to school children, the information, therefore the language, must have a certain fixed quality about it.

One of the features of language this research has uncovered, is the changing nature of some of the language of science. Most of these are relatively minor areas. The largest area of change was and still is that of taxonomy - an area which non-scientists might naively expect to be fixed in concrete.

What is surprising is that even in an area that might be expected to be the most fixed, the area of taxonomy, there is currently much discussion about even such basic topics as how many kingdoms there are. These are not matters of detail for the professional, they directly affect the whole approach and content of science curricula in schools. Similarly, the Association for Science Education can report for chemical nomenclature that,

> As we are now in a state of transition between the use of a very large number of trivial names and the full use of systematic names in the literature, the Sub-committee has listed in Parts 7 and 8 as recommended names not only systematic names but also some semi-systematic and non-systematic (trivial) names which appear likely to continue in use. (ASE 1985 p58).

It would be interesting to know how valid this quotation is in 2009.

Even something as simple as the decimal point is changing. The Association for Science Education now recommends that instead of the dot being written in the middle of the line, it is written on the line, thus 0.5 instead of 0·5 which makes for potential misunderstandings because the full stop is often used as a sign of multiplication (ASE 1985 p24).

6. Different styles are adopted
At school level Widdowson specifically conjectures that science textbooks are the same in different languages (1979 p51). The results have shown quite clearly that different styles are possible, and when one style is used exclusively, then a pupil going from one language to another will not necessarily be able to follow a new style.

The classic examples of this from my results come from mechanics, and the unit vector notation, which, while I am assured is known in England at University level, is certainly not used for Nuffield Physics 'A' level or any other 'A' level syllabus I have seen. Then there is the fact that students in Tunisia were not taught graphical ways of resolving questions. Neither were they taught to do things like approximations, so the concept of the 'order of magnitude', a pre-sixteen year old concept in England, was totally unknown, though the equivalent words in French do exist.

This vector notation is not just a few symbols, it encapsulates a whole different approach to mathematics, and consequently to physics. I cannot imagine British pupils at a similar level understanding the Tunisian French way easily, even when explained in English, since it is a completely different approach.

Also various notations such as the symbol for the numerical value ‖ ‖ are not used in English.

Where different styles are adopted in different languages, scientific language cannot be constant.

7. Existing language problems
The existence of specialised vocabulary and symbols in a language does not mean that the language of science is exempt from the normal differences between languages. This may seem obvious, but it is a point worth making. Building a layer of special language use that may be constant does not necessarily mean that this standardisation is cut off from the normal vagaries of each language. In some cases the specialisation is removed from the existing host language, eg some abbreviations that are the same in English and French, even though the initial letters of the verbalised phrase give a different order for the initial letters. But most of the time existing language differences such as prepositions do impinge on scientific language. [Défourneaux considers prepositions to be so important in science between English and French that he devotes a whole chapter to their clarification. (Défourneaux 1980 Part 6 chapter 2 page 151ff).]

8. **Usage of scientific versus non-scientific terms**
   The use of mixed words in science gives problems for pupils within one language. Therefore it is likely that such difficulties will be increased when crossing languages. Cassels & Johnstone (1985) have shown that it is often the use of normal words with an extra, specific, scientific meaning (the mixed words) that gives more difficulties to pupils than a completely new word. In contrast there is the trend in Britain to avoid technical words. (See IOB 1989 p29 cited in chapter 4) This fits well with the recommendations of Barrass which include the advice that,

   > Teachers should use no more technical terms than are necessary. . . . Technical terms should not be used in syllabuses and examination papers for introductory courses if there is an acceptable and easily understood everyday English equivalent. (1979 p191).

9. **Reversals of changes**
   In ASE (1985) the point is made that disagreements within international bodies "have led to reversals of their previously agreed recommendations". (p11-12). Therefore the sub-committee responsible for the publication had no option but to follow these changes, whatever they thought of them. The areas mentioned by the sub-committee are rates of reaction and cell diagrams. (p15-16,18-19). The details are complicated, and at this point of the discussion not relevant. It is sufficient to note that language change is not always in the forwards direction.

Differences in curricula: the relative importance of the subjects

My original research focussed on Tunisia, which, for sciences, broadly follows the French Baccalaureate system. There were some major differences in the curricula between England and Tunisia. This is not the place to do a thorough comparison, but several important differences are worth noting.

In the baccalaureate system, a collection of subjects must be passed, but not every subject has the same weighting. The weightings are given by 'coefficients'. So a good pass in mathematics would be of more use than a good pass in biology for instance. Other subjects are also included, which vary between Tunisia and France. Past examination papers are readily available on the web.

In the French 'Bac C', and in the comparable baccalaureate in Tunisia 'maths-science', mathematics has a coefficient of 5, as does physical science, but biology has only a coefficient of 2. Within physical science, chemistry has only one third of the marks allocated, so has an effective coefficient of 5/3, which is less than that given to biology.

England's tradition is of three subjects such as physics, chemistry and mathematics, studied at 'A' level. The other traditional combination is to do 'A' level physics, chemistry and biology, with supplementary mathematics, commonly covering elementary calculus and statistics. Depending on the school, with 'A' level physics, chemistry and mathematics, an extra, 'subsidiary' subject such as biology is often possible. The British 'A' levels have often been criticised for being too narrow. They need not be narrow, the examinations exist which permit extra subjects to be taken at lower levels. The problem in my opinion is that students are not often required to do these extra subjects, so can suffer needlessly from specialisation too soon. The advantage of the baccalaureate system is that a range of subjects at main and subsidiary level is compulsory. The International Baccalaureate also has the advantage of making a foreign language compulsory even for science students.

In comparing the various systems the following generalisations can be made concerning the Maths-physics Bac of France or Tunisia.
1. Mathematics is the single most important subject.
2. Biology is taught to a very low level.
3. Chemistry is the weakest of the three sciences.

1. Mathematics is king

Thousands of pupils, in France and in Tunisia, who have been strong in the sciences but weak in mathematics must have suffered from the way that mathematics is the most important subject. A mathematics examination is even compulsory for those doing an arts baccalaureate. The importance of mathematics can be considered under several headings.

a. Weightings

Because of the way the coefficients are arranged, weakness in mathematics is the most severe handicap in the overall result in the examinations.

b. Kinds of mathematics taught

Differences in the type of mathematics taught have already been noted. These have included details such as the 'order of magnitude' and more fundamental differences such as the use of unit vector notation. Other significant differences include the reliance in physics on algebra to the almost exclusion of graphical techniques. Over a decade later I have not seen any evidence that this reliance on algebra has changed.

From the French viewpoint, the level of mathematical skills required in England is elementary, especially the way that calculus is not required knowledge for students doing physics 'A' level.

In the 1980s in France and Tunisia the mathematical skills required to do approximations were not taught whilst in England, estimating an answer before doing a detailed calculation, was and still is an important technique, and the 'A' level physics examinations can include estimation questions.

c. The amount of mathematics used in physics

This can be difficult to estimate. The figures in figure 1 below though are indicative. Figure 1 gives the marks allocated to mathematics in physics examinations taken in England, Tunisia and France, according to my judgement on inspection of the papers. This is the figure without counting the practical examination, which would tend to reduce the percentage, and accentuate the differences. The emphasis on mathematics was to the detriment of practical work.

Figure 1: Marks allocated to mathematics in written physics examinations

June 1988	England. AEB	53%
June 1989	England. AEB	54%
June 1987	Tunisia (National examinations)	67%
June 1989	Tunisia (National examinations)	69%
June 1988	France (Paris region)	84%
June 1988	France (Marseille region)	84%

Testard-Vaillet (1992) notes that:
Les maths ont un poids important parce qu'elles sont faciles à évaluer. On ne sais pas bien noter ce qui est expérimental, observations, analyse de situations compliquées, questions ouvertes laissant un peu de liberté aux candidats. (p27b)

> [Maths is very important because it is easy to test. It is very hard to give fair marks for observations, experiments, complicated situations, and open ended questions which give some liberty to candidates].

La résolution de problème de physique? Rien des maths appliquées. (p26b)

> [An examination question in physics? It is nothing but applied mathematics].

2. **Biology is taught at a relatively low level**
In the maths-physics bac, biology suffers. It is given more importance in the experimental sciences bac. Given that universities in England will often accept people for a biology degree without biology at 'A' level if there is evidence of good standard in the other sciences this is not very significant.

3. **Chemistry is the weakest of the three sciences**
Chemistry is considered to be the servant science in England. Students wishing to study physics to 'A' level can be obliged by teachers to study chemistry. Similarly, students of biology can be seriously handicapped if they do not study chemistry, especially as much of the recent developments in biology are in the domains of genetics and biochemistry, both of which require a foundation in chemistry.

4. **Discussion**
It could be argued that mathematics is also a servant science, and I would not disagree. Schools offering students physics 'A' level usually offer them supplementary mathematics as noted above. I suspect it is rarer to see courses in supplementary chemistry offered. The point here is that in the French system the supremacy of mathematics happens at the price of downgrading chemistry. In England, chemistry is given much more importance.

Naturally therefore, in a smaller French syllabus, key topics will either not be treated in comparable depth, or, will be ignored altogether.

There is also the problem in Tunisia/France that chemistry is taught as part of physical science. In practice in Tunisia this means that separate teaching hours were allocated to the two subjects, but that the same teacher usually taught both subjects. In Britain, chemistry is usually taught by specialists who have done a degree in chemistry not physics.

It is a generally known fact of life that when two subjects are combined, unless extreme care is taken, then one of them will get downgraded in importance. (Tyner 1975 Rowe & Stone 1977, 1979, Hughes 1979). There has been no attempt in the baccalaureate to give higher weight to chemistry, and this difference must be considered as a serious deficiency in the French baccalaureate system for any English person comparing the two systems.

To its credit, the International Baccalaureate has corrected these deficiencies. The system of subject groups has been made more flexible with subjects being put into groups and pupils taking one subject from each group. Mathematics in various forms comprises one group, which can be taken at main or subsidiary level. Similarly the separate sciences are offered, with physical science a possible subject in which equal weighting is given to each of the two disciplines.

One of the associated assumptions of the constancy of the language of science is that the science taught in one country will be essentially the same as that in another. Yet these are huge cultural differences, which are bound to affect what is taught.

References

ASE. (1972) *Chemical nomenclature, symbols and terminology for use in school science*. 1st edition. Association for Science Education.

ASE. (1985) *Chemical Nomenclature, Symbols and Terminology for use in school science.* 3rd edition. Association for Science Education.

Barrass R. (1979) Vocabulary for introductory courses in biology: necessary, unnecessary and misleading terms. *J. Biol. Educ*. 13:3, p179-191.

Cassels JRT, Johnstone AH. (1985) *Words that matter in science*. The Royal Society of Chemistry.

Défourneaux M. (1980) *Do you speak Science? Comment s'exprimer en anglais scientifique.* Gauthier-Villars.

IOB. (1989) *Biological Nomenclature, recommendations on terms, units & symbols*. 1st edition. Institute of Biology.

Maher J. (1986) The development of English as an international language of medicine. *Applied linguistics*. 7:2, p206-218.

Maillot J. (1981) *La traduction scientifique et technique.* Publ: Technique & Documentation, Paris.

Rowe MH, Stone J. (1977) Naming of neurones. *Brain Behav. Evol*. 14, p185- 216.

Rowe MH, Stone J. (1979) *The importance of knowing our own presuppositions*. Brain Behav. Evol. 16, p65-80.

Tyner CF. (1975) The naming of Neurons: applications of taxonomic theory to the study of cellular populations. *Brain Behav. Evol.* 12, p75-96.

Watts, S. (1990) Making sense of the Genome's secrets. *New Scientist* 4 August 1990. p37-41.

Widdowson HG. (1979) *Explorations in applied linguistics*. Oxford University Press.