SCIENTIFIC
LANGUAGE
AT PRE-UNIVERSITY LEVEL
BETWEEN FRENCH AND ENGLISH

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Thesis presented for the degree of Ph.D
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ABSTRACT

KEYWORDS: scientific language, French, English, English for Special Purposes (ESP), baccalaureate, Tunisia.

In 1983 two pilot schools in Tunis began teaching sciences and mathematics, one through French, the other through English, but based on the French curriculum and textbooks. The content and language of science was assumed to be similar: only the host language changed.

In the pilot schools, physics, chemistry, and biology lessons were observed, set textbooks and their translations were compared, teachers' meetings attended, and sixth year pupils were tested. The validity of the assumption that scientific language is similar in French and English was assessed, and some of the consequences explored. The work was restricted to communication through words and non-verbals such as symbols.

The results show that the assumption is only fully valid for the symbols of the elements and amino acids, and the SI system of units. Scientific language is not necessarily constant between French and English.

Implications are drawn for linguistics and for the teaching of English to students of science: the differences cannot be ignored, because many of them are fundamental ones.
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ACKNOWLEDGEMENTS

I wish to express my gratitude to all who have helped me in the long quest towards a Ph.D.

Firstly, this research would not have been possible without the consent of the Ministry of Education, and the Ministry of Foreign Affairs, in Tunisia.

Secondly, Mme Soua, Head of the English school, and Mme Boulahla, Head of the French school, gave me free access to their establishments. I am grateful to them, and to the teachers who freely gave much assistance and allowed me to observe lessons.

I wish to thank Dr Clark, and his successor Mr Handforth, Heads of the British Council in Tunis, for their encouragement in the research, and their willingness to write letters of introduction on my behalf.

Many people gave detailed suggestions and advice, and most are listed in Appendix 2.

Finally I wish to thank my supervisors in England, Joan Smith, Maureen Pope and Clive Turner for enabling this extensive piece of field and linguistic research to take place.
GLOSSARY

1. For convenience, the *Lycée pilot de l'Ariana* is referred to as the 'English school', and the *Lycée Bourguiba* as the 'French school'. The teachers from Britain working in the English school have been referred to as the 'British' teachers. The words 'English' and 'French' refer to language not people unless the context indicates otherwise.

2. To distinguish between the first second and third language, the convention used by linguists of L1, L2 and L3 has been used. For pupils at the two schools these are respectively:

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<td>L1 Arabic</td>
</tr>
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<td>L2 French</td>
</tr>
<tr>
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<td>L3 English</td>
</tr>
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3. For want of a better abbreviation, the assumption that scientific language is similar between French and English has been labelled CSL: Constancy of Scientific Language.

4. All figures, tables, and boxes are given the label 'Figure' so as to simplify the numbering sequences.

5. Most of the time, material in French is supplied with a parallel translation in English. Where no acknowledgement is given the translation is mine. When quoting bilingual sources this has been indicated eg 'Translation: Défourneaux'.

6. The custom in phonetics is to indicate a symbol using the / / marks around the symbol. I have chosen to use the more well known convention of single inverted commas ' '.

7. Some may distinguish between ESP, English for Special Purposes, and EST, English for Science and Technology. For thesis purposes ESP will be retained.
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1. SUMMARY OF THE BACKGROUND TO THE THESIS

One of the aims of the Department of Educational Studies at the University of Surrey is to do research into cross cultural differences and approaches in the understanding of science, as taught in schools. The context of the two pilot schools in Tunisia provided a setting in which this aim could be pursued. In one of these two schools, the 'English school', a French based curriculum in science and mathematics was taught in English to Tunisian pupils, while the comparable 'French school' taught science and mathematics in French.

The assumption made in the English school was that science was the same in English and French, that is if someone spoke and wrote English and French well, there would be no difficulty switching languages when studying science. [1] Scientific language, both non-verbals such as symbols and equations and the verbals, such as definitions and terminologies was assumed to be constant between English and French and to be independent of the host language.

1. The meaning of 'sameness' is defined in Chapter 3 'Basic terminology Section 2 'Constancy'.
2. THE TUNISIAN SITUATION

Tunisia's Education system broadly follows that of France, with the major difference that instead of all the education being in French, two languages are involved, Arabic and French. After six years in primary school of mainly Arabic but including a considerable amount of French, pupils take an examination, the *sixième*, which is comparable to the old 11+ examination in England. Those who succeed go to a *Lycée* (like a grammar school) leading, seven years later, to the baccalaureate. [1.]

Throughout the *lycée* the sciences and mathematics are taught in French.

In 1983 two experimental grammar schools (*lycées pilotes*) were set up, with pupils recruited from those with the best results in the *sixième*. In one of the schools, the English school, the sciences were taught in English not in French. The British Council were involved in retraining Tunisian science teachers to teach in English, sending them to Britain for a year, initially to Leicester University, then later to Bristol University and arranging refresher courses for them in the summer. The British Council also provided books and helped to recruit British teachers from 1986-1990.

From the beginning it was envisaged that the most successful students would go on to English speaking universities for their degrees. (*Lycée* Ariana 1984). Those that could not get a grant for this, would return to the French language system of Tunisia. To this end students had to continue studying the French language while at school, and it was assumed that the students would have little difficulty changing back to French since scientific language was assumed to be constant.

The *lycées pilotes* had an accelerated science curriculum compared to other Tunisian *lycées*, and drawing from the same pool of pupils, the two schools were broadly parallel in their curricula, which gave a good basis for research comparing science in French with science in English. The only important difference between the two schools was supposed to be the language in which sciences and mathematics were taught.

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1. Note in France, the 'middle school' system is now used, and the word *lycée* strictly speaking applies to the last four years of secondary education. In Tunisia the word is used to mean secondary education from the *sixième* to the baccalaureate.
taught. The teachers at the English school were obliged to follow as closely as possible the Tunisian curriculum and ways of teaching.

In the field situation then the assumption was held that science, and specifically, scientific language, is the same in English and in French. The field situation also provided propitious circumstances for testing this assumption.

3. OUTLINE OF THE METHODS USED

The research was conducted over the school years 1986-1989. In 1986-87 British teachers at the English school were interviewed regularly. Classes of biology were observed in 1987-88, concentrating on the most advanced year, which was newest to the teachers and was where translation of textbooks was being done, and the tensions of teaching a French curriculum in English were most real and most frequently talked about. In 1988-1989 classes of physics and chemistry were studied, partly because of teachers had informed me of major differences meriting study, and partly because here the theory could receive a more thorough testing in the areas of symbols, equations and chemical formulae. Towards the end of the school year 1988-89 several tests were given to the pupils to assess the significance for the pupils of some of the differences found, and to study for instance how well they were able to cope with them. My length of stay in the schools helped me to win the confidence of the teachers. I functioned in the lessons as a 'participant observer', and, at the request of the Headmistress of the English school, I attended departmental teachers meetings. I had access to all the translated material. My frequent presence in the school meant I was often present when a new teaching difficulty or translation point was being discussed. I also had opportunity to question the teachers, and to obtain invaluable backup information from my studies of the textbooks and translations.
4. CONSTRAINTS

The notion of CSL, Constancy of Scientific Language, is too big to investigate at all levels. I have therefore restricted the thesis to non-verbal and verbal communication. Also, because the theory is not spelt out in detail, I have first identified several areas where CSL might reasonably be expected to be valid. These are for the verbals: faux amis, definitions, linkwords, prefixes and suffixes, abbreviations, eponymes, diseases, taxonomy, and chemical terminology (Section III Chapters 8-18); and the non verbals: symbols, indices, equations, and miscellaneous (Section IV Chapters 19-24). The questionnaire results are discussed in Chapter 8 (faux amis), 18 (chemistry), 23 (physics), and 24 (student opinions).

It was necessary to clarify the terminology used to describe language in science, in particular that 'scientific language' refers to both words used exclusively in science, and common words which have a science specific meaning. (See Chapter 3 'Basic Terminology').

In each topic area, the sub-hypotheses were formulated in response to the question: if scientific language is constant what would one expect to find, what would be the consequences and wherever possible how could the material available best be used to test this. Material used to test the sub-hypotheses was collated from several areas, including lesson observation, a study of the textbooks and use of reference books and other literature.

To my knowledge, no one has ever before documented where scientific language at baccalaureate level differs when the host language is changed between English and French, and to what extent there is constancy in scientific language at this pre-university level.
5. FINDINGS

The differences between science in English and in French are classified and discussed in Section III 'Verbals' (Chapters 8-18) and Section IV 'Non verbals' (Chapters 19-24). It has been found that for only a very few linguistic features such as the symbols of the elements is scientific language completely constant between French and English. Most of the time the assumption was found to be only partly tenable and sometimes it was found to be completely untenable.

In Section V, After a results summary (Chapter 25) and a discussion of the validity and reliability of the results (Chapter 26), the questions as to why CSL is not always valid, and the forces acting for and against the constancy of the language of science are discussed (Chapter 27). Finally, some of the implications of the research findings for linguistics (Chapter 28), and for the teaching of English as a foreign language to science students (Chapter 29) are considered and the broad conclusions are stated in Chapter 30.
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1. INTRODUCTION

This chapter introduces the Tunisian situation and the pilot schools, as the context in which the assumption that scientific language is constant was studied. For general references on Tunisia and the education system see Appendix 17.

2. THE BROAD LINES OF THE TUNISIAN EDUCATION SYSTEM

The Tunisian education system is broadly based on the French system. All education is free, but pupils have to buy their own textbooks, which are printed by the government and sold at low prices.

a. Three levels

1) Primary school education
   This is available to all, male and female, a great achievement when it is realised that just before Independence in 1957 only 20-25% of Tunisians who were of school age were in education. (Riguet 1984 p13). There are six years, and French is introduced in the fourth year, for 9½ hours a week (Tunisie 1984 p51, Tunisie 1986a p33). After six years there is a nationally set examination called the sixième which leads to the secondary level. Only those who pass are allowed to proceed, the rest repeat the last year (French: doubler) or leave the system.

2) Secondary school education
   There are two broad types of school, the professional (technical) schools, and the 'Lycées' which have a three year common curriculum, followed by a choice between: a) Sitting an examination leading to four years of study in the écoles normales which culminates in an examination at baccalaureate level, but with the obligation upon the students to become primary school teachers. b) Four years of study leading to one of the three baccalaureates, Lettres, Math-Science, or Math-Technique. [1.]

1. Strictly speaking in France the word 'lycée' refers to the last four years of secondary education. Tunisia uses the word both in the strict sense, and in the wider sense, of post primary education leading to the baccalaureate.
3) **University education**

This comprises various colleges and faculties. For a general degree system, there is a diploma after two years, the third year is called 'Licence' but has less importance than the British 'Bachelors', more important being the *Maîtrise* after four years. To proceed further then requires a mémoire of 20,000 words called the C.A.R., 'Certificat d'Aptitude à la Recherche' followed by courses, examinations and a thesis leading to a D.R.A., 'Diplôme de Recherches Approfondies' which is roughly equivalent to the French 'Doctorat de troisième cycle' or the British M.Phil. The highest qualification, as in France, is the 'Doctorat d'État'.

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**b. Bi-lingualism**

Almost all pupils speak the Tunisian dialect of Arabic when they first enter school. Unlike Algeria or Morocco there is no Berber minority in Tunisia except in a few villages in the south. French is taught from the fourth year of primary school, though this has varied as ministers of Education have changed. French is used for the language of mathematics and science in the secondary schools and University, except for the *écoles normales*, (the teacher training schools for primary school teachers), where Arabic is used. All students in schools get training in modern literary Arabic.

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**c. Centralisation**

The Ministry of Education sets the Curricula, publishes textbooks, and sets the examinations for the *sixième* and the baccalaureate. A system of inspectors enforces the syllabi. In theory teachers have the right to change the order in which material is taught but not the content, but in practice this freedom is rarely taken. Compared to British teachers before recent changes, there is very little scope for teacher adaptation or innovation.
d. The Tunisian baccalaureate

This is based upon the French idea of a baccalaureate examination. Once the kind of baccalaureate is chosen, the subject combination is fixed. Each subject has a 'coefficient' assigned to it, and students must achieve an overall average of 50% to pass. The examinations are on the final year of the syllabus only. Students who almost get the required 50% have their year's test marks considered, and some are allowed to resit one or more papers, usually before the summer vacation begins. [2.]

In the 'maths-science' baccalaureate, taken by the students in the French and English schools, physical science and mathematics each had a coefficient of 5, and biology had a coefficient 2. Other subjects such as French, philosophy and English were also examined. For a further discussion of the baccalaureate see Chapter 27 'The forces operating for and against CSL'.

e. Miscellaneous

The French cultural 'mission' maintains several schools, preschool, primary schools and lycées. These are mainly for the benefit of the French foreign community and are fee paying. Students follow a curriculum set by France and taught in French by teachers from France, with Arabic and religion for Tunisians taught by Tunisians. The examinations taken at the end of the secondary school are one of the French baccalaureates, with papers set by France. Boarding facilities are available for students whose parents live outside the main cities, and only in Tunis are the final four years taught.

Unlike Britain the private education system in Tunisia is of low standing with low success rates.

2. The exact details of where the cutoff marks are, can vary from year to year.
3. THE PILOT SCHOOLS

a. History

There is little published literature on this subject. According to the Directrice of the English school, Madame Soua (1987, Interview T9) plans for the English school originated in 1978 with the Prime Minister, Hedi Nouri. Construction began in 1979, with the first intake in 1983. The English school, is more properly known as the "Pioneer school for The Teaching of Science and Technology in English (Lycée Pilote pour l'Enseignement des Sciences et la Technology en Langue Anglaise)" (Labadi 1984 p75).

According to Labadi, one of the teachers of English at the English school, the objectives of the English school were to
1) substitute English for French in the teaching of science and technology
2) "to prepare the pupils for higher education in anglophone countries (ie. The United States, the United Kingdom and Canada)." (Labadi 1984 p76, Lycée Ariana 1984 p10).

It is clear then that at the beginning it was conceived that at least some of the students who passed their Baccalaureate examinations, would go abroad for further study. Also, according to Le Temps of 18 June 1989,

En effet il était question jusqu'à une récente date de créer un institut supérieur de technologie à Carthage avec le concours de la Grande-Bretagne et des États-Unis où l'enseignement se ferait en anglais et vers lequel les diplômés du Lycée de l'Ariana seraient orientés. Mais il semble qu'après l'unification du régime d'enseignement des lycées pilotes, cet institut supérieur de Carthage qui aurait le caractère d'une université libre à l'instar de l'université américaine de Beyrouth n'a plus sa raison d'être.

In effect, until recently, the idea existed to found a technology institute at Carthage with the cooperation of Britain and the United States, in which teaching would take place in English and towards which students from Lycée Ariana would be directed. But it seems that, now the pilot schools have had their regimes unified [ie French used not English] the setting up of this institute at Carthage, which would have been like a free University like that of the American University of Beirut, is no longer justified.
This was a sensitive point in both schools during the period of my research. As I understand it, the British Government policy is to sponsor post-graduate training in the UK, therefore Tunisia could not expect much help there unless the Tunisian government itself was willing to provide a large part of the sponsorship. Unfortunately this question was not sorted out before the school started, and it is not surprising that although in May 1989 it was decided to expand the pilot schools to six, adding an extra four at Sfax, Sousse, Gafsa and El Kef, it was also decided to revert to the teaching of sciences at the English school in French. In view of all the hard work put in by the staff at the English school, and all the resources invested in it by the British Government amongst others, this change was regrettable but not without reason. Very sensibly, students who had begun in English would finish in English, but as of September 1989 the intake to the English school would be taught in French not English.

It is important to note though that from the beginning it was envisaged that some pupils would have to revert to studying sciences in French. These pupils would either be those who left for any reason during their course, or those students unable to obtain scholarships to go abroad after their baccalaureate. Therefore French language was taught at the English schools and maintained at five hours a week in years 4–6 when the other lycées reduced it to three hours a week.

The French government sponsored up to fourteen teachers at a time to work in the French school, which in the year 1987–8 had 23 classes of 25–30 pupils.

In the English school there were fewer British nationals. All were working in sciences, computers and mathematics and none worked teaching English as a subject. The teachers were sponsored by the British Council. In 1985 there were two teachers rising to five in 1986 with the last teachers finishing in 1990.

On the Tunisian side, the Tunisian government recruited each year teachers who were sent to England, first Leicester University, then
to Bristol University, where they completed a specially arranged teacher training course designed to enable them to teach their subjects in English. This was supplemented by short intensive summer courses in England, particularly Bristol.

The French school was received in its entirety from the French government, as it was a Mission française school called 'Lycée Carnot'. When it became a pilot school it was renamed 'Lycée Bourguiba'.

As for the examination results. Only the first set are available at the time of writing this thesis. The English school achieved a pass rate of 93% and the French school 94%. Le Temps reported in a page one headline of 21.6.90 that the level of success at the first attempt of examinations was 80% for the French school, with no mention of the English school, but in the inside pages, when the actual numbers were given, 89/117 pupils passed at the first attempt, which is 76.07% not 80% and the English school actually did marginally better, with 72/89 ie 80.9% succeeding at the first attempt. The national figures, excluding private schools and independent candidates for the Maths-Sciences baccalaureate were 33.02%. In the twenty-three students getting the highest grade of result, a 'mention très bien' (over 80%) the English school had four and the French school had five students. (La Presse 1990).

b. Similarities between the English and the French schools

In view of the comparisons I will make between French and English, and in particular between pupils in the two schools it is important to identify the similarities and the differences between the two groups. The similarities are:

1) All pupils had a similar primary school education, similar in the sense that no English was taught, and they all followed courses for six years in Tunisian government primary schools. Unlike Britain, this meant a common syllabus with state textbooks.

2) All students had, in accordance with the regulations for entry
into a pilot school, never repeated a year, had a maximum age of 13 in October of the year of entry, and had succeeded in the 'sixième' with a mark of at least 80%. (Lycée Ariana 1984).

Students admitted to the French school in 1988 had a mark of 19.2/20 to 17.8/20 (96 to 89%) and to the English school of 18.55/20 to 17.6/20 (92.75% to 89%). (La Presse 1988).

3) The students came from all over the country and were at least 80% boarders.

4) The maternal language was the Tunisian dialect of Arabic.

5) The syllabi for all subjects in the lycée were the same. This also includes the subjects taught. The only exceptions to this were:

a) Students at the English school had a term of Intensive English before starting biology and mathematics in English. Students at the French school, having had French in the primary school were able to continue mathematics and start biology in the first term. By the time of the fifth and sixth year, where most of my research took place, these initial starting differences had probably evened out. [3.]

b) In the fourth year, one class of students were allowed at the French school to proceed towards the Arts baccalaureate. This option did not exist at the English school: right from the first year of entry all students were oriented towards the Maths–Science baccalaureate, and the few students who needed to do the Arts baccalaureate were encouraged to leave and go to a normal lycée.

c) At the English school French was taught as language only, ie no other subject used French as the 'vehiculing' language, whereas in the French school, English was taught as language only.

6) The same subjects were taught in Arabic ie history, geography, art, music, home economics, religious and civil instruction, and games.

7) All students were taught classical Arabic.

---

3. There is much more French than English spoken and heard in Tunisia. There is a French channel on TV, much official business both written and spoken takes place in French, and French books and magazines are freely available to borrow and buy.
8) Students studied mathematics, physical science (from now on referred to as physics or chemistry as appropriate, as the lessons were divided up this way, but taught by the same teacher), natural science (biology), technology and computer studies in the given vehiculing language of the school, i.e. French at the French school and English at the English school.

9) The school routines were similar, for instance testing five times a year.

10) All students sat the same baccalaureate examinations, the first ones for the schools being in June 1990. The examinations were national ones, and an English translation was prepared for the students at the English school.

11) Both schools had non-Tunisian teachers, and received foreign aid that included books and computers.

12) Science subjects were divided up into time for practicals, in which half the class was taught, and theory lessons to the whole class.

13) No fees were payable, and poor students received financial help to enable them to stay in the state provided hostel.

14) Students came from all over the country. The information in Appendix 15 shows this in detail for the English school and there is no reason to doubt that the French school was not similar.

15) There was a high teacher to pupil ratio, especially when it is known that much of the time in science was spent in half classes, the full class being 30 students or less. [4.]

---

4. TEF, (T45;3) warned me to be careful with this teacher to pupil ratio. In February 1988 he had estimated that there were 67 teachers at the English school for about 500 pupils, making a teacher to pupil ratio of 1:8. But this was misleading as the children got around 36 hours per week of tuition. This is in comparison to English pupils who get around 36 periods of 35 minutes of instruction i.e. 21 hours per week. Also, the teaching hours for each teacher were less than in England, being 16 hours a week teaching, and 2 hours a week preparation in the English school, compared with 21 hours or more in a school in England.
c. Differences between the English and the French schools

The best way of presenting these differences is in the form of a comparative table, without further discussion as in the figure 2.1 below.

<table>
<thead>
<tr>
<th>Figure 2.1 French and English School Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>French school</strong></td>
</tr>
<tr>
<td><strong>French Language</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>English Language</strong></td>
</tr>
<tr>
<td><strong>Sciences/Maths</strong></td>
</tr>
<tr>
<td><strong>Numbers of Classes</strong></td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Resources</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>School Location</strong></td>
</tr>
<tr>
<td><strong>Science Textbooks</strong></td>
</tr>
<tr>
<td><strong>Other Books</strong></td>
</tr>
</tbody>
</table>
FIGURE 2.1 CONTINUED

<table>
<thead>
<tr>
<th>TUNISIAN SCIENCE TEACHERS</th>
<th>Degree through French</th>
<th>Degree through French + one year in UK learning to teach in English. (one teacher had been in America)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MILIEU OUTSIDE SCHOOLS</td>
<td>Arabic, French</td>
<td>No English</td>
</tr>
<tr>
<td>APPROACHES</td>
<td>Tuniso-French</td>
<td>Tuniso-French and Anglo-Saxon</td>
</tr>
<tr>
<td>INSPECTORS</td>
<td>NOT necessarily the same set for each school as the two schools were in different administrative regions</td>
<td></td>
</tr>
<tr>
<td>STUDIES AFTER BACCALAUREATE</td>
<td>The majority will probably do degrees in Tunisia through French. A select few will get scholarships abroad.</td>
<td></td>
</tr>
</tbody>
</table>

For detailed information concerning the hours of study per subject see Appendix 5. The major differences between the schools for the hours of study are:

1) While both schools began physical science in the first year, unlike other schools where this was begun in the fourth year, in the French school studies of these subjects began in the first term of the first year, whereas this was delayed until the second term of the first year in the English school. In fact the English school delayed starting physical science and natural science until the second term.

2) The English school began the first term with an intensive course of English, and it was the English teachers who began teaching another subject in English in the first term, namely computing. Intensive English continued throughout the first year.

3) The French school taught English from the first term, unlike a normal school which postponed it until the fourth year. The level of English was less than at the English school and no other subjects were taught through English, as noted in figure 2.1 above.
6. THE ENGLISH SCHOOL AND CSL

a. The CSL assumption

In the interview with the Directrice of the English school (T9, 26 May 1987) it became clear that she believed science was a universal language and that mathematics was the easiest subject to teach in English at the beginning as lots of symbols were used.

She went on to explain that as all the students were heading for the Tunisian baccalaureate, the curriculum had to be the same, except for certain options such as computing, and the accelerated English course. The students, it was argued, would easily be able to fit back into the Tunisian University system [French based, for sciences] because "the technical words are mostly the same". (T9:23).

The whole existence of the school was based upon this one undemonstrated assumption that science and mathematics are sufficiently similar when taught in English and French to make the language only a host for the content, and making it easy to switch languages when studying science. Scientific language: both the non-verbals such as symbols, indices, equations and graphs; the words, the definitions and the terminologies; and also the way of doing school level science, were assumed to be identical in English and French. Scientific language was constant so that if learnt through one host language it would transfer readily and not need to be relearnt in another host language. A method or an equation learnt in English would be the same method or equation in French, only the carrier language changing.

Circumstances were such as to provide a good situation in which to study this assumption, at school level, because the two schools were following the same curriculum with similar pupils; only the host language of instruction was different.
This assumption was reinforced by other pressures namely:

1) The English school pupils had to learn a subject in exactly the same way as their French school counterparts.

2) The British and Tunisian teachers were obliged to teach a subject the "Tunisian" way as specified in the national textbooks and syllabi, and by the inspectors.

This meant that, for instance, when in translating the textbooks there was a choice of vocabulary, the wording closest to the French had to be used. The clearest example of this occurred when a Tunisian teacher (TEB) wrote "In mammals, the growth of pelage is related to photoperiods". I corrected "pelage" to "fur" when asked to proof read the translation. (The word "pelage" exists in English but it is not used in schools and is not the most common word). TEB insisted on retaining the word "pelage".

b. The translation process

The inspectors insisted that the official Tunisian textbooks had to be translated, so as to adhere closely to the Tunisian system. Various exceptions were permitted eg third year biology used a British textbook, but when Mackean's "Introduction to Human and Social Biology" (1985) was suggested by the biology teachers as a textbook to be used in the sixth and seventh years and supplemented by translated material, the inspector refused it. (T75:14-17, 103:6-9). When asked for his reasons he explained that one must not give the pupils more information than necessary, and that ultimately he did not feel he had the right to authorise the use of an English text unless it reflected the Tunisian textbook closely. The inspector insisted on translation. "La traduction est irrefutable". (T75:17).

In fact, few sections of the textbooks were translated word for word. If possible similar material was culled from existing texts in English. At times the opportunity was taken to clarify or update the French text. [5.]

5. For instance, year five biology calculations on molarity, in which old units of 'normality' were updated to use 'moles', and old units were changed for the new units.
The first year textbooks were written under the supervision of a specialist from England. The other textbooks were translated by the subject teachers. When I arrived in 1987 the biology department were behind in their work, so material was given out as handouts, later incorporated into a book. The teachers meetings were often used for discussion of translation difficulties. In spring 1989 the physics and chemistry textbooks were divided up among the teachers, each one doing a section. There was little opportunity for a native speaker to do a final proof read, so inevitably the material was uneven in quality. Also in certain areas such as the translation of a force having direction and sens, opinion changed over time. (See Chapter 9 'Definitions').

5. CONCLUSIONS

In the field situation, the theory that scientific language is constant (CSL) was an assumption which undergirded the whole pilot school in English project. The assumption was supported to varying degrees by several pressures to conform as closely as possible not only to the Tunisian curriculum but also to the French usage of language. CSL was an assumption held in a real teaching situation with real practical effects on the way science was taught.

In the next chapter the terminology used to describe language used in science is presented, while in Chapter 4 there is a wider discussion of the various meanings of 'scientific language'.
SECTION I INTRODUCTIONS
CHAPTER 3
BASIC TERMINOLOGY

1. INTRODUCTION

As has been explained in the Introduction and in Chapter 2 'The situation in Tunisia', scientific language was, in the English school, regarded as 'the same' or 'constant'. At no point though was 'scientific language' or 'constancy' ever defined by those involved in the English school. For the purposes of research a greater precision in these terms is required, which is what this chapter provides.

2. CONSTANCY

The assumption was widely held in the English school that scientific language was constant. If anyone knew well both English and French, and knew their science in English then they would have no difficulty studying science in French.

At no point was any greater precision made. At least four alternative possibilities can be identified. These are summarised in figure 3.1 below.
FIGURE 3.1 ALTERNATIVE MEANINGS FOR CONSTANCY IN SCIENTIFIC LANGUAGE

<table>
<thead>
<tr>
<th>SAME WORD</th>
<th>DIFFERENT WORD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SAME SENSE</strong></td>
<td></td>
</tr>
<tr>
<td>same word</td>
<td>different word</td>
</tr>
<tr>
<td>same sense</td>
<td>same sense</td>
</tr>
<tr>
<td>eg French: oxygène</td>
<td>eg French: azote</td>
</tr>
<tr>
<td>English: oxygen</td>
<td>English: nitrogen</td>
</tr>
<tr>
<td><strong>DIFFERENT SENSE</strong></td>
<td></td>
</tr>
<tr>
<td>same word</td>
<td>different word</td>
</tr>
<tr>
<td>different sense</td>
<td>different sense</td>
</tr>
<tr>
<td>eg French: dire, to say</td>
<td>English: dire, terrible</td>
</tr>
</tbody>
</table>

In the English school it was assumed that most of the time the same words existed in French and English with the same senses. Occasionally different words existed with the same sense. Similar words having different senses, or different words with semantic fields that did not fully overlap, were assumed either not to exist or to be so rare that they were negligible in importance.

This thesis tests constancy mainly in terms of the same word form with the same sense. Sense is taken to mean fully overlapping semantic fields and identical denotations and connotations. The same word form means identical spelling or with only only minor spelling differences.

3. 'SCIENTIFIC' AND 'NON-SCIENTIFIC'

When various writers are consulted it becomes evident that there is no standard terminology to distinguish between:

a) words which although they are used in science, do not have a meaning specific to science,

b) words which have both a common usage in ordinary situations and a different and precise usage in science,

c) specialised words used only in science with no meaning outside science.

A common terminology is to use 'technical' versus 'non-technical' (eg Cassels & Johnstone 1985). In this case there is imprecision concerning the words classified in b) above. Cassels & Johnstone (1985) call the scientific part of b) 'normal English in a science context' (p1) while
Trimble (1985 p128) refers to words with a common and a science meaning as 'sub-technical'. Trimble adds to the confusion in that he has a two fold definition of 'sub-technical' as being both words that are in common use between several scientific disciplines, and those common words with a special meaning in science.

Newmark (1988 p152-4) says that Paepcke (1975) distinguishes between four varieties of technical language, as in figure 3.2 below.

**FIGURE 3.2 PAEPCKE'S (1975) VARIETIES OF TECHNICAL LANGUAGE**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Scientific</td>
<td>chambre de congélation</td>
</tr>
<tr>
<td>2. Workshop level</td>
<td>compartiment réfrigérateur</td>
</tr>
<tr>
<td>3. Everyday usage level</td>
<td>congélateur</td>
</tr>
<tr>
<td>4. Publicity/sales</td>
<td>freezer (as a French word)</td>
</tr>
</tbody>
</table>

Newmark criticises this saying "a scale like this one is likely to be valid only for one or two terms in a few fields". (p153). He then suggests his own scale (p153) based on medical vocabulary, which is presented in figure 3.3 below.

**FIGURE 3.3 NEWMARK'S (1988) VARIETIES OF TECHNICAL LANGUAGE**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Academic</td>
<td>phleghmasia alba dolens</td>
</tr>
<tr>
<td></td>
<td>(Latin and Greek words)</td>
</tr>
<tr>
<td>2. Professional</td>
<td>varicella, tetanus</td>
</tr>
<tr>
<td>3. Popular</td>
<td>chickenpox, lockjaw</td>
</tr>
</tbody>
</table>

Newmark's own criticisms of his scale are that these are general categories to which a word is often arbitrarily assigned; nomenclature is often clouded by obsolete, obsolescent or regional terms; there is a frequent tendency to use a trademark as the name of a product eg 'bic' for 'biro', and there is the problem of eponyms which are not recognised by another country and language. My criticisms are firstly
that the distinction between 'academic' and 'professional', at least viewed from a school perspective, is a very fine one: both are technical levels. Secondly Newmark fails to distinguish between common words with no special meaning at all in science, and 'mixed' words which have both a common meaning and a science specific meaning.

As a translator Newmark is interested in another distinction, that between 'technical' and 'descriptive' terms. He gives the following sentence in English with a possible French translation:

The submarine's surface is perfectly smooth, with the forward diving planes, rear rudder and radio and sonar bubbles as the only protrusions.

On a donné au sous-marin une forme parfaitement hydrodynamique; seuls les gouvernail et les dômes longeant la radio et le sonar font saillie.


In the example given, 'smooth surface' is a descriptive term and Newmark argues it ought to be translated by the descriptive term 'surface lisse' instead of the technical term 'forme hydrodynamique'.

But even this so called technical term 'forme hydrodynamique' to a scientist is a descriptive term. Both components 'forme' and 'hydrodynamique' have a scientific meaning in their own right, (depending on the context and discipline, for a scientific word can have more than one precise meaning), and together they form a descriptive technical term. Therefore this terminology of 'technical' and 'descriptive' is not helpful in determining appropriate levels of language used in science. The terminology presented below in figure 3.4 is much clearer, with 'forme hydrodynamique' being classified as a specialised term and 'surface lisse' as a mixed term with a science specific meaning.

There are not enough precisely defined terms to express all the distinctions needed to describe the language used in science in relation to the language used outside science. Part of the problem lies in a failure to distinguish between a term and its meaning. The terminology that will be used in this thesis is presented in figure 3.4 below.
FIGURE 3.4 TERMINOLOGY: LANGUAGE IN SCIENCE

<table>
<thead>
<tr>
<th>Term</th>
<th>Meanings</th>
<th>Example</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>non-specialised</td>
<td>common</td>
<td>water</td>
<td>non-scientific</td>
</tr>
<tr>
<td>(totally)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mixed</td>
<td>common OR</td>
<td>cell</td>
<td>scientific</td>
</tr>
<tr>
<td></td>
<td>science specific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>specialised</td>
<td>science only</td>
<td>bacterium</td>
<td></td>
</tr>
</tbody>
</table>

A 'cell' can be in common usage, a 'room', as in a 'jail'. The word has at least two science specific meanings: in biology as a unit of protoplasm, usually with a nucleus, cytoplasm and enclosing membrane, and in electricity it is a receptacle for generating electricity by chemical reactions, or decomposing compounds by electrolysis.

A common word can often be made science specific by adding qualification, for instance 'heavy water' (French eau lourde) refers to water containing atoms of deuterium.

The words 'sub-technical' or 'semi technical' (Newmark 1988 p154) have not been used, both because of the dual definition of Trimble (1985 p128) and because they could mean the 'mixed words' or the 'science specific meaning' of mixed words. 'Science specific' neatly enshrines the examples where the usage in science of a mixed word is referred to. 'Technical' and 'non-technical' could equally well have been used for 'scientific' and 'non-scientific', but as this thesis is about the language of science, terms with 'science' in them have been retained. However the words 'technical' and 'non-technical' would have had the advantage of making figure 3.4 applicable to other academic disciplines.

A clear distinction has been made, as shown in figure 3.4, between words of 'science only' meaning, and 'scientific' words, which in this thesis includes mixed words with a science specific meaning. Similarly 'non-scientific' words are both all those non-specialised words with a common meaning, and the common meaning of mixed words.
The French authors Vinay & Darbelnet (1975 p65) have used terms which are close to the terms I have chosen to use. These are "mot usuel" (lit: usual word) for what I have called 'non-specialised'; "mot technique déguisé" (lit: disguised technical word) for what I have called 'mixed'; and "mot technique" (lit: technical word) for what I have referred to as 'specialised'.

The distinctions are also important for CSL. It is the non-scientific words which are translated in the normal way, and the scientific words which are assumed to be constant. This is expressed in figure 3.5 below, taking English and French as the example languages.

**FIGURE 3.5 WORDS WHICH ARE TRANSLATED AND WORDS WHICH ARE ASSUMED TO BE CONSTANT ACCORDING TO CSL**

<table>
<thead>
<tr>
<th>English</th>
<th>Relationship</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>non-specialised, common</td>
<td>&lt;---translation----&gt;</td>
<td>non-specialised, common</td>
</tr>
<tr>
<td>mixed, common</td>
<td>&lt;---translation----&gt;</td>
<td>mixed, common</td>
</tr>
<tr>
<td>mixed, science specific</td>
<td>&lt;---constancy------&gt;</td>
<td>mixed, science specific</td>
</tr>
<tr>
<td>specialised</td>
<td>&lt;---constancy------&gt;</td>
<td>specialised</td>
</tr>
</tbody>
</table>

**4. CONCLUSIONS**

Constancy refers primarily to similar form and sense.

A terminology has been established as in figure 3.4 in which 'scientific' words are in contrast to 'non-scientific' words. A 'scientific' term can be either the 'science specific' part of a mixed term, or a purely 'specialised' term. It is these 'scientific' words that were assumed to be constant between host languages, in particular, between the host languages of French and English.

In the next chapter the subject of scientific language is discussed in more detail.
SECTION I INTRODUCTIONS

CHAPTER 4

SCIENTIFIC LANGUAGE

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   c. Ewer (1971) .............................................................................................. 5
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1. WHAT IS SCIENTIFIC LANGUAGE?

a. Introduction

Is science any more special than any other subject in being less culture bound, and less subject to the usual differences between languages and consequent problems when translation is undertaken? CSL would imply that scientific language is special, but what exactly is scientific language?

There are occasions when everyone knows what is being talked about, and attempts to define the obvious only make the picture confusing. Other people take the approach that before one can discuss anything fairly, what is meant by the key terms must be explained. To leave a key term undefined leads to imprecision and possible confusion.

One of the main problems in ESP is that the subject matter covers both science and language, and most practitioners do not have a sciences background.

To me as a former science teacher the question 'what is scientific language?' has a rather obvious answer. Scientific language or discourse is the textbooks, the language of the classroom and laboratory, and the language required for discussion, reports, essays and examinations. To me it is also the language of magazines such as the New Scientist and Scientific American. [1.] Only at the graduate and postgraduate level would scientific language be the journals and theses.

The question is then put, what makes this language different from any other language used in any other discipline? Each discipline has to have a certain amount of specialised vocabulary, but is the language of science more than this?

1. These magazines should be broadly accessible for most of their content to a wide range of educated people, and not just to those with a degree in science.
The question is important for language teaching. If there are certain areas of language that are used more frequently in science than in non-science oriented language course, then these are the areas to concentrate on in the ESP lessons.

Similarly, if the vocabulary of science is largely international and constant then there is no need to teach it afresh in ESP.

It is important to know what we are talking about also if effective learning strategies are to be devised for students.

The question has been discussed in the literature, and some areas have been put to experimental test. I will concentrate mainly on summarising some of the reviews, and further references can be found in them for the details.

b. Strevens (1977, 1976)

Strevens in a survey article (1977) asks what is the nature of scientific discourse and what is different about it compared with the rest of 'normal' language. (p153-4). He says that scientific discourse uses a lot of words, roots and affixes of Greek and Latin origin, and uses, or has access to, symbols, numbers, names of chemicals etc which are largely international in character.

In many respects scientific language is normal in that a scientist functions in a host language using the same system of pronunciation, the same accent, the same common grammar, rules of spelling and orthography, and even a lot of the common non-specialised vocabulary as anyone else. [2.]
For Strevens scientific discourse is like a different style, therefore the differences can be explained not in terms of the basic components of the language, but in terms of, ... the statistical properties of the mixture in which they occur, and the intention, the purpose, behind their selection and use. (1977 p153)

Therefore the features of scientific prose for Strevens are,

(i) rather long sentences containing many clauses, often in complex degrees of dependency and with much embedding;
(ii) long nominal groups containing strings of adjectives or nouns acting as adjectives, each providing the greater specificity that comes from modification upon modification, and
(iii) frequent passives which have the effect of putting important ideas in initial position where in English they carry salience of meaning.(1977 p154 layout of quotation altered for clarity).

Or, as he put it in an earlier article (1976)

'Scientific English' is simply 'English used by scientists or for the purposes of those engaged in science'. It has the same grammar, pronunciation and spelling as are found in all kinds of English; it includes much of the general vocabulary of English, though with a large number of specialized items or of familiar words used in specialized ways; it also carries an array of linked symbols and visual symbolizations which nevertheless can be verbalised by those who know the rules for doing so.

What then is different or special about 'scientific English'? A brief and oversimplified answer is that the particular mixture of grammatical and vocabulary items typically found in 'scientific English' may display some or all of an array of features, including eg:

- long and complicated noun-phrases . . . ;
- a higher proportion of passive constructions . . . ;
- the frequent use of logico-grammatical items . . . ;
- a high proportion of items of specialised vocabulary . . . .

Equally important is the fact that the argument, the rhetoric, the communicative function of scientific English is chosen so as to serve the particular purposes of the writer or speaker.(1976 p64 layout of quotation altered for clarity).
c. Ewer (1971)

Ewer compared the English of science with that of the more 'general' English course (E.L.T.) given in schools. He notes the wide variation due to lexis, but also found variations at the level of grammar. He notes the differences, as in the figure 4.1 below, and concludes,

it is therefore clear that any E.L.T. (English Language Teaching) materials for science students must place special emphasis on these items. (p67)

FIGURE 4.1 EWER'S LIST OF GRAMMATICAL ITEMS THAT NEED STRESSING IN ESP (1971 p67)

<table>
<thead>
<tr>
<th>Group I: Items essential to basic scientific English but not presented and exercised in any of the courses:</th>
</tr>
</thead>
<tbody>
<tr>
<td>-ing forms replacing a relative</td>
</tr>
<tr>
<td>Infinitive as substitute for longer phrases</td>
</tr>
<tr>
<td>Words similar in form but with different meaning for the same function</td>
</tr>
<tr>
<td>Most prefixes and suffixes</td>
</tr>
<tr>
<td>Most structural and qualifying words and phrases</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group II: Items essential to the basic scientific English but not presented and exercised in two out of the three courses or dealt with inadequately:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compound nouns</td>
</tr>
<tr>
<td>Passives</td>
</tr>
<tr>
<td>Conditionals</td>
</tr>
<tr>
<td>Anomalous infinitives</td>
</tr>
<tr>
<td>Cause-and-result constructions</td>
</tr>
<tr>
<td>Words similar in form but with different functions</td>
</tr>
<tr>
<td>Past participle usage</td>
</tr>
<tr>
<td>The prepositional (two part) verbs common in scientific English.</td>
</tr>
</tbody>
</table>

d. Robinson (1980)

In Chapter two, 'Survey of the theoretical positions' Robinson gives a brief historical survey of ESP, reviews 'register analysis', 'discourse analysis' and the 'communicative approach' amongst others.

Robinson says that the existing data is insufficient to establish and differentiate a clear 'register' of science. The 'surprise' of Ewer and Latorre at the "great variety of writing in scientific
English" (1967 p224) is reported, and the fact that different sub­
registers "tended to use distinct structures". (1967 p224). There
is though broad agreement that scientific English is general
English plus the extra components of science. (Robinson 1980 p17).
She says that there is a great need for less generalisation and
greater precision that could account for differences of opinion.
Swales for instance has advocated that the main verbs in scientific
texts are generally in the present simple tense (I go) whereas Close
emphasises the continuous form of the verb (I am going). (Robinson
1980 p19.)

A broad agreement that the discourse markers, and connectives
(linkwords) are important, does seem to exist. (p21), though
ironically Robinson remarks of connectives that they are perhaps
important
... not because they are special to ESP but because the
general ELT (English Language Teaching) has so far ignored them.
(p21).

Discourse markers then are not necessarily unique to science, but
are very important, as Dawe (1983) argues. (See Chapter 11
'Linkwords'.)

e. Coffey (1984)

This article, as Coffey says in the first sentence, is an update of
Strevens (1977) discussed above. His conclusion about register
analysis is that,
... register analysis cannot be used as the main basis for
selection [of ESP material], because there is no significant way
in which the language of science differs from any other kind of
language. It is still useful in the setting up of minor targets
in the field of syntax. It offers better guidance in the field
of lexis. (p4-5).

So the language of science is not just another register, and the
concept of register is of little help in designing ESP material.
Widdowson, in his article "Literary and scientific uses of English" (1974a) compares the scientific language with literary language, with particular reference, not to lexical items or the frequency of use of certain grammatical forms, but to the different ways of using the same language. He says that both involve the use of language to communicate something which lies beneath the surface of apparent reality as it is reflected in ordinary language use. (p283).

He gives several examples. Literary language has use of the single persons as amalgams of the normal use of two other persons. (p286).

\[
\begin{align*}
1/\text{we} & = 1 + \text{he/she} \\
\text{You} & = \text{you} + \text{he/she} \\
\text{He/she} & = 1 + \text{you}
\end{align*}
\]

In each case the amalgam is singular and complex "in which neither person retains its original identity". (p287)

Scientific language on the other hand avoids the first and second person (p288), thus detaching a message from its sender and receiver. The passive is used. 'We' is also used, but in a special way, to refer to both the person communicating and the person being addressed.

It is important to recognise that the 'depersonalised' statement of the scientist represents a way of referring to phenomena in a 'non-ordinary' manner which is as much an essential part of science as is the 'subject matter' (p289).

New terms in literature are complex (wind can be inanimate and human) in science they are compound such as "copper electrode" (p290). This to Widdowson is not a point of grammar. The example given of a compound, "copper electrode", while grammatically equivalent to "the electrode which is made of copper" (p290) does not have the same value. The compound term is a name of something already viewed as having a distinct separate entity, and the stress is on this name, not on describing the electrode.

Scientific English then to Widdowson is characterised in communicative terms by for instance the impersonal passive, the use of 'we' to refer to writer and reader, and compound rather than complex terms.
g. Discussion

It is obvious that scientific English is somehow different to ordinary English, but attempts to state precisely where these differences are, have largely failed. Strevens' generalisations are useful guidelines, but are not applicable to all scientific writing. Ewer's lists are a step in the right direction but are as much based on educated guesses as hard experimental data that are widely applicable. Widdowson's argument that scientific language uses impersonal forms is an over-generalisation: some styles do, but not all journals require the use of the passive, for it is sometimes important to state who is doing the action, because the person can affect the results.

Part of the problem is the sheer complexity and variety of language. Another part is the broadness of the question which may need breaking down into smaller components. The world of science is vast. What part of this scientific world is being analysed? Once the answers start arriving for small clearly defined areas, the evidence can be put together and wider conclusions made with a higher level of confidence.

A comparable question is what distinguishes the language of history from normal English, and on what evidence. Therefore what is special about science, and is science more than any other specialised subject of enquiry.

For the purposes of this thesis, scientific language, is the language of the science textbooks, the classroom and the examinations.
2. ZYLBERSZTAJN'S CONCEPTUAL FRAMEWORK

Most of this thesis is concerned with the language of science at school pre-university level. Zylbersztajn (1983 p1.7,8 see also Swift 1986 p2.33-2.35) has a simple framework to conceptualise the major transformations of knowledge in the context of secondary school science education. Zylbersztajn sees at secondary school level science belonging to the scientist, the curriculum, the teacher, student (ie after learning has taken place at school) and the child (ie the person before formal training in science). The processes linking the transformations in knowledge are curriculum planning, lesson planning, and classroom activities.

FIGURE 4.2 ZYLBERSZTAJN'S CONCEPTUAL FRAMEWORK
(Original abbreviations written in full, after Zylbersztajn 1983 p1.7)

While this is a simplified picture, a child may for instance interact directly with other sources of information, the model is helpful in distinguishing between various kinds of science.

If we apply the Zylbersztajn framework to CSL, while it would be expected that the science of the child could differ widely between the two languages and cultures, there will be no differences for science of the scientist, science of the curriculum or science of the teacher, and also few differences for science of the student, particularly students just before university entrance. So in curricular planning and in lesson planning the constancy of scientific language could safely be assumed.
This can be illustrated in an adaptation of Zylbersztajn's conceptual framework to two languages as in Figure 4.3 below.

FIGURE 4.3 SCIENCE IN TWO LANGUAGES AS PREDICTED BY CSL

The bulk of this thesis concerns science of the curriculum and science of the teacher. Some reference is made to science of the scientists, particularly in collecting comparative data from sources like Défourneaux (1980, 1983) and Maillot (1981). Some attempt to look at the science of the students is also made in the questionnaires given to sixth year students. For the science of the curriculum and the science of the teacher, scientific language is assumed to be constant.

The science of the curriculum for this thesis includes textbooks and examination papers. The science of the teachers includes interviews and my attendance at meetings where lessons and translations were discussed. It also includes material from the many lessons I attended in which I noted both what was said and what went onto the blackboard.
3. CONSTANCY OF SCIENTIFIC LANGUAGE AT PRE-UNIVERSITY LEVEL

This thesis is firmly rooted in the secondary school, unlike most ESP teaching which is to undergraduates. As students at undergraduate level will have had science at school, it is this basic science rather than specific specialised science that all ESP students will have in common. Therefore this thesis in concentrating on pre-university science is dealing with foundational science. If there are differences in the area of foundational science, these will be important for any English teacher of a mixed group of science students to know about.

Most of the references to CSL though are to the professional scientist, or to undergraduate courses (eg Widdowson 1979 p23,24 Swales 1984b p71 though not Brian Wilson 1981). Therefore it could be argued that to test CSL at school level is unfair, because science is not necessarily a universal language at school level.

But even if all the references to CSL were to university teaching and the professional scientist, it would still be a valid extension to include the language of school science. School science is science of a more elementary and a more commonly established level than that of a professional scientist, who may well have to work with competing theories and incomplete and changing data. School science is concerned with scientific statements generally accepted to be true, it is not involved in advancing the frontiers of science. Therefore one would expect scientific language to be even more constant at school level than at the level of the professional scientist. This is particularly valid for the final years of school science, which are distant from the initial years, when the pre-scientific world view of children with minimal formal teaching in science is likely to still be dominant.

Also, school level science is foundational to the science of the working scientist. Therefore if CSL can be shown to be invalid at school level, the CSL in the foundations of the working scientist is undermined. In those areas where a working scientist depends on and is constrained by a background of school science, scientific language may not be constant.

3. A discussion of the views of these authors will be found in Chapter 28.
4. 'SCIENTIFIC' VERSUS 'NON-SCIENTIFIC' TERMS IN TWO LANGUAGES

English is a rich language. Part of this richness is due to words imported from other languages. It means that in science a choice of words that refer to the same thing is often available. The choice can be between a word of Latin or Greek origin; and a word of Anglo-Saxon origin. The former are sometimes called 'scientific' and the latter 'non-scientific'. For instance, 'erythrocytes' (a scientific word) are commonly called 'red blood cells' (a non-scientific word).

Cassels and Johnstone (1985) have studied this phenomena at school level. In their opinion,

The problem lay, not so much in the technical language of science [4.] but in the vocabulary and usage of normal English in a science context [5.]. (p1),

and

Things are at their most dangerous stage when both learner and teacher know the meaning of a word and each assumes that the other shares the same meaning. (p15).

It is the 'mixed' words, those having both a common and a science specific meaning that are most likely to be words where the teacher assumes the science specific meaning is understood, and the student understands the word only in its common sense.

Trimble (1985 p128-9) reports that students who had few problems with neither technical vocabularies nor 'general English' still had weaknesses in three areas: memorising, less technical noun compounds, and sub-technical vocabulary (words in common to several scientific disciplines and common words having a special meaning in science). Once again it is the 'sub-technical' (Trimble) or 'mixed' (this thesis) words that give problems.

Clearly if the science specific words can give problems within one language to native speakers, the situation is bound to get more complicated with two languages as is the case in Tunisia. Firstly there is the problem that a person may not be a native speaker in at least

4. ie 'specialised' language (cp Chapter 3 'Basic terminology' figure 3.4).
5. ie 'mixed' language (cp Chapter 3 'Basic terminology' figure 3.4).
one of the languages. (In fact in Tunisia neither French nor English was
the native language of the pupils). Secondly the distinctions between
both scientific versus non-scientific words, and the common versus
science specific meaning of mixed words, exist in both languages. And it
is by no means automatic that each language will make the distinctions
in the same place: varicella in French is both a non-specialised and a
specialised name, whereas in English it is specialised only, the non-
specialised name being 'chicken pox'.

Ideally both sets of distinctions must be learnt, with this additional
complication that French and English may not make the same distinctions
in the same way. Thirdly, there is the distinct possibility in the
Tunisian system where sciences are taught through a foreign language
that a pupil will learn the scientific meaning of a mixed word and not
know the common meaning.

If scientific language is constant then semantic fields for all
scientific terms, whether mixed or not, will be the same, not only the
forms of the words or symbols.

It is also an open question as to whether or not the French prefer
scientific vocabulary to non-scientific when a choice exists. Certainly
the British teachers and some Tunisian teachers expressed the opinion
to me several times that given a choice French will use the scientific
word. (T17:15, 32:5, 32:7, 80:6, 84:11). The question is raised, but the case
either way has yet to be made.

What can be said with confidence is that there is a trend in Britain
in schools to avoid scientific words. This trend can only exacerbate
the problem with mixed words. Thus in 'Biological Nomenclature' it is stated
that "Whenever possible, English terms [such as Red blood cell] should be
used in preference to Latin and Greek Terms [such as erythrocyte]".
(1OB 1989 p29 cp Barrass 1979). Even Savory can make the remark that
though science has a many Greek and Latin words, which is apparently a
distinguishing feature of scientific prose, there is in English the "well
established belief that such words are to be avoided where possible".
(1953 p23).
In the English school, because of the decision to follow the French as closely as possible, the advice to use non-scientific words rather than scientific words was not followed, and the trend of following the French led almost invariably to the scientific word being preferred when there was a choice.

This is not to say that there are no critics within Tunisia of the high scientific vocabulary demands on pupils. Skik (1986) did a word frequency study of scientific French words used in the official first year mathematics and *science naturelle* textbooks. [6.] He compared what he found against the third edition (1972) of *Le français fondamental* (F.F) spoken French (France 1972), and an unspecified edition for written French. He concludes that for the biology text:

*Comparaison avec le F.F.*

*En résumé, cet ouvrage se caractérise par la trop grande richesse de son vocabulaire: les trois quarts des termes utilisés ne figurent ni dans les ouvrages du Primaire ni dans le Français Fondamental. (p238)*

For the purposes of this thesis as explained in Chapter 3 'Basic terminology', both the science specific meanings of mixed words, and the specialised words have been included in the comparisons between French and English. This means that one would expect (given CSL) that the one to one correspondence between scientific words would extend not only to science specific terms, but also that where a mixed word has a science specific meaning in one language this would be paralleled in another language. A word that is mixed in one language would have a parallel mixed word (not a specialised word) in another; a word that is specialised in one language would have a corresponding specialised word (not a mixed word) in another language. Where both scientific and mixed terms exist in one language, both terms would also exist in the other.

---

6. The mathematics textbook was without date, the biology text was the 1982 edition).
6. DISCUSSION

It will not be possible in the scope of one thesis to test all the aspects of the constancy of scientific language. Instead, I have concentrated on the verbal and non-verbal levels of communication. The question pertains to how valid the assumption of constancy is for each linguistic feature. It will be shown that this is often only partly valid, that there are a few very restricted linguistic features where it is totally valid, and there are other areas where the theory is invalid.

To say that there is constancy of scientific language is to say that a science specific word in English will have a corresponding science specific word in French. Similarly a mixed word in English will also be a mixed word in French, and at least for the science specific component, there will be one to one correspondence between them. The divisions between non-specialised, mixed and specialised words should correspond between English and French. Faux amis among scientific terms would not be expected, and the definitions and terminologies should be the same.

Before any attempt to teach English to French speaking students of science can be made differences between science through English and science through French must first be documented. Only then can it be known what prior knowledge of science and its conventions can be safely assumed to be constant and left without any formal teaching.

Documentation of differences must also precede an evaluation of their significance. Ewer (1971) quoted above in figure 4.1 lists some features of scientific English and points out that given the differences and the difficulties they cause for students,

The important thing here is to determine clearly which of the difficulties that students appear to encounter are significant. (1971 p68)

This raises the question as to what is a significant difference. Ewer sees a significant difference as one giving significant difficulties to the students. This helpfully stresses the student's opinion about the differences (in contrast to the teacher dealing thoroughly with the points he himself may have had difficulty with, or conversely, points he has a special facility in teaching) but begs the question as
to what is a significant difficulty. Ewer describes a significant difficulty as that which gives rise to 'unacceptable' mistakes i.e. that interfere materially with communication between scientist and scientist.

In this thesis a provisional attempt is made to assess the significance of some of the differences. In particular some of the faux amis were tested in sentence completion exercises (cp Chapter 8 'Faux amis' Section C 'Faux amis questionnaire'). In addition students were asked how confusing they found some of the differences and these opinions were contrasted with their actual ability to cope with the differences. Students were found to be over-optimistic.

Some of the examples given have a greater significance than a mere difference, because they exemplify larger trends and differences of approach to a subject. These will be pointed out in the results, and in the discussion chapters in section V.

It is in schools that the foundations of mathematics and sciences are laid. Whatever the future specialism of a student is, it is here that the core of knowledge and skill is established, and the core, however deficient it is in certain areas, will be in the common possession of all science students at University who turn to learning English. This is particularly true given the narrow range of options possible in the baccalaureate in the French system.

The question is, does this core differ when languages are changed, and are the differences inherent in the language? Can the constancy of the language of science be assumed by teachers of ESP? If not, which areas can be assumed with confidence, and which cannot?
SECTION II METHODOLOGY

CHAPTER 5

FOUNDATIONS OF THE PROJECT

FIGURE 5.1 CALENDAR OF THE MAIN EVENTS OF THE THESIS

1. DEVELOPMENT OF THE PROJECT AND METHODS

2. THEORETICAL PERSPECTIVES: PRINCIPLES
   a. Research as an apprenticeship
   b. Study the situation first, then derive and test hypotheses
   c. Proceed cautiously, and stay long enough to get good results
   d. Understand one's role
   e. Work in a way that leaves a return door open for further research
   f. Observation should be validated by comment from people in the field situation
   g. Evidence needs corroboration
   h. Study the complex by concentrating on the simple
   i. Define your hypotheses so that they are testable
   j. Compare with other countries
   k. The thesis should be so written that it is clear and understandable to people in the field situation

3. PRACTICAL CONSIDERATIONS
   a. Negotiating access to the schools
   b. British teacher interviews 1986-87
   c. Local sponsorship
   d. Authorisations
   e. The schools
     1) The English school
     2) The French school
     3) The pupils

4. FORMULATION OF HYPOTHESES
### FIGURE 5.1 CALENDAR OF THE MAIN EVENTS OF THE THESIS

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easter 1985</td>
<td>Holiday in Tunisia. First heard about the English school.</td>
</tr>
<tr>
<td>Summer 1985</td>
<td>Preliminary discussions with Dr Joan Smith: prospective supervisor at Surrey University.</td>
</tr>
<tr>
<td>July-August 1986</td>
<td>Research proposal written.</td>
</tr>
<tr>
<td>May 1987</td>
<td>First visit to the English school.</td>
</tr>
<tr>
<td>Summer 1987</td>
<td>Visit to University of Surrey to consult library and supervisors Drs Pope and Smith.</td>
</tr>
<tr>
<td>Summer 1988</td>
<td>Visit to the University of Surrey to consult library and supervisors Drs Pope and Smith.</td>
</tr>
<tr>
<td>Sept 1988 - Nov 1988</td>
<td>Re-applied for permissions to do research.</td>
</tr>
<tr>
<td>April-June 1989</td>
<td>Questionnaires administered.</td>
</tr>
<tr>
<td>Summer 1989</td>
<td>Visit to the University of Surrey to consult library and supervisors Drs Pope and Smith. New supervisor (Mr Turner) to replace Dr Smith proposed.</td>
</tr>
<tr>
<td>Oct 1989 to date</td>
<td>Full time teacher of English, University of Tunis.</td>
</tr>
<tr>
<td>Summer 1989</td>
<td>With new supervisor, Mr Turner, the first draft of the thesis discussed.</td>
</tr>
<tr>
<td>Sept 1990 - June 1991</td>
<td>Second then third drafts of the thesis were prepared. Dr Pope (co-supervisor) left the University of Surrey.</td>
</tr>
<tr>
<td>Summer 1991</td>
<td>Detailed discussions on the thesis with supervisor Mr Turner, with comments from S. Hunston.</td>
</tr>
</tbody>
</table>
1. DEVELOPMENT OF THE PROJECT AND METHODS

This thesis will be easier to understand after having read the following personal note as to how I, a former science teacher, first came to start a research project in Tunis. The subsequent timetable of events, as summarised in figure 5.1 above is also of use.

I came to Tunisia on a private holiday, Easter 1985. At the same time I read about the English school in an advertisement in the Guardian, asking for teachers for the English school. Though I did not reply to the advertisement, the seeds of a research project were sown. Such an unusual situation of a school in Tunisia teaching the sciences through English instead of French was worth further investigation.

In the summer of 1985, I talked to Dr Joan Smith who was then in the Educational Studies Department at the University of Surrey, and was my ex-anthropology lecturer from the Department of Human Biology and Health. [1.] She encouraged me to go back to Tunis, learn some Arabic and study the background to the situation such as the education system.

In the summer of 1986 I wrote a research proposal. As a self financing student I was independent enough to follow my own interests. I contented myself in 1986-7 with a slow approach, beginning with a series of in-depth interviews with the British teachers, culminating in an official request to see the English school, to speak to the Head and the staff in May 1987.

Discussions with the British teachers had highlighted one area that could be investigated using the situation of the two schools and their similarities and differences: the constant demand by pupils for 'definitions'. What if the definitions given in one language were different when given in another? In the early days of lesson observation, the search for definitions given by pupils, teachers, and in textbooks was a guiding light, until it became part of the general

1. A department that is now closed, which is regrettable, for it turned out employable graduates familiar with both pure sciences such as physiology and biochemistry, and the social sciences such as psychology and anthropology.
quest to test the assumption that scientific language is constant.

In the autumn of 1987 I made a formal request to the Ministry of Education for authorisation to observe classes in the two schools (see Appendix 1 for the letter used). While my application was being processed, on 7 November there was a sudden change of presidents in Tunisia. The then Prime Minister Ben Ali, had the ageing President Habib Bourguiba declared incapable of fulfilling his duties and took over power. This change may have served to delay my authorisation, but also to have facilitated it, as the new government was potentially more open to something as unusual as a Ph.D student in a pilot school. From January to June 1988 I observed biology lessons, my area of expertise, in the first and fifth years.

After renewing my authorisation, from November 1988 to June 1989 I observed classes in physics and chemistry, as advice from teachers was that there were many interesting differences between English and French to be found in these subjects. During the course of this year the work shifted from an anthropological approach to that of gathering data to test the assumption that scientific language is constant. It was to my advantage that the long periods of observation in the schools obtained for me sufficient confidence from those in the English school that I could study a potentially sensitive topic as one of the assumptions made in the school.

From October 1989 onwards I have held a post teaching English language in the Faculty of Human and Social Sciences at the University of Tunis. This job has enabled me to work and to have time to write up the thesis in the country of my fieldwork.

Given the interest in the Department of Educational Studies at Surrey University in studying the perspectives held by different groups of people when confronted with similar areas of knowledge, an interest which was deepened during the course of preliminary discussions with my prospective supervisors, the English and French schools merited a second look. This is especially so when the fact is born in mind that both schools had to follow the Tunisian-French curriculum, so that even in English the French language and curriculum had to be followed as closely as possible.
As my knowledge of the situation increased it became obvious that the situation was an ideal test-bed for the assumption that scientific language is constant. Even if it had not proved to be a useful situation in this respect, it would have been interesting in its own right to, for instance, have done an ethnograph, an analytical comparative description of the two schools, because the schools were unique in Tunisia.

Much of the evidence assembled concerns French learners of English. The two main authors cited (Maillot and Défourneaux) wrote in French, and the translation work in the English school (mainly textbooks) was from French to English. This follows the same pattern as English for Special Purposes (ESP): the demand is more for science through English than science through French. It is therefore reasonable to draw a lot of the evidence from sources working in this direction. Material going from English to French, i.e. English speakers desiring to communicate about science in French, is also scarce. In contrast I, as a native speaker of English was continually having to learn the language of science in French, therefore was working in this other, English to French, direction.

3. THEORETICAL PERSPECTIVES: PRINCIPLES

Broadly speaking, anthropology can be divided into three branches, physical anthropology with its links with genetics and ethology; prehistoric archaeology; and cultural (USA) or social (Britain) anthropology also known as ethnography. Ethnology is often taken to be equivalent to ethnography, particularly in the USA, but in Britain refers more to the history of peoples. Social anthropology overlaps with sociology particularly where field research is concerned. Ethology on the other hand is a branch of zoology which studies the behaviour of species, often interpreted as the result of evolution moulded by natural selection. (Bullock & Stallybrass 1977: anthropology, ethology, ethnography & ethnology).

I was greatly influenced at the beginning by the sociologist Burgess (1984) and the anthropologists Werner & Schoepfle (1987), the latter expanding upon Spradley (1979, 1980). Burgess did his field
work in a British school and has written an account of the school (1983) and various books on methodology (eg 1984). Werner & Schoepfle are Americans who describe various techniques of anthropology, techniques applicable to schools not just to work in remote tribes. All these authors draw on material from social anthropology, ethnography, ethnology and sociology, the distinctions between them being of academic interest. It was from these authors, and others cited below, that I established the principles for the research in Tunisia.

a. Research as an apprenticeship

Because the research was an apprenticeship, especially in the early stages, I was free to experiment and to learn from my mistakes. In particular, there was one path that turned out to be a lot of work for little results, that of the observation of the first year classes. [2.] The time was not wasted in that my presence in the schools for those lessons helped relationships with the teachers who provided so much of the material for the thesis.

b. Study the situation first, then derive and test hypotheses

Burgess (1984) discusses the problem of imposing a hypothesis on a situation before the situation is known adequately.

In common with many field studies my work was 'exploratory'. It had no well worked out hypotheses that were to be refined and tested. However, in common with all researchers, I did have a set of questions to address which were generally framed. (p34).

Burgess at this point is particularly interested in the problem of how to frame a research proposal, particularly for grant making bodies which may require a well thought out set of hypotheses and research methodology, and yet the situation is too unknown to propose hypotheses with confidence. In a similar vein he later writes,

Uncontrolled methods should be used to determine how controlled methods can be used. (1984 p145).

2. This may have been because the amount of material covered was small, and included very little language specific to science.
Stephen Wilson (1977) has written:

Formal theory should enter only after the researchers have become convinced of its relevance. (p250).

The ethnographer must constantly make decisions about where to be, what kind of data to collect, and to whom to talk. Unlike the prestructured research designs, the information that is gathered and the theories that emerge must be used to direct subsequent data collection. (p256).

I initially asked myself what was different between the two schools, and what was different when sciences were taught to a Tunisian-French curriculum, but in English rather than in French. I also attempted to describe each situation accurately, drawing inspiration from my own teacher training, where I had been taught to ask questions about a new school, to learn where things were, to study classroom layouts, to know the particular procedures and customs of that school for a wide variety of tasks. I took note of the helpful ideas in Denicolo (1985) such as to notice the general scientific orientation of the teacher, the focus of the teaching (pupil or subject-centred), the methods used, the rapport with pupils and how explanations were couched.

In the summer of 1988 I came to the point of decision after two terms work in the schools, whether to proceed to write an ethnography of the schools, or to compare teaching methods, or to test the assumption that scientific language is constant. I chose to test the CSL assumption because I believed this could be of greater significance and importance. A change of emphasis was then required, from accurate description and understanding of a field situation, to active seeking out of data relevant to the testing of my hypotheses. It also meant the use of new methods of data collection, such as comparison of the French textbooks with their English translation.

c. Proceed cautiously, and stay long enough to get good results

Stephen Wilson has two sets of questions for assessing the work of an ethnographer. The first set probes the researcher's ability to move beyond his own perspectives, the second set probes his effectiveness in coming to understand the perspectives of the
participants. The questions from the second set include:

1) How long was the researcher in the setting?
2) How well did he understand the language of the participants?
(S. Wilson 1977 p262 based upon Naroll 1967)

Werner & Schoepfle in their list of minimum standards say,

An ethnographer should make a serious effort to learn the language of the people who are the topic of the ethnography.
(1987 2 p334 point 14)

To answer Wilson's questions, I was there two years learning Arabic and making initial enquiries, and four terms over two years in the schools. I spoke French well enough to communicate with teachers and others in authority, to read the textbooks and to take notes in class. I spoke dialect Arabic well enough to have a good relationship with the 'door keepers', the ever present porters and others who can ease or hinder admittance into schools and offices (for instance in the Ministry of Education). I could also maintain social relationships in dialect, and follow the broad subjects when the teachers switched into dialect. I can translate official documents written in Classical Arabic. In addition, knowing both Tunisian dialect and French, I could follow conversations when 'code switching' occurred and people moved in and out of French and dialect.

d. Understand one's role

My status in the schools was that of a 'participant observer' in the classes and as a 'teacher-researcher' to the teachers and authorities. I sought an identity as one of the group of teachers with one difference, that I was outside the system and only indirectly involved in it, and could therefore be trusted with confidential information or opinion. This is against the advice of S. Wilson who says that, "He (the researcher) tries not to be identified with any particular group in the setting", (1977 p254) and "The observer tries to explain his unique status of belonging to no one group."

I found early on that neutrality as an observer was not possible, and that since my access and much of my information depended on the cooperation of the teachers, the best approach for me was to stress
that I was a science teacher, who was turning to research.

Teachers have a suspicion of researchers as people who cannot teach and who get lost in unreal theories. I had to earn my right to their cooperation, both by my tact and confidence keeping, and also by helping them out in their jobs and giving a teacher's opinion when asked. This resulted in me eventually being allowed to help with translations and to being asked for my opinion during lessons. I once taught a class at the teacher's request, and another time when teachers were in short supply helped to supervise a test.

e. Work in a way that leaves a door open for other research

An ethnographer should conduct his or her fieldwork and field relations in such a manner that other ethnographers will be able to follow and do re-studies. (Werner & Schoepfle 1987 2 p334 point 15).

Renewal of my authorisation in 1988 was presumably with the consent of the Heads concerned, and I did my best to follow the advice of Werner & Schoepfle. But clearly the opportunity to do follow on research is passing, as the student intakes from September 1989 into all the pilot schools are to be for teaching of the sciences in French.

f. Observations should be validated by comment from people in the field situation

Werner & Schoepfle express the principle strongly,

We consider it absolutely essential that valid ethnographic data be the result of observations only if such observations have been subject to native comment. (1987 1 p266 italics by the authors).

In the first year of work in the schools I produced a report, describing my work, and what I had found. Two Tunisians (Madame Jamoussi TFG and Mahdi Abdeljaouad TFH) read it and gave their comments.
In the schools, I would often ask teachers to explain something, and on occasions would produce a document which I headed "Have I understood?". In all such cases teachers would see what I wrote down for their replies. Otherwise, to ensure confidentiality, my notes were not shown to anyone, and this limitation of confidentiality over-rode the importance of so called 'native comment'. To counteract this, I tried to make sure that the next principle ('g' below) applied.

**g. Evidence needs corroboration**

Wherever possible a piece of evidence was corroborated from more than one source, the source being a person or a document. In some cases, as opinion could change, the same question needed to be asked more than once of an informant.

This raises the subject of 'triangulation'. The word comes from navigation, in which by taking a bearing on three or more points of known location, and marking the intersection on a map, a triangle of three lines is created, within which is one's position. The word is used in social sciences for the cases where more than one method is used to gather and cross-check data. The word is unfortunate in that it implies a mathematical precision that is inappropriate. I prefer the idea that different methods give evidence which, if it is conflicting, signals that further investigation is required, and if it is in agreement, becomes evidence that is corroborated by other evidence from more than one method. Evidence that is taken from more than one approach is also potentially more useful. For instance, mere documenting of faux amis is interesting in its own right. But the significance for the teacher of faux amis is increased when it becomes clear that the pupils at the English school were overconfident in their mastery of them.

Triangulation to me also implies the ability to cross discipline boundaries with impunity, and to use evidence from more than one discipline. In this thesis I have sought to combine linguistics, anthropology, science teaching, languages, and implications for the teaching of English to science students in another language (ESP).
It also means I have felt free to combine evidence variously from observation in schools, from interviews, from my study of the textbooks, with evidence from dictionaries and writers such as Maillot and Défourneaux. It is more convenient in this thesis to incorporate information culled from my search of the literature with experimental evidence and observation than to keep these two areas strictly separate. To separate experimental evidence from evidence from the literature would be to fragment my results when their very nature renders them fragmented enough.

h. Study the complex by concentrating on the simple

This means that when I came to study the constancy of scientific language I identified four broad layers:

1) symbols,
2) words,
3) sentences and documents,
4) the wider context of teacher methods and styles and differences between the two education systems.

I decided to concentrate on symbols and words, but to know enough of the other layers to be able to place them in their wider context. This is very similar to the comment made by Osborn & Gilbert (1980) that, 

Firstly, from a learning theory viewpoint, an analysis of students' conceptual understanding of words used in a particular subject may well need to precede analyses of more complex understandings and skills required of students in that subject. (p311).

In fact, many times in the thesis, a point of detail at the level of symbols or words has implications at higher levels. The classic example of this is the use of unit vector notation, and the implications for the whole approach to the teaching of physics.
j. Define your hypotheses so that they are testable

Once I had a good knowledge of the situation I was ready to use the situation to test the theory. For this hypotheses were needed (referred to as 'sub-hypotheses' in the results chapters).

The theory of CSL was not fully worked out in detail, so it needed to be re-phrased, and (sub-)hypotheses written with sufficient precision that they could in principle be shown to be at variance with the evidence. Hypotheses needed stating in operational terms, i.e. in terms of the actual experimental procedures used to establish their applicability. (Bullock & Stallybrass 1977 'operationalism'). Each sub-hypothesis needed to be phrased in such a way that it was open to the possibility of falsification by specifically collected data.

This is in conformity with the methodology of Karl Popper in which falsification is regarded as a more significant finding than confirmation.

...the critical method - or critical approach - consists, generally, in the search for difficulties or contradictions and their tentative resolution. (Popper 1982 p115).

(Popper proposes that)...we formulate our theories as unambiguously as we can, so as to expose them as clearly as possible to refutation. On the other hand he also says that we should not abandon our theories lightly, for this would involve too uncritical an attitude towards tests, and would mean that the theories themselves were not tested as rigorously as they should be. (Magee 1982 p23).

The research in this thesis began in an ethnocentric framework and as it proceeded used the more rigorous procedures of the experimental scientist to define and test the hypotheses. By looking at many small areas where CSL might be held to apply, and writing sub-hypotheses in a way that evidence could be used to falsify them, I was able to assess where the theory is applicable and where it is not with gradations in between these poles. This is explained further in Section 4 below 'Formulation of hypotheses' and Chapter 7 'Cornerstone hypothesis'.
k. Compare with other countries

Ideally, I would have liked to have compared my work with similar work done in another Arab country. From my searches of the literature I have yet to find anything comparable, despite the fact that tri-lingual schools are known to exist in Syria (T69, TFJ 4.88) and also the non-Arab state of Turkey. (Personal conversation, TEQ, spring 1986).

Interesting work has been done in countries like Morocco (Bentahila 1983, Lakramti 1982, 1987) and Arrayed (1980) has done some work in Bahrain. There is also a small, but growing literature on tri-lingualism (otherwise known as 'multilingualism'). For instance, Housen & Baetens-Beardsmore (1987) reports on the European Community schools where three or more languages are the norm, and Genesee & Lambert (1983) report on tri-lingual education.

I. The thesis should be so written that it is clear and understandable to people in the field situation

Preferably the thesis had to be of some use to people in Tunisia. This means for instance that features of English and of British life which a British reader might assume may need explaining. This is similar to the converse requirement that the situation in Tunisia needs explaining for non-Tunisian readers including details that a Tunisian reader would assume as common knowledge.

In my view this point could have been usefully added to the list of standards set by Werner & Schoepfle (1987 2 p334) cited above.
3. PRACTICAL CONSIDERATIONS

a. Negotiating access to the schools

There were no set procedures for obtaining access to schools in Tunis. I once saw some primary school science lessons on the personal invitation of a teacher. I also saw lessons in a normal Lycée on the recommendation to the Head, of a lecturer in the University TFG. Access to the pilot schools though required approval from the Ministry of Education, and in particular, the Secretary of State for Education in charge of secondary and primary schools, Mr Mohamed Hédi Khellil.

Burgess has some helpful comments. He says for instance,

> Each fieldwork contact is thus sponsored by someone in authority over those you wish to study. (Burgess 1984 p39 citing Walker 1980 p49).

This proved to be true. Authorisation came in each case on the recommendation of someone in authority, as examples given later show.

It was also true that access negotiation revealed relationship patterns, (Burgess 1984 p40). Familiarity with these was a great help later in discussions with the teachers as to where for instance the opposition came from to the use of English textbooks as opposed to translations. Partly through negotiating access I was able to later draw up the concept map reproduced in Appendix 4.

Gaining access involved a continuing series of negotiations, at many levels. For instance, authorisation from the Ministry of Education presumed the willingness of the Heads to have me in their schools. In turn, the Heads (rightly) insisted that I could only observe classes that the teachers were happy for me to see. In addition, each school was different, and particularly with the questionnaires, this influenced greatly how much I could do.

There was the additional complicating factor that I could not at the beginning give clear statements of what I intended to do, as I was in the process of developing my hypotheses.
As Burgess says,

... access influenced the kind of Investigation which could be done and the position that I could take. (1984 p45)

How access influenced the research will become apparent in the next chapter in which the procedures used in the Investigation are explained. At this point it is worth noting that the longer I worked in the schools the easier it was to use different methods. Being in the schools frequently helped me to discuss interesting points as they arose in lessons: teachers rarely noted interesting differences and told me later.

b. British teacher interviews 1986-87

Before the summer I approached Dr Clark, the then Head of the British Council in Tunis. Through him I was introduced to TEG and helped him to settle in to Tunis. Through TEG I met TEA, TEF and TEH. I conducted seven interviews with them, (T2-6 & 8) a discussion of which follows in Section 2 of the next chapter.

c. Local sponsorship

On the advice of Dr Pope at the University of Surrey I also sought and got some local academic help from Dr Stott, who until 1987 was lecturing in the University at Tunis. Before he left he introduced me to Madame Jamoussi, (TFG) who in turn introduced me to Mahdi Abdeljaouad (TFH), then Head of Mathematics at an institute that retrained teachers in Tunis, the Institut Superieur de l’Education et de la Formation Continue. He in turn helped with valuable comments, and with paperwork for residency.

d. Authorisations

The initial interview with the Directrice of the English school was granted upon simple request from Dr Clark, Head of the British Council, to a contact he had in the Ministry of Education.

Regular access required a formal letter from Dr Pope, then Deputy Director of the Department of Educational Studies, University of
Surrey, to Doctor Clark, so that he in turn could write the covering letter for my request to the Ministry of Education to observe lessons in schools. My letter of request I wrote with the help of Madame Jamoussi. (See Appendix 1).

Residency in Tunisia required that I classify myself as a 'chercheur universitaire' and was facilitated by help from the British Embassy. Renewal for a second year was possible once a new letter of authorisation had been obtained.

e. The schools

Romdhane (1984, 1987) also did research in the two schools. He records how he explained his presence to the pupils by saying that his work was University research which was completely independent of the school authorities and had nothing whatsoever to do with testing them.

1) The English school

In the first visit (May 1987, T9) I had an hour's interview with the Directrice followed by a mini-staff meeting with the science teachers and a tour of the school seeing several science lessons.

For 1987-8 I arranged with the Directrice a timetable of observation, which had to be provisional because I had to check with the French school. I was invited to attend teachers meetings, especially those on Friday mornings devoted to lesson material preparation and I was asked to help out the teachers in as many ways as I could. I also received borrowing rights to the school library, an invaluable right as I then had access to translations of the school textbooks.

Due to a misunderstanding over the length of my authorisation, when the new school year (1988-89) started I found I needed the authorisation re-issuing. For this reason I was not able to start work again in the schools until late November of 1988.
2) The French school

In January 1988 I was very politely received by the Directrice, and after explaining the project, was passed on to the deputy head responsible for staff and timetables (TFL) who took me to see the teachers. Unlike the English school it was effectively the deputy head in the French school who dealt with all the details of my access to the lessons.

3) The pupils

I intended with the permission of the teacher, to introduce myself to the classes, giving my name, stating that I came from a university in England, and that I was interested in observing some lessons with no interest whatsoever in assessing them.

As far as possible I stuck to this. But reality was not so simple as to make it possible to do my own explaining in all cases. In practice I did not even always have time to first explain myself properly to the teachers, therefore some classes got more information than others. In three cases I was introduced as "a student like you" (T11,12,15). TEA who knew me well from interviews introduced me as being from Britain interested in how science was taught in English (T14). TEB said I was not a teacher but was here simply to observe lessons (T16). At the French school TFA said I was someone working in 'psycho-pedagogie' who was doing a comparison between the two schools and their "façon de procéder". (T21).

At the French school I had very little informal contact with the pupils. At the English school I had more, and several times during the year I was asked "you are going to be a pupil here?" (T14) or, why was it that I needed to come to class since I knew it anyway. (T36:12).
4. FORMULATION OF HYPOTHESES

Given the situation in Tunisia, in January 1989 sub-hypotheses were formulated, existing data from the English and French schools was used to test them and further data was actively sought.

I formulated the sub-hypotheses by dividing up the subjects into small distinct areas, and in each case asking the question,

If CSL is a valid assumption here, what will be the consequences?

Sometimes in asking the question the subject was subdivided even further, until I had a set of topics with their sub-hypotheses. The data was then collected under these subjects and sub-hypotheses, and sub-conclusions drawn.

Inevitably some evidence is stronger and more convincing also some sub-areas have received a more thorough testing. This has been noted in the results. The evidence though is cumulative. The results show that scientific language cannot be assumed to be constant between French and English.
SECTION II METHODOLOGY
CHAPTER 6: PROCEDURES

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   b. The main results of the interviews
   c. Broad topic meriting further investigation
   d. Early hypotheses

3. LESSON OBSERVATION
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      1) Options
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6. CONFIDENTIALITY

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8. TEXTBOOKS AND TRANSLATIONS
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9. OTHER SOURCES OF EXAMPLES AND MATERIAL TO CROSS CHECK THE DATA
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    FIGURE 6.3 TIMETABLE OF THE QUESTIONNAIRE ADMINISTRATION

11. OTHER CROSS CULTURAL METHODS CONSIDERED
1. INTRODUCTION

In this chapter the procedures used in the thesis are presented and discussed. The experimental research began with interviews of British teachers working in the English school. These are presented and the early results of this method assessed in Section 2. The work continued with observations of lessons (Section 3), and the procedures reported here include an account of how I decided to observe which lessons, and why changes were subsequently made. Sections 4 and 5 explain the teachers' meetings and other interviews, and discuss the question of confidentiality. Section 7 explains a concept map finalised in August 1988 after the first two terms of lesson observation, the map being presented in Appendix 4. The study of textbooks and translations, and the use of other sources of data is presented in Sections 8 and 9. The questionnaires are discussed in Section 10, and Section 11 deals with other cross-cultural methods which were considered.

2. TEACHER INTERVIEWS 1986-87

a. Description

In the early days of the project it seemed possible that I might never get permission to go into the schools, therefore the indirect route of interviewing the British teachers would have had to have sufficed. Also at that stage all I knew was that there was an interesting situation, for which I might need good Arabic, so I was concentrating on that while moving slowly towards the school. In such an informal setting I took notes and either typed them up a few hours later, or, especially for evening interviews, I went over my notes talking into a cassette recorder as soon after the interview as possible, the final notes being an amalgam of original notes and the tape.

Because I did a series of interviews, I was able to ask for clarification of anything not understood. Each time I went with prepared questions, but all interviews were open ended.
b. The main results of the interviews

The main results of the interviews were:
1) I gained practice in interviewing
2) Information was obtained about the school
3) Good relationships were established with the British teachers
4) Hypotheses were generated.


c. Broad topics from the interviews meriting further investigation

1) The British teachers were surprised when they arrived in 1986 by the constant demand of the pupils for definitions.
   The pupils constantly demand definitions and think that in this way they have understood them once learnt. (TEA T6:6)
   Well, things here are defined, not done. (TEG commenting on practical work T5:33)
   The pupils are very keen to know, yet while this is encouraging, all three teachers found the constant demand for definitions tiring. (Observation note, T3:18).

2) The British teachers were having to adapt not only to a different curriculum but also to a different way of teaching, and the problem of teaching a curriculum based on French which was taught in English.

d. Early hypotheses

I intended in 1987–8 to do three things:
1) To learn as much as I could about the two schools, in particular exploring the different perspectives on teaching common topics, given that the curriculum and the students were the same, and that in theory only the host language changed.
2) To collect examples of definitions from both schools, 'definitions' being understood in its wide sense of concise memorisable explanations.
3) To compare the definitions given in the two languages and to study the differences. I planned to use Werner's MTQ system of analysis as explained in Werner & Schoepfle (1987), Werner & Topper (1976).
3. LESSON OBSERVATION

a. Which classes to observe 1987-88

A researcher cannot be at every lesson, at every meeting of teachers. In addition for every hour of observation there is the writing up, and the not to be minimised travel time.

In addition I was confronted with the fact that my work was comparative, so I had to be in regular attendance at two schools. Timetable constraints meant I could not be at all the classes and meetings I wished to attend. Other reasons for missing a class included illness of myself or the teacher, the class had a test or a film or was simply cancelled, or an extra class would be arranged and I would hear about it too late to try and attend. At the end of the spring term and the beginning of the summer term I deliberately stayed away from the schools in order not to add to the stress of the teachers during their busy times.

Therefore for terms two and three of the academic year 1987-8 I chose to observe:

1) Classes of biology, as this was closest to my expertise, and I already had a good relationship with TEA, a British biology teacher.

2) First year classes, because the first year course at the English school started in January 1988, (the first term was devoted to intensive study of English) and while I had missed a term of the course in the French school, I was in at the beginning of the formal science teaching of the pupils.

3) Fifth year classes, as, in 1987-88 this was the top year, the year in which everyone was teaching the syllabi in English for the first time. This made it the most talked about year, after classes and in the Friday teachers meetings. The teachers, exceptionally, were also behind in their work of translating the textbook, therefore discussion of the translation went closely with lessons using that translated material. In addition and as a bonus for the research, the textbook turned out to be a particularly difficult one to translate.
4) The theory lessons of the fifth year. Time did not permit attendance at more than the occasional practical.

It was not possible for me to predict in advance where the definitions would be found. When I asked the teachers I got conflicting information. I did not have access to syllabi until after I had started observing lessons. Therefore the choice had to be made on the other criteria noted above.

b. Appraisal, spring 1988

By the spring holidays of 1988 it was evident that definitions were not used as much as I had expected. A few hours of fifth year biology observations in another school also showed that definitions were used much more frequently there than ever I saw in the pilot schools. The comments made by the British teachers in their interviews were not far off the mark at all. It is possible that definitions are widely used as a style of teaching, and that the new British teachers were faced with pupil expectations of them, which had diminished by the time I entered the schools. I also later asked a French teacher of biology TFA about this point and he did not disagree. Lakramti (1982) has this to say,

En français les élèves attendent que tu leur dictes les définitions. Les inspecteurs recommandent aux enseignants de donner les définitions et de les illustrer ensuite par des exemples, afin d'éviter aux élèves le problème de s'exprimer.

In French the pupils expect you to dictate definitions. The inspectors encourage teachers to give definitions and then to illustrate them by examples, so as to avoid the problems pupils have to express themselves.

It is quite possible then that definitions are used more in French, especially the French of North Africa, than in English. The early guiding light of definitions was in the event useful, as it led on to the testing of the CSL assumption. The subject of definitions was to form a useful chapter (Chapter 9) in the testing of the CSL assumption.

I therefore in the spring of 1988 took time to appraise the work. I read through the lesson notes, and considered the options.
1) Options

a) To look at physics. But teacher information was that the most interesting part was the fourth year first term. I eventually caught the end of this subject area, in December 1988.

b) To look at chemistry, especially the early years. My initial ideas prior to doing the teacher interviews had been that the particulate theory would have been interesting to study when taught in English and French, particularly looking at language and the change from the pre-scientific world view of the younger students. But I was in the process of rejecting this as a study area. I had begun in biology and wished to continue, and none of the examples of definitions given to me in the teacher interviews came from chemistry. (In Tunisia chemistry is taught as part of physics). If it were to have been an option, I would have had to have waited until the following year.

c) To look at mathematics. As subsequent work in physics was later to show, a lot of differences between French and English exist in the domain of mathematics. There were two problems here. The amount of lesson time given to mathematics was high, at least four hours per week. (See Appendix 5) This would have been a difficult subject to study using class observation. Secondly and crucially, there is my own limited competence in mathematics. I am confident that someone qualified to teach mathematics to a high level could do a lot of profitable work to elucidate further the differences between mathematics in English and mathematics in French.

d) To cut the first year, and see what definitions were given in a normal lycée, concentrating on the fifth year biology already studied.

e) To cut fifth year biology and concentrate on the early years, and the pre-scientific world view. This option I note for the sake of completeness. The most interesting material was coming from the fifth year work, especially when linked in with the teachers meetings.
2) **Factors guiding the choices**

a) A term of observation was too little to give a reason for major changes. My instinct was that dividends from working with the teachers would come as the relationships were built up. The longer I stayed with particular teachers the more likely it was that early observations would be confirmed, expanded or rejected. After a term of working in the schools, teachers' confidence in me was growing.

b) Whatever I added to my busy observation timetable would mean compensating with cuts elsewhere.

c) I should stay with the fifth year, as lesson observation there was complemented by discussions in the teachers meetings.

3) **Decisions made, spring 1988**

I decided after this appraisal to slowly trim back the first year, to concentrate on the fifth year, and to see a few lessons in a normal lycée. This proved to be the right decision because soon after I resumed lesson observations a lot of interesting discussion took place about the fifth year curriculum.

c. Which classes to observe 1988–89

By December 1988 I was concentrating on CSL. I was still uncertain which subject areas would best test this area, except that teacher comment had suggested fourth year work on forces as an interesting area. TEK also told me there were problems in organic chemistry, and invited me to see his sixth year physics classes, which continued the work on forces of the fourth year. These were therefore the classes I observed. I was torn between studying physics and chemistry, and wanting to pursue the discussion of the sixth and seventh year biology texts, particularly as TEJ told me they were not finding human biology as easy as they had thought to translate. It was not possible for me to persuade the teachers to keep notes of interesting points. They felt I needed to be there myself to take notes as they soon forgot. Some did though make a point of telling me some of the more memorable differences they noticed. So while concentrating on the physics and chemistry, I kept
in touch with biology. I also obtained and studied the English translations, as explained later in Section 11 below.

d. Procedures for taking lesson notes

Burgess (1984) devotes chapter three to this whole question, and discusses some of the published lesson observation schedules. McNamara (1980) criticises the results from classroom observation arguing that a classroom is a highly complex situation (p 124). The problem is especially seen in data reduction, and the fact that "at some point the researcher makes the decision to observe selectively and record limited and specific aspects of the classroom life". (p 114). MacDonald & Rogan (1988) also discuss some of the observation schedules and make the interesting comment that "it was assumed that science lessons have common features, irrespective of the cultural context" though "some features of the lessons in the Ciskei classrooms would arise directly from the context in which they occurred" (p 228). Some measure of constancy in science lessons across cultures is therefore a stated assumption. Also presumably the test instruments used are applicable in different cultures, and that valid world wide comparisons are possible.

The method I found most helpful was that of Swift (1986 pages 6.6-6.7) He distinguished between an observational note (eg part of a conversation), a theoretical note or comment which are reflections on the observations, and a methodological note which is an instruction to oneself.

In my notes, I had not only conversation to monitor, but what was happening, and also what went on the blackboard. I therefore developed a set of abbreviations as in figure 6.1 below.

I kept actual observations on one side of a sheet and descriptions and comments on the other side. After typing up, anything important was circled and labelled and commented on in pencil, to distinguish it from notes made in the lesson.
FIGURE 6.1 ABBREVIATIONS USED IN LESSON OBSERVATIONS

<table>
<thead>
<tr>
<th>BB</th>
<th>Black board</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Teacher</td>
</tr>
<tr>
<td>Px</td>
<td>Pupil, a, b, c etc</td>
</tr>
<tr>
<td>TD</td>
<td>Teacher dictation</td>
</tr>
<tr>
<td>PBB</td>
<td>Pupil at blackboard</td>
</tr>
<tr>
<td>PD</td>
<td>Pupil dictation.</td>
</tr>
<tr>
<td>NQ</td>
<td>Not an exact quotation</td>
</tr>
</tbody>
</table>

All lessons observed were labelled T plus a number, and a record was kept of when, where and which teacher this set of records applied to. (See Appendix 3).

In typing up my notes I arbitrarily wrote them as a list of points for ease of cross referencing.

I noted special circumstances at the beginning and anything extra at the end. Because of the high symbol load that exceeded the capabilities of my computer, I had to put a lot of extra material in by hand after typing up the lesson. I used small notebooks I could hold in my hand for class notes, typing up as soon as possible afterwards, and including copies of any handouts. [1.]

For one lesson I wrote up my notes on the same day, then a week later, having forgotten I had written them up, did so again. (T61). Comparing the two later it was clear the two were similar: errors due to delay in typing were negligible.

Recording lessons was a sensitive issue. The Heads authorised it provided the teachers agreed. All those I asked agreed, but I felt ill at ease with it. To record properly would have meant equipment that would have intruded too much, bearing in mind I could not set up the equipment before observing a lesson. In the early days it was useful, especially as I had less idea of what I was looking for than in the second year of observation. Taping gave more work, and because I could not set up the microphone in a prominent position the quality was poor. Its main use for me was to add to and clarify

1. A term used by some British teachers to refer to written material given out to a class for students to keep, the American word being a 'ditto'.
my notes. Early on, I forgot on one occasion to take the recorder with me, and in the lesson the teacher came round for a confidential discussion. This gave me more information than I would have got had I been recording, an event subsequently repeated (eg T37:4). At other times the students were so restless that the teacher found it hard to keep them quiet even for a short dictation. Recording would have been embarrassing.

In such circumstances I would have had the option to record properly, and either to turn off the recorder, or to agree to wipe the tape afterwards, just as there were times when I stopped taking notes and left gaps. Without a tape I was reduced to getting incomplete parts of conversations down in my notes. But this was offset by the fact that a lot of work was done on the blackboard. I eventually abandoned taping as the advantages (for instance in terms of trust from the teachers), were worth more to me than accurate records of conversations in the class. The reduced workload in writing up the lessons also enabled me to see more lessons, and to have more time for other work such as analysing the textbooks.

e. The question of participation in the classroom

In general I stayed silent in the lessons, positioning myself at the back to one side if I could. This was easiest to maintain in the French school with only the occasional discussion with the teacher while he or she was waiting for the class to finish some task. At the English school I could not maintain silence. The Head had specifically asked me to join in the classes as much as the teachers allowed, so that the pupils would hear the voice of one more native speaker. Some teachers at the English school deliberately involved me, usually to cross check information, or to check pronunciation.

My policy was to help where asked, but otherwise to maintain a polite silence. I cannot say that I lost anything by this participation, and I gained again in the improved relationships with the teachers.
4. TEACHERS' MEETINGS

a. Description

The last two hours of Friday mornings were timetabled as departmental meeting time at the English school, for the departments of mathematics, science, and English teaching. This was meant to be for lesson preparation and textbook translation. It should be understood by those unacquainted with the French or Tunisian way of organising schools that teachers in Tunisia do not attend school all day as they do in Britain, and meetings, unless in work time, are rare. Teachers come, teach their contracted number of hours, and leave. In view of the extra work the teachers had in translation at the English school, and to encourage cooperation, two hours of work time was timetabled for these meetings. As such they proved very useful to me. I listened, participated, asked questions, and sought to help the teachers in any way I could.

b. Assistance given to the teachers

This included:
1) Doing some of the translation work, an invaluable experience in its own right. [2.]
2) As a result of the meetings, seeking out articles, and information from dictionaries and other sources to help the teachers in their preparation and translation. My ideas were not always accepted, (rightly so, as the employed teachers had the final say,) and seeing why not was in itself interesting. I was also encouraged to see some of my ideas rejected as it enabled me to argue strongly at times without fear that I was interfering.
3) In the physics and chemistry departments, I often helped the teachers try out equipment and experiments.

2. In particular I translated work for the fifth year biology which used calculations of molarities involved in titrations.
5. OTHER INTERVIEWS

At various times over the years in Tunisia, I interviewed, or discussed my work with many people. I never recorded these interviews, but took notes, and usually had the chance to repeat any questions at a later date if I was not clear. The interviews were always unstructured although I usually had a list of points to cover noted in advance.

5. CONFIDENTIALITY

I made no written agreements on this, and was never asked to. Several times I reassured teachers that what I heard would not be repeated.

It has not been possible to conceal the identity of the schools as Burgess did with his school. I have named my informants since those in Tunisia who know the people would be in a position to see through any changes of name. This has meant having to be more tactful in my write up than perhaps Burgess needed to be. When the thesis came to be written there was nothing that materially affected the results and discussion that needed to be excluded for reasons of confidentiality.

Confidentiality was an issue when, due to my involvement in the schools, I heard information from more than one source. It took hard work to maintain a tactful neutrality and at the same time keep good relationships. I recognised at the time that I had to be particularly careful not to take the side of the British teachers. In one area I had no hesitation at intervening: when there was a misunderstanding due to problems of changing languages.
7. CONCEPT MAP

Drawing inspiration from Novak and Gowin (1984) I drew a 'concept map' of how the situation in Tunisia focused on definitions. The version presented in Appendix 4 is the sixth, after TFH had checked it with me. Almost all of it is still relevant to CSL in the Tunisian context. Concept maps are not without their critics. Sutton (1980a) for instance says:

... Herron (1978) criticises Novak for failing to distinguish 'concepts such as cell, earth and force' from 'logical operations such as seriation, correspondence, classification, proportional reasoning, and hypothetico-deductive reasoning'. Perhaps, however, the ability to carry out such operations is a result of possessing corresponding concepts. (p118).

I found it extremely useful to draw the concept map in that it helped me to identify the different features bearing on definitions, and what influence that people such as inspectors and documents (eg official syllabi) had on them. By submitting the map to external checking (TFH) modifications were made and the accuracy of my understanding of the situation was confirmed. If the ethnographic route had been pursued further no doubt such a map would have provided a good basis for further questions, research, and analysis.

8. TEXTBOOKS AND TRANSLATIONS

I bought virtually all the textbooks used for physics, chemistry and biology in the Tunisian secondary schools. I also copied large parts of the translations made at the English school. I had verbal permission from the Ministry of Education to copy any documents the teachers chose to give me, so there was no problem of copyright. I also routinely accepted copies of any class handouts, and was able to copy syllabi and other official documents circulating in the schools. Some material was too faint to photocopy so notes had to suffice.

a. Methods used for data collection

For my purposes I could find little guidance on how to analyse a textbook. I therefore developed the following methodology:

1) For French material, I read the books and marked all instances I
could find where the French differed from the English when predictions from CSL would expect a similarity. Any unusual instances I would check with the English translation to see how the teachers decided to translate the French.

2) For the English (translated) material, I would look for instances where the material, though in English, was not necessarily current scientific English. Whenever I found an instance like this I would try and find the parallel instance in the French book and see if there was material relevant to the hypotheses.

3) As examples built up, with observation data, if I was in any way not clear, I would ask the teachers concerned, and note their answers in writing in front of them.

In this way I was able to cover textbooks and subject areas that I could not observe in the lessons.

b. Analysis

At the stage of the thesis write up, I took these observations, compared them with relevant examples from Maillot and Défourneaux and others, and cross checked the accuracy of my data, fitting them into the sub-hypotheses.

As my field work ceased with the sixth year, I only analysed the first six years of textbooks, with a less detailed look at the seventh year biology text.

Such a method is obviously like using a fishing net to trawl for data, with some fish not getting caught. But I gathered enough data to give many of the sub-hypotheses a fair test, so there was little profit in restudying, or persuading someone else to read through the texts, (over 20 volumes) and gathering examples they found. Those that have not received a fair test are noted accordingly in the results. There will always be more examples to be documented.
9. OTHER SOURCES OF EXAMPLES, AND MATERIAL TO CROSS CHECK

THE DATA


My three main sources, outside the schools, were Maillot (1981) 'La traduction scientifique et technique' and Défourneaux (1980, 1983) 'Do you speak science?' and 'Do you speak chemistry?'. There is a dearth of good books on technical translation, possibly because the demands are high: the author has to be qualified in the subject as well as in languages. All three books above were written by Frenchmen, and sometimes the English reader suffers in that the French is assumed and the English explained.

b. French Sources

I always had in mind the question whether an example was of genuine French usage, or Tunisian usage in French. This was particularly true of the vector notation and similar symbols. Therefore I checked this against the Anabac books, which republish the baccalaureate examination papers from France each year. I consulted that ubiquitous one volume mini-encyclopaedia, published annually, Le Quid. (Quid 1985) and made extensive use of various dictionaries such as Robert (1984) and Larousse (1984). Only if these sources failed me did I seek further information and ask, for instance, native French speaker subject specialists.

Unfortunately, to my knowledge, there is no subject association comparable to the British 'Association for Science Education' and hence no equivalents to their documents on nomenclature. (ASE 1981, 1985), and the Ministry of Education in France, despite their detailed syllabi (eg France 1983, 1986, 1987, 1988), did not publish such documents either. This makes detailed comparisons with French harder to make.
c. English sources

The ASE material, (with reservations as noted in the results as needed), I regarded as normative for England, along with the Institute of Biology report on Biological Nomenclature (IOB 1989) when it became available towards the end of my time of field research. Their standards have been broadly accepted by examining boards and textbook writers and publishers. The ASE's high reputation is based upon good sources of information and on good teaching practice. The reports had the advantage of being directly applicable to secondary schools. I also found "Henderson's Dictionary of Biological Terms" (1979) helpful for the biology, and much better than the dictionary by Abercrombie (1973) which was available in the English school, and was used by TEA.

For cross checking the English I used Whelan & Hodgson (1989) 'Essential principles of physics' and Simkin & Williams (1989) 'Advanced biology'. These texts were available in Tunis at the British Council library. When these proved inadequate I used the Encyclopaedia Britannica (1976), and other sources in British libraries when I returned each summer. I also made extensive use of the Longman Concise English Dictionary (1985).

d. Bi-lingual dictionaries

For routine work, 'Harrap's New shorter French and English dictionary (1978) was nearly always adequate. Harrap's Science Dictionary (1985) proved a big disappointment. For a critique see Chapter 28.

e. The importance of school level terminology

It is always possible that in comparing French and English, similar specialised words might exist, and might well be used by specialists. The fact that a specialist word exists is not important, if similar pupils in England would not use the specialist word. Maillot and Défourneaux, for all their helpfulness, were working in the areas of technical translation and university science respectively. Therefore what they wrote had to be sifted, and the question constantly asked if it was applicable to schools.
10. THE QUESTIONNAIRES

a. Introduction

At some point I wished to involve the pupils. In view of the mounting data about CSL, from books and teachers and lesson observation, the question was how significant were these differences for the pupils. I therefore designed a series of tests (questionnaires) for the pupils of both schools.

FIGURE 6.2 THESIS REFERENCES TO THE QUESTIONNAIRES
(A = Appendix, Ch = Chapter)

<table>
<thead>
<tr>
<th>Questionnaire section</th>
<th>location</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGLISH SCHOOL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemistry: French version</td>
<td>A6</td>
<td>Ch 18</td>
</tr>
<tr>
<td>Chemistry: English version</td>
<td>A6</td>
<td>Ch 18</td>
</tr>
<tr>
<td>Words in science</td>
<td>A9</td>
<td>Ch 8 Section C</td>
</tr>
<tr>
<td>Physics Q1, Q2,</td>
<td>A7</td>
<td>Ch 23</td>
</tr>
<tr>
<td>Physics opinions</td>
<td>A8</td>
<td>Ch 24</td>
</tr>
<tr>
<td>Pupil backgrounds</td>
<td>A15</td>
<td>A15</td>
</tr>
<tr>
<td>Pupil viewpoints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1 books &amp; subjects</td>
<td>A11</td>
<td>A12</td>
</tr>
<tr>
<td>Q2 geology</td>
<td>A11a</td>
<td>A14</td>
</tr>
<tr>
<td>Q3 confusion ratings</td>
<td>A11</td>
<td>A10 (results)</td>
</tr>
<tr>
<td>Q4 scientific</td>
<td>A11a</td>
<td>Ch 8, A13</td>
</tr>
<tr>
<td>FRENCH SCHOOL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemistry: English version</td>
<td>A6</td>
<td>Ch 18</td>
</tr>
<tr>
<td>Physics Q1, Q2</td>
<td>A7</td>
<td>Ch 23</td>
</tr>
<tr>
<td>Physics opinions</td>
<td>A8</td>
<td>Ch 24</td>
</tr>
<tr>
<td>Pupil viewpoints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1 geology</td>
<td>A11b</td>
<td>A14</td>
</tr>
<tr>
<td>Q2 scientific</td>
<td>A11b</td>
<td>Ch 8, A13</td>
</tr>
<tr>
<td>Chemistry: French version</td>
<td>A6</td>
<td>Ch 18</td>
</tr>
</tbody>
</table>

It was not possible under the circumstances to do a pilot series of questionnaires. Partly this was because teacher cooperation was at a premium. Also differences between the two schools account for why I managed to administer the sections over several weeks at the English school, whereas time was much shorter, and only available after the summer examinations in the French school. Partly the very nature of the questionnaires required me to administer them as quickly as I could to the whole available population, as this minimised discussion among the
pupils about them. Errors that crept in despite proof reading by myself and at least one other teacher are few, and are mentioned in the relevant sections of the results and appendices.

The various parts of the questionnaire, and details of the chapters where they are presented are as in figure 6.2 above. The timetable of the administration of the questionnaires is presented later in figure 6.3.

b. Design of the questionnaires

1) Organic Chemistry

The objective was to give the pupils several formulae, written in the way they were not used to, and compare their success with similar questions given to them in the language they were familiar with. I therefore wrote down several formulae, with differing degrees of complexity and involving several different features. Then I re-wrote the formulae in the French way and checked with TFC that this was right. I also looked at examples given in the sixth year French chemistry text.

I then kept the first two questions the same, and changed the order for the remaining six questions in the third language. In each case the order at the English school matched the order at the French school on the basis of second and third language (L2 and L3).

I took the precaution of asking the pupils at both schools how much they had read about organic chemistry in their third language. In the case of the English school this resulted in two distinct groups for comparison purposes, those who had read material in French and those who had not.

I considered, on the first test, giving half the pupils in each class the third language version and the other half of the pupils the second language version. Because of the small population, each pupil had to do two tests. To mix the texts, and then repeat them, so that a pupil randomly did one test first and then the other, would have been almost impossible in the circumstances. By
giving the tests, in L3 first, then in L2, (the language in which they had studied science), I achieved the element of surprise for L3, and was able to see what they could do in L2. by doing it this way any talking between pupils after the first test would not have mattered because talking would merely improve the L2 score so narrowing any difference between L3 and L2. Thus the difference found is more significant because the experimental pressures were against finding a difference.

Similarly the test had to be given twice as the total population was too small to give reliable results to use the L3 version with half the population and the L2 version with the other half, then making comparisons, assuming that the abilities in the populations were similar. The pupils were never told they would be tested again on the same material and at the English school once the second L2 version was begun the tests took place as quickly as possible, thus minimising talk between the pupils.

The test given was one of recognition. CSL involves the skill of accurate recognition of material in another language as well as the correct use of scientific language in another language. Therefore pupils were asked to draw the formulae they saw named.

I considered simply giving a table, with French formulae In one column and English formulae in another in a different order, pupils being asked to match the formulae. This I judged to be too easy. By asking the students to draw the named formula this showed me whether or not they had correctly read the name, and there were no clues as to the correct answer.

It was only later, while administering the questionnaires that the idea came to me to ask pupils who had finished quickly in L2, to try re-writing the formulae in L3. This implies a higher level skill: not just recognising formulae but being able to re-write them in L3. There are clear differences between organic chemistry names in English and French therefore constancy cannot be assumed. I wanted to know if these differences have significant practical importance; even given the differences could
pupils both recognise and change easily and rewrite formulae. I did not ask the same extra question at the French school, partly as I was more pushed for time there, and partly because the pupils at the English school had had exposure to English and French, whereas the pupils at the French school had only had exposure to French organic chemistry names.

2) Physics

I wanted to study how the pupils actually do a question in physics, since my research had suggested that the ways of solving problems were different. Therefore I had to force students to work as closely as possible to the English way.

This meant choosing an area of syllabus overlap between the UK and Tunisia, taking English questions that the students would find easy to do, and so direct the questioning that the English way of solving them was almost obligatory. I then translated these questions into French, staying as close to the English as I could. The translations were checked by one of the physics teachers at the French school (TFF).

The questions I chose were adapted from Abbott (1969 p51) and Duncan (1983 p103). Both were GCE 'O' level textbooks and well below the difficulty of questions normally asked of the students in Tunisia in the sixth year.

3) Opinions on the physics

Having given the pupils what I thought were easy questions, I wanted their reactions to this exercise. In particular, did they see any difference between my questions and the ones they were used to. Later I coded the answers first by reading through them to establish a code for the variety of responses, then by re-reading and coding the responses.
4) **Faux amis**

These tests were only given to the English school. The students at the French school studied English as language, and if time had permitted I would have liked to have given them the same questions to test their knowledge of faux amis. I used four tests:

a) **Translation** of six expressions. Question 1a), *Ingénieur électrique* comes from reading Maillot (1981 p46). *L'ordre de grandeur* I specifically included as the term, 'order of magnitude' is well known to equivalent pupils in English, and is not used in Tunisia, despite being such a basic concept. Several teachers at the English school when they saw the question protested that it was not known. I wanted to see if it was, and if so, was there confusion between 'grandeur' and 'magnitude'.

b) **Word substitution exercises.** I first drew up a list of possible words from my research into faux amis which had wide meanings. Then I wrote down similar words in English and French and some sentences using them. At this stage 'acclimatise' and 'electrical' were rejected as I could not phrase a sufficient number of sentences. For *expérience*, *sensibilité* and *respiration* I then looked at similar words in French, and from Robert (1984) took some French phrases, which I then translated back into English. Sentences were included where the French and the English gave the same or a similar word, ie the word was not functioning as a faux ami but as an 'ami loyal' (Newmark 1988 p181) in that sentence. These acted as controls, in that some sentences demanded a knowledge of the differences between English and French, and in other questions there was no difference. Any evidence students were treating them as a faux amis would be further evidence that pupils had difficulties between English and French. My sentences were finally read by TEJ and modifications made.

c) **Confusion ratings.** I gave five examples of differences between English and French and asked students to rate themselves for how confusing they found this. With one of them, 'humidity' I had the advantage of being able to check how accurate these self images were, in that this word was also used in the substitution exercises.
d) 'Science'. In view of the evidence that 'science' was understood differently in French and English, I wanted to find out how the pupils viewed the matter. This I did by simply asking them what they understood by 'science' and what was the opposite.

5) Viewpoints on textbooks and school subjects

I considered adapting the questions of Swift (1986 page A5.3) on the professions, and which ones the pupils regarded as scientific and why. This, by comparison with Swift, and by using both schools would have tested cultural differences as to what is scientific. I also wanted to list the subjects in the student timetable and ask them to rate each subject for how 'scientific' each one was. But Swift had an even smaller population than I did, making comparisons difficult.

Related to this, I would have liked to have asked the pupils their opinions on how accurate translation should be between the different subjects. If CSL was valid then translation of material in science would be viewed as easier than translation for other subjects, as do theorists like Savory. Fortunately I did not ask this question as in the questions I did ask, pupil opinion on how badly translated their English texts were came through very clearly, and a question on translation would have given results that were mixed up in the local problem of achieving accurate translations, given the lack of time and resources there were to do the work to a high standard.

I eventually rejected these ideas as the questionnaire was getting full, and I considered them to be of lesser importance to the other tests and questions.

What I did do though was to ask student opinion in the English school on the differences between English and French textbooks, and between English and French subjects. This part illustrates what could be done with a wider focus than just the verbals and non-verbals. As this goes beyond the scope of the main thesis the results and discussion are relegated to Appendix 12.
6) **Pupil Origins**

I took the opportunity afforded by time at the English school to check the backgrounds of the pupils. The information confirmed that given from other sources such as the head of the English school. Unfortunately time did not permit similar questions at the French school. (See Appendix 15).

7) **Geology Questions**

While this thesis is concerned only with English and French, there was one small area of the biology curriculum which overlapped with geography lessons in Arabic. I simply could not miss the opportunity provided by permission to use questionnaires to find out what the pupils thought about this. All the results and discussion will be found in Appendix 14.

c. **Administration of the questionnaires**

All questionnaires were administered under examination conditions. I did not instruct the pupils not to talk about it afterwards, as that for me was a sure way of stimulating interest and so provoking the discussions I did not want.

The two physics teachers of the sixth year at the English school TEK, TEL were willing to use class time for the questionnaires, providing the Head gave her assent which she did. (This could so easily have been refused as my official authorisation did not mention questionnaires). Thus it was possible to administer the French version of the organic chemistry test at the English school in fifteen minute sessions of lessons in early May 1989 and the other sections later.

The teachers at the French school preferred to have all the questionnaires done in one session per class after the end of year examinations. This meant the number of questions had to be kept at a lower number, and the organic chemistry was administered first and last in each session, ie on the same day, which was not ideal as I did not want the pupils to remember the first test, but was the best I could negotiate.
In addition I could not be present at classes 2 & 3 in the French school when they answered the questions, so I had to rely on fully briefing the teachers and leaving written instructions. Because the questionnaire was like an examination this gave no problems that I am aware of.

All questionnaires were typed on a computer, the Amstrad CPC 6128 and run off in condensed enlarged draft mode on a Star LC-10 printer, using continuous stationary. The questionnaires were administered as in figure 6.3 below.

**FIGURE 6.3 TIMETABLE OF QUESTIONNAIRE ADMINISTRATION**

<table>
<thead>
<tr>
<th>English school</th>
<th>French school</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry (French version)</td>
<td>All Questions</td>
</tr>
<tr>
<td><strong>Cls</strong></td>
<td><strong>Cls</strong></td>
</tr>
<tr>
<td>1 Wed 26 April 10-11am</td>
<td>1 Th 8 June 9 -10am</td>
</tr>
<tr>
<td>2 Fri 28 April 9 -10am</td>
<td>2 Th 8 June 10-11am</td>
</tr>
<tr>
<td>3 Wed 26 April 11-12am</td>
<td>3 Th 8 June 11-12am</td>
</tr>
<tr>
<td>4 Fri 28 April 8-9 am</td>
<td>4 Tue 6 June 8-9 am</td>
</tr>
</tbody>
</table>

| Chemistry (English version) and other questions | (Cls = class number) |
| **Cls** | |
| 1 Sat 10 June 10.30-12 am | |
| 2 Tue 6 June 4-5.30 pm | |
| 3 Sat 10 June 9-10.30 am | |
| 4 Th 8 June 3-4.30 pm | |
11. OTHER CROSS CULTURAL METHODS CONSIDERED

Other possible methods that might work cross culturally are word association (Sutton 1980ab, Preece 1976, Riguet 1980, 1984) and 'Burr models' which Ross & Sutton (1982) argue show the import of interconnections with prior knowledge in the development of meaning and "seems well suited to the investigation of cultural differences of understanding". (p312). Schaefer (1979) and Ross & Sutton (1982) asked pupils to write their own definitions.

The 'Interview about instance' techniques (eg Osborne & Gilbert 1980, DM Watts 1983) in which for instance diagramatised pictures of examples of 'work' taking place are used in interviews to elicit pupil understanding as to what is happening, has promise in a cross cultural situation.
SECTION II METHODOLOGY
CHAPTER 7
THE CORNERSTONE HYPOTHESIS

1. RECAPITULATION

In Chapter 2 the situation of the English school and the French school was described. It was shown that scientific language was assumed to be constant in such a way that the scientific language learnt in one host language would transfer readily into another host language. In Chapter 3 'Basic terminology' 'constancy' was explained as meaning similar form and sense. Also 'scientific language' was defined as including the science specific component of 'mixed' words, and the specialised words of science. It is this scientific language which was assumed in a field situation to be constant in form and semantic fields, with similar distinctions in French and English between the specialised and mixed terms.

In Chapter 4, scientific language was explained as referring to the language of textbooks, the language of the classroom and laboratory, and the language required for discussion, reports, essays, examinations and science magazines. In Zylbersztajn terms scientific language referred to the science of the curriculum and the science of the teacher. Pre-university science is foundational, concerned with well established statements. Therefore one would expect the scientific language at pre-university level to be more constant than the scientific language of the professional scientist working near to the frontiers of knowledge.
2. HIERARCHY OF COMMUNICATION

To this assumption that the language of science is constant, a hierarchy of communication can be added, between symbols at one end, and the broader culture of science at the other end. This results in four convenient levels. These are:

1) Communication in non-verbal form, such as graphs and symbols
2) Communication in verbal form, such as single words, parts of words, and short phrases
3) Communication through sentences and paragraphs, including topics such as rhetoric and style, a good example being the frequent use of the passive in English scientific texts
4) Communication involving the wider context of approaches to a topic, syllabi, styles of teaching and learning, and examinations.

This thesis is about testing the first two levels only ie what Widdowson (1979 p45) described as 'non-verbals' and 'verbals'.

3. THE CORNERSTONE HYPOTHESIS OF THIS THESIS

The cornerstone hypothesis which is tested in this thesis is that in any area of school science, particularly at the verbal and non-verbal level, every aspect of scientific language will be constant between English and French. The host language changes, but not the scientific language.

Furthermore, following the approach of Popper, sub-hypotheses have been framed in such a way that they are open to test, the aim being to see if they can be falsified. Wherever possible multiple examples that might falsify the sub-hypotheses have been sought, and for each feature tested, the question has been asked not simply 'whether or not' but 'to what extent' there is constancy.
SECTION III VERBALS

CHAPTER 8

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A. GENERAL INTRODUCTION

Faux amis are also known as 'deceptive cognates'. They are "words which look the same in the two languages but which have different meanings". (Batchelor & Offord 1982 p31). They are numerous between English and French, and whole books have been written about them. (eg Koessler 1975, Thody & Evans 1985, Van Roey 1988). But such books, as Maillot laments, seem to neglect scientific words. [1.] The opposites of faux amis are amis loyaux (singular: ami loyal) (Newmark 1988 p181). It is quite possible for a word to function sometimes as a faux ami and sometimes as an ami loyal. Van Roey et al acknowledge this and helpfully divide up their material into three sections. For each faux ami sentences in French and in English are given. The first examples are of the word where it is the same in English and French: an ami loyal. The second examples are where the word in French cannot be translated by the same word in English: a French faux ami. The third examples are where the word in English cannot be translated by the same word in French: an English faux ami. The practical importance of this is that once one becomes aware that a word is a faux ami, one can over-react and not get the usage correct, suspecting a faux ami when in reality the word is functioning as an ami loyal. This in fact happened in the questionnaires reported on below. The example provided by Van Roey et al to explain the layout of their book (page xxix) is given below in Figure 8.1. It illustrates these three terms, though the distinction between an English and a French faux ami will not be used in this thesis since the importance is in the distinction between ami loyal and faux ami.

1. For the exact quotation for this point see Appendix 16 where Maillot (1981 p31) is cited.
RESULTS: VERBALS Faux amis 8.4

FIGURE 8.1 FAUX AMIS AND AMIS LOYAUX
(After Van Roey 1988 p xxix)

<table>
<thead>
<tr>
<th>Ami loval</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Le chat s'est réfugié sur la plus haute BRANCHE du cerisier.</td>
</tr>
<tr>
<td>b. J'appartiens à la BRANCHE pauvre de la famille.</td>
</tr>
<tr>
<td>Toutes les BRANCHES de la science [du savoir] sont représentées dans la bibliothèque.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>French Faux ami</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Ma fille s'oriente vers une BRANCHE scientifique.</td>
</tr>
<tr>
<td>Il est de loin le meilleur dans sa BRANCHE.</td>
</tr>
<tr>
<td>b. Les BRANCHES des lunettes [du compass, des ciseaux] sont tordues.</td>
</tr>
<tr>
<td>c. Alors, vieille BRANCHE, comment ça va?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>English faux ami</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. One of the two BRANCHES of the river is extremely dangerous.</td>
</tr>
<tr>
<td>b. Our shop has BRANCHES all over the country.</td>
</tr>
</tbody>
</table>
If scientific language is constant there will be no faux amis. However many might exist in non-scientific language, constancy is assumed not just for words with a Latin or Greek origin but for all scientific words.

In this chapter of the results, first some faux amis that can be considered to be words used in science are documented (Section B). The work is mainly derived from reading the literature, lesson observation, teacher comment, and my own study of the textbooks.

Secondly, using a questionnaire, the significance of faux amis for the pupils at the English school is tested. (Section C).

Thirdly, a rather unusual example of a faux ami of pronunciation is noted. (Section D)

Finally, because of their importance, the words 'science' and *science naturelles* are given their own section (Section E) in which information from the dictionaries is complemented by the results of the questionnaire as to what pupils understood by the word 'science'. The word 'science' exemplifies in a word the different approaches to and understanding of what science is all about.
B. FAUX AMIS IN THE LITERATURE AND IN THE SCHOOLS

1. INTRODUCTION

This section studies in detail some of the faux amis found in the literature and in the course of observation work in the schools.

2. SUB-HYPOTHESES

There are no faux amis in scientific language between English and French at secondary school level. There will always be one to one correspondence between scientific terms in English and French.

3. RESULTS

a. General

Example 1, experience / expérience

The French word expérience is used where the English would use 'experiment'. This was a confusion I noticed several times in the English school and therefore included it in the questionnaire to see how frequently the noun 'experience' would be used instead of the noun 'experiment'. (eg T40:12).

The situation is more complicated than just a simple question of equivalence of terms. In French the verb 'experimenter' exists but not the noun form 'experiment', though 'experimentation' does exist and has similar meanings in English and French. Expérience can be translated as 'experience' or 'experiment' and experimenté can be translated by 'experienced' or 'experimented'.

Défourneaux (1980 p117) makes the comment that the English word 'experience' and its derivatives refers to acquired experience ('l'expérience acquise') and not to experimentation. The English verb 'to experience' he translates as 'éprouver'. Van Roey (1988 p286) makes a similar point in a footnote to the example
'expérience' (p285-6). These points, and other examples from Harrap's (1978) are summarised in figure 8.2 below.

FIGURE 8.2 EXPERIMENT AND EXPERIENCE

<table>
<thead>
<tr>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>expérience</td>
<td>experiment</td>
</tr>
<tr>
<td>expérimenté</td>
<td>experimented</td>
</tr>
<tr>
<td>qui a de l'expérience</td>
<td>experienced</td>
</tr>
<tr>
<td>du métier, (observateur) averti</td>
<td>experienced</td>
</tr>
<tr>
<td>(oeil) exercé à</td>
<td>experienced in</td>
</tr>
<tr>
<td>rompu aux affaires</td>
<td>experienced in business</td>
</tr>
<tr>
<td>épreuve personelle</td>
<td>experience</td>
</tr>
<tr>
<td>la pratique</td>
<td>practical experience</td>
</tr>
<tr>
<td>faits à ma connaissance</td>
<td>facts within my experience</td>
</tr>
<tr>
<td>avez-vous déjà travaillé dans le métier</td>
<td>have you had any previous</td>
</tr>
<tr>
<td>éprouver</td>
<td>experience</td>
</tr>
<tr>
<td>faire l'expérience de, il m'est arrivé</td>
<td>to experience</td>
</tr>
</tbody>
</table>

This then is an example of a common word 'expérience' which is a faux ami in non-scientific and scientific language.

Examples 2 & 3, evidence / évidence, proof / preuve
Thody & Evans (1985: p30) explain that 'une évidence' is "that which is self-evident or goes without saying". So the English 'evidence' is not an exact equivalent of the French 'évidence', rather, 'evidence' is closer to 'preuve' or 'temoignage'. The English word 'evidence' is 'une preuve, un temoignage'. 
Robert (1984), under 'expérience' has "l'expérience démontre, confirme, vérifie, prouve que". Thus the French 'preuve' can bear the combined English senses of 'evidence', and 'proof'. In contrast the French word 'évidence' has the meaning 'that which is self evident'.

Harrap's (1978) under 'preuve' gives (examples numbered by myself for convenience of discussion):

- Proof, evidence, token.
  a) Faire de la preuve de quelque chose, to prove something.
  b) Fournir la preuve contraire, to produce proof to the contrary.
  c) Preuve directe, direct evidence.
  d) Preuve indirecte, indirect evidence.
  e) Preuves testimoniales, (witnesses') evidence.

Note how phrase b) could equally well be translated into English with the word 'evidence' not 'proof'. The context of the phrase would have to determine which sense was meant. The word 'preuve' can clearly bear two senses in English. Therefore Thody & Evans' statements quoted above are misleading. 'Proof' in English is "the cogency of evidence that compels acceptance of a truth or fact" (Longman 1985), while 'evidence' is much less strong, and is:

1. an outward sign, an indication. 2. Something especially a fact, that gives proof or reasons for believing or agreeing with something. (Longman 1985).

Proof is stronger than evidence. Everyday usage might not separate them that much, but a scientist and a scholar habitually makes the distinction in order to avoid misleading statements that make evidence appear stronger than it is, simply by referring to evidence as proof.

Van Roey (1988), under 'évidence' (p278) and '(se) prouver' (p564) makes the difference between the various meanings of the English 'evidence' and explains that:

TO PROVE s'emploi dans le sens de 'démontrer quelque chose, établir la vérité par les témoignages, des raisonnements et non dans le sens affaibli de témoigner, indiquer'.

TO PROVE is used in the sense of 'to show something, to establish the truth by evidence' (lit: witnesses) and not in the weaker sense of 'to witness, to indicate'.
To English ears to say that an experiment provides 'proof of' instead of 'evidence for' something, is nowadays usually to claim too much. An experiment provides evidence for, gives reason to believe, shows, or, in Popperian terms, disproves something, but it rarely if ever proves anything conclusively. When going from English into French it would be easy to misuse 'évidence' when what may be meant is 'les preuves'.

The usage of the noun 'evidence' also requires care. TEK was a good teacher who often asked me about points of English. Even he said, at least twice in one lesson, "There is another evidence". (T265:7). Longman (1985) at this point is also lacking, in failing to give the expressions, 'piece of evidence' and 'to bring forward, to give evidence'. Vinay & Durbelnet (1977 p119-120) explain that 'evidence' is a collective, therefore a phrase is needed for the singular unlike the French. Hence English singular 'a piece of evidence' plural 'evidence' and French singular 'une preuve' plural 'des preuves'.

'Evidence' and 'proof' are therefore important faux amis in scientific English, with the complicating factor that 'evidence' in English is a collective.

Example 4, chronometer / chronomètre
Both the English and the French words have the sense of accurate clock. But in English the word is not used for timing events, for that the term 'stop watch' is used. I acknowledge that TEJ first pointed this out to me.

Example 5, control / contrôle
In scientific English a control is

An organism, culture etc used in an experiment in which the procedure or agent under test in a parallel experiment is omitted and which is used as a standard of comparison in judging experimental effects. (Longman 1985).

In scientific French 'un contrôle' means a test, verification, inspection. The sense of standard of comparison is absent, another word 'témoins' being used.
Thody & Evans (1985 p23, 180-1) mention this word as a faux ami, without unfortunately discussing the meaning this word has in science. Even Maillot (1981 p34) only discusses the wider senses.

Défournéaux (1980) makes no mention of the word, while in his other book (1983 p112,155) he has only a reference to controls as meaning 'les commandes' of an aeroplane.

The narrow scientific sense of a controlled experiment is an experiment with some features acting as controls, seems to escape mention. Harrap's Science dictionary (1985) has témoin as 'standard' but no reference in the English-French section to the English 'control'. The translation of the English 'control' is témoin, as Robert (1984) confirms in one of the definitions of témoin.

Therefore the noun 'control' is a faux ami in scientific language.

b. Biology

Example 1, humid / humide
Humidity is the degree of water vapour in the air. 'Humide' is a wider word, covering English words such as damp and moist.

In a biology teachers meeting Teacher TEA said, to quote my notes:
The pupils often say 'humidity' when they mean 'water' or 'moisture'. The concept is not understood. Why? (T45:12).

I observed for myself that some pupils were confused. TA, in a fifth year class, asked why a population graph levels off.

P: shortage of humidity.
T: What does this word mean? P: Water. (T36:10).

In a fifth year lesson with TFA at the French school I was able to see an example of the use of 'humide' and to understand the confusion caused by the faux ami. I was not able to get down the exact words used, but in the writeup I made the following comment:

In this lesson I at last saw why pupils have problems with 'humidity'. Here used for 'moisture content' whereas to me humidity can only refer to gases. I was the next day able to point this out to TEA and she agreed. (T66:10)
Therefore when TEA came to the question of humidity in a handout I wrote in my notes that:

T took time, going through the handout to explain the problem with the word 'humidity'. Here is one example of fruitful interaction between TEA and myself. TEA said that humidity in English meant "the amount of water vapour". A pupil then gave the expression "faux frères" for such confusion. (T71:4).

This is one of the words I was able to test later in the questionnaire as to how confusing the students found such a faux ami.

Van Roey (1988) has a reasonably helpful section on this word, distinguishing between humid, moist, damp and wet. Humid is said to apply though to hot and humid climates only, which is insufficient: 'applying to water vapour' being a better explanation.

'Humid' is therefore a faux ami in scientific language.

Example 2, respiration /respiration
Here there are a cluster of words which are confusing enough even within one language, and are potentially more confusing when two languages are involved.

Basically in English there are two words where French has only one. Longman (1985) defines respiration as:

1a the process by which air or dissolved gases are brought into intimate contact with the circulating medium of a multicellular organism (eg by breathing)
b (a single complete act of) breathing
2 the processes by which an organism supplies its cells with the oxygen needed for metabolism and removes the carbon dioxide formed in the energy-producing reactions
3 any of various energy-yielding reactions involving oxidation that occur in living cells.

So respiration can mean the process of breathing or the use of oxygen by cells.

Henderson (1979) prefers to restrict the use to the cell level and explains in a later entry called "Respiratory movements" that these are movements which facilitate the supply of oxygen and the removal of carbon dioxide, and by implication cellular respiration.
RESPIRATION n. [L. respiration, breathing] the processes by which energy is acquired in a living organism or cell, by the breakdown of organic molecules, especially hexose sugars with the release of waste carbon dioxide; see also aerobic and anaerobic respiration.

RESPIRATORY MOVEMENTS any movements connected with the supply of oxygen to respiratory surfaces and the removal of carbon dioxide, such as the movements of the thorax and diaphragm in mammals.

The result of these differences of meaning in English was confusion for teachers and pupils alike. The subject was discussed at a teachers meeting and there was disagreement among the teachers. (T28:17).

Some pupils were additionally confused because of what they had been previously taught. It is worth remembering that the first year pupils at the English school were attempting to study biology in their third language, English, after only a term of studies of English. Therefore they were often restricted in what they could say. Not for the first time I suspect, a scientific meaning of a word was learnt before its common meaning.

I saw some of this confusion for the pupils, as the following extract shows. The extract comes from one of the very first lessons the pupils had of biology [2.] in which the teacher is explaining the characteristics of living things. The teacher is TEC and the topic in question is the nature of respiration.

P: to take oxygen and to give off . . .
P: to breathe
T: to take oxygen and give off, what is the name of the gas?
P: carbon dioxide [struggled to pronounce this]
T: How do you spell carbon dioxide?

[T writes this on the blackboard, also the word oxygen]
P: ???? T: Say it again?
P: The respiration is to use oxygen and to give off carbon dioxide (T12:26 on 11 Jan 1988).

2. I was not able to get comparable material of the first year in the French school as, for reasons of access to the schools, I was not able to start until 11 January 1988, and at the French school pupils began biology in the first term ie September 1987. The French school pupils did not need an intensive language course in French as they had already been exposed to French at the primary school for ten hours per week for four years.
It is not clear from this example in which sense respiration was being used, breathing or cellular respiration. Possibly the teacher meant one and the pupil meant another.

In French the distinctions are clearer. Respiration at the cellular level and respiration meaning breathing are distinguished by adjectives. Thus Larousse (1984) in its initial explanation assigns 'respiration' alone and unqualified to the cellular level of gaseous exchange. The dictionary goes on to define: 'respiration pulmonaire' for animals, 'respiration branchiale' for fish and crustacea, and 'respiration trachéenne' for insects. Also Robert (1984) has: 'respiration interne, tissulaire' referring to gas exchange between the blood and the body and 'respiration cellulaire' referring to oxidation inside cells.

Larousse (1984) continues:
Chez l’homme et les mammifères terrestres, la respiration revêt deux aspects: 1° mouvements d’inspiration et d’expiration de l’air dans les poumons...2° échanges réalisés au niveau des alvéoles pulmonaires, entre l’air et le sang.

In man and land mammals, respiration has two meanings. 1° movements of inspiration and expiration of air in and out of the lungs ...2° exchanges which take place at the level of the alveoli in the lungs between the air and the blood.

At the French school the following definition was given:

Chez l’homme la respiration se manifeste par les mouvements réguliers de la poitrine. (T13:9 12.1.88 dictating).

In man breathing shows itself through regular chest movements.

So if the primary sense of 'respiration' for man is respiratory movements this would agree with sense one of Longman (1985) (cited above page 8.11) in which 'breathing' (Henderson’s 'respiratory movements) would be the preferred English term, respiration being restricted to gaseous exchange, and later for more advanced students, restricted to the oxidation reactions in the cells which yield energy. But 'respiration' clearly has another sense as the process of ventilation. Here lies the confusion.
'Respiration' is therefore a faux ami of scientific language and also illustrates the lack of one to one correspondence between English and French for scientific words.

Example 3, lens / la lentille.
Quite simply the French have a separate name for the lens of the eye, they call it 'le cristallin'. Neither Robert (1984) nor Larousse (1984) apply the word 'lentille' to the eye. TEJ is to be acknowledged for first pointing this out to me. Harrap's Science Dictionary (1985) fails to make the distinction and does not even list 'cristallin' in the French-English section.

'Lens / lentille' is therefore a faux ami in scientific language.

Example 4, prick, sting / piqûre
Strictly speaking, this is not an example of a faux ami (for different words are used) but an example of a lack of one to one correspondence between English and French. It is included here as there were not enough examples showing a lack of correspondence that were not also faux amis to make a separate chapter.

There is one word in French for the two in English. I am indebted to TEA for pointing this out.

Example 5, sensible / sensible
I observed this difficulty several times. (T34:7, T27:7, T12:34, and hearing at the French school "la sensibilité de l'oscilloscope" (T273:12) English: sensitivity of the oscilloscope). In the transcript of a recorded example below, the context is the going over of a test, and the answer to the question as to what are the differences between animals and plants.

P: animals can (?) move but plants can't move and er sensibility er animals can't think but plants can. (T34:7).

The equivalent of sensible is 'sensitive' not 'sensible', The French for 'sensible' is sage, rassonnable. (Thody & Evans 1985 p205).
Défourneaux (1983 p111) points out that, "l'adjectif anglais sensible signifie sensé ". Van Roey contrasts the English 'sensible' with the French word 'raisonnable' which has more the sense of being wise, or prudent, than its English counterpart 'reasonable'.

'Sensible' and cognates is therefore a faux ami of scientific language.

c. Physics

Example 1, density

Maillot points out (1981 p33) that there are two traps.

\[
\text{English: - density,} \quad \text{specific gravity} \quad \text{French: - la masse spécifique,} \quad \text{densité}
\]

I was able to use this later in the test on the significance of some faux amis for the pupils.

Note that the term 'specific gravity' is outmoded in Britain. If the concept is to be referred to at all, ASE 'SI Units' (1981 p31) recommends the use of the phrase 'relative density'. This latter is the term used by Whelan & Hodgson (1989 p71).

'Density' is therefore a faux ami of scientific language.

Example 2, electrical engineer / ingénieur électrique

Maillot (1981 p46) gives this example and points out it is more than just a faux ami, for the adjective 'electrical' is translated by a substantive [3.] in French: 'électrique'. This difference was tested for in the questionnaire. The English 'electrician' meaning 'electrical engineer' also exists, which adds to potential difficulties.

3. Functioning syntactically as a noun, Longman (1985)
Example 3, electronic / electronique.

m\textit{icroscope electronique} = electron microscope

Here 'electronique' could if taken at face value refer either to an electron beam, or to the use of transistors and other electronic devices. The normal equivalent 'electronic' refers to transistors not to electrons. 'Electronique' is therefore a faux ami as there are two possible English translations, 'electron' and 'electronic'.

Example 4, solid / solide

'Solid' refers to the state: neither liquid nor gas, or to an object that is not hollow, or to something that is strong. The French 'solide' can have most of these meanings, including additional ones such as secure, tough, sturdy, hardwearing, and well established (Van Roey 1988 p660). But the French 'solide' can never bear the meaning 'strong' For that, the French 'résistant' is needed (Défourneaux 1980 p109, 126). 'Solid' can therefore be a faux ami.

Example 5, resistant / résistant

La résistance mécanique = mechanical strength
résistant = strong
travail résistant = negative work (SEP78)

While in the other known senses 'résistant' is an ami loyal, in the examples above it is a faux ami, with two other words, 'strong' and 'negative'. The case of the collocation of 'work': 'negative' is discussed in Chapter 10 'Descriptives'.

d. Chemistry

Example 1, trouble / trouble

Limewater is a common test substance and in scientific English it is described as turning 'milky' in the presence of carbon dioxide. In French, normal limewater ('eau de chaux') is described as limpide and in the presence of carbon dioxide it becomes trouble. I first noticed this while observing a first year lesson in French. This is a potential point of difficulty especially going from French to English: one does not say limewater becomes 'trouble'! 'Trouble' is therefore a faux ami of scientific language.
Example 2, mineral / minéral
The end product of respiration is described as, in French, "composés organiques et minéraux" (le inorganic). (6FB283). The opposite of organic, in French, can be 'inorganique' or minéral. 'Chimie organique' has as its opposite 'chimie minérale' (Robert 1984) not 'inorganic'. Défourneaux (1983 p81) states that the word 'mineral' exists in English to designate the products of a natural 'mineral' origin, and sometimes exists even as a synonym of inorganic eg mineral acids. But usually the French equivalent of 'minéral' is 'inorganic', not 'mineral'. 'Mineral' is therefore a faux ami in scientific language.

Examples 3 & 4, corpse / corps, substance / substance
A corpse in English is a dead body. The French word corps can be variously translated in English. Figure 8.3 below gives the details.

FIGURE 8.3 CORPS (Harrap's Science 1985 and 6FB27).

<table>
<thead>
<tr>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corps composé</td>
<td>compound</td>
</tr>
<tr>
<td>corps pur, acides, basiques</td>
<td>pure, acidic, basic</td>
</tr>
<tr>
<td>corps marqué</td>
<td>tracer (substance)</td>
</tr>
<tr>
<td>le corps humain</td>
<td>the human body.</td>
</tr>
</tbody>
</table>

There are several related faux amis here. The French 'corps' has a wider range of meaning than the English 'corpse' meaning dead body. The word 'compound' does, according to Robert (1984), exist, but it is an anglicisme. 'Substance' has more the sense in French of the old English usage, as in the Authorised Version of the Bible rendering of Hebrews 11:1, "Now faith is the substance of things hoped for, the evidence of things not seen".

'SUBSTANCE. Ce qui est perma-

nent dans un sujet sus-
ceptible de changer. Opposé à
accident. Essence, nature,
substrat, substantiel.
(Robert (1984)).

'SUBSTANCE. That which is
permanent in something which is
open to change. The opposite of
accident. Essence, nature,
substrate, substantial.

'Corps' and its compounds is therefore a faux ami, as is 'substance'.
Examples 5 & 6, motive / motif, unit / unité

The French 'motif' means both a 'recurring pattern' and a 'motive'. (Thody & Evans 1985 p40). For instance, for a recurring pattern: 'Le motif qui se répète CH\textsubscript{2}CH\textsubscript{2}...'. (T268, sixth year chemistry class).

The English would be 'unit' in this case, not 'motive'. 'Unit' is in itself a faux ami of the French word 'unité' (Eng: unity, unit) which otherwise has similar meanings to the English.

'Motive' and 'unit' are faux amis of scientific language.

Example 7, metalloid / métalloïde

Défourneaux (1983 p81) points out that the English for the French 'métalloïde' is 'non-metal'. Robert (1984) gives a double definition, the English sense of 'metalloid', and the sense of 'non-metal'. [4.]

Longman (1985) defines 'metalloid' as "an element (eg arsenic) having some properties of typical metals and some properties of typical non metals" ie it is intermediate in terms of properties between metals and non-metals.

The French 'métalloïde' can have two meanings: 'non metal', or 'mixture of metal and non-metal'. English has two terms, with 'metalloid' being restricted to that class of substances with properties in between that of the classes of metals and non-metals.

'Metalloid' is therefore a faux ami of scientific language.

4. METALOIDE 2\textsuperscript{o} moderne (1960):
corps simple qui a des propriétés métalliques, mais aussi des propriétés opposées et forme en particulier des composées amphotères. On les appelle aussi les non-métaux. (Robert 1984)

Synonyme ancien de non-métal (Larousse 1984)

Old synonym for non-metal.
RESULTS: VERBALS Faux ami 8.19

e. Mathematics

Example 1. magnitude / magnitude
The French 'magnitude' does exist for relative brightness in astronomy, but 'grandeur' is definitely the preferred word. For instance 'order of magnitude' is translated by 'ordre de grandeur'. An important distinction in mathematics and in science is the difference between approximation expressed as plus or minus a number (percent or absolute) and an approximation expressed to the nearest order of magnitude. [5.] I was repeatedly told, at both schools when I was designing the questionnaire, that the 'order of magnitude' was not taught by the sixth year therefore pupils would not understand it. I included it anyway as I would expect bright fifth years in UK to know this well, and thought that the pupils in Tunisia could have come across it. 'Magnitude' is a faux ami in scientific language.

4. DISCUSSION

No doubt with further work, more faux amis among words with a special meaning in science could be discovered. It is an interesting point also that many of the faux amis studied also show lack of one to one correspondence in the semantic fields between English and French, a point that is discussed further in Chapter 28. Even given similar forms of words, they are not necessarily equivalent. The results show that it is an over simplification to assume that scientific language will be the same in English and French. Consequently it can no longer be safely assumed that no work needs to be devoted to the vocabulary of science when someone is changing languages.

5. SUB-CONCLUSIONS

Faux amis exist in scientific language, just as in non-scientific language.

5. For instance 90 is not the same order of magnitude as 150 but 210 is, for 210 has the same number of figures as 150. In scientific notation 210 is expressed in the form 2.1 × 10² whereas 90 is only 9 × 10¹. 90 has only one power of 10, whereas 210 has two powers of 10. Both 90 and 210 are approximately 150 (ie 150±60 or 150±40%). But only 210 is of the same order of magnitude as 150. In science to say that a result is 'to the same order of magnitude as expected' can be more useful than saying 'the result was approximately what was expected'.
C. FAUX AMIS QUESTIONNAIRE

1. INTRODUCTION

A strict view of CSL implies that there are no faux amis in scientific language. The question asked in this section is, given that faux amis exist, what is their significance? Do they cause difficulties to pupils?

If CSL is even partly valid, then even when faux amis exist, they will not matter, they will not cause difficulties, and they will be widely known and accommodated for by teachers and pupils alike.

The trouble with faux amis is that they are subtle: it is so easy to assume a word is the same in English and French, and to be in error. Once a word is known to function sometimes or always as a faux ami then the main difficulty of ignorance can be removed. Therefore in designing a questionnaire in a way that so obviously tests mastery of faux amis I was avoiding the main problem of faux amis. Ideally tests of faux amis need to be concealed so that pupils would be unlikely to guess what I was testing.

In the event the form of test used was such that it tested how confusing faux amis are even when highlighted. In fact, if CSL is valid, then highlighting them should be even more reason for them not to cause difficulties, for known faux amis would give no problems.

It could be argued that the test instrument is a test of English. This is a fair argument, but the test instrument was more than that. All the words chosen were well known, and, with the exception of 'electrical engineer' and 'order of magnitude', had been met in the lessons.

It would have been interesting to give this English test to the pupils at the French school, and to design a test in French for the English school. There simply was not time for this refinement, though three of the six questions were formulated starting from French phrases as explained in Chapter 6 'Procedures'.
2. SUB-HYPOTHESIS

Given that faux amis exist, then if CSL is even partly valid, faux amis will not matter, they will not cause any difficulties, they will be known and accounted for by the pupils. Pupils will be able to cope whenever there is a lack of one to one correspondence between words.

3. RESULTS

(See Appendix 9 for the questionnaire and Appendix 10 for the numerical data. Question 1 required students to translate the French into English. Questions 2-6 asked for the missing words in sentences.)

Q1. 'Give the English for:—'

Here I gave six examples in French which involved faux amis. 'Le cristallin' (lens of an eye) and 'l'ordre de grandeur' (order of magnitude) were simply not known to the pupils at the English school. This is despite the fact that 'le cristallin' had been pointed out to me by TEJ, and the relevant section of the syllabus had certainly been covered by the time the test was administered. 'L'ordre de grandeur' was included even though I was fully aware of the fact that the concept was not covered in the Tunisian syllabuses. In the event no one knew the French phrase.

Similarly the pupils were just not familiar with the English surrounding the word 'electrical', a confusion explained in detail by Malliot (1981 p46). Few students (7 out of 89) knew the difference between a 'chronometer' and a 'stop-watch' or 'stop-clock', strong evidence that 'chronomètre' was a faux ami of significance to the pupils.

'La masse spécifique' le 'density' caused difficulties to 78% of the pupils. This word 'density' is an important and fundamental one, more so than perhaps the other words tested because it denotes a concept and is not just a label for part of an object. 'La densité' was even more confusing, with 95% of wrong answers (83/87 attempts). It is worth noting how few (10/63 = 16%) said they were aware of this as a faux ami before I pointed it out to them in the
test. Many more (28/63 = 44.4%) knew about 'la masse spécifique'.

Q2. Experiment and experience

Sentences a) and e) gave no problems of faux amis: students were well aware that 'experiments' are done in class. This is evidence which, if taken on its own, is in favour of CSL. Sentences b) and d) led to 'experiment' being confused with 'experience' in 30/84 (= 35%) and 30/83 (= 36%) of attempts respectively. In both these cases the questions had been set based on French phrases, as explained in Chapter 6 'Procedures'. Sentences c) and h) led to a confusion of 'experienced' with 'experimented' (French: 'expérimenté') in 5/88 (= 6%) and 26/87 (= 30%) of attempts respectively. Sentences f) and g) were put in as controls in that they both use the word 'experience' where there is no faux ami with French, i.e. when 'expérience' is an ami loyal. It is interesting then that some students (9/89 = 10% and 11/86 = 12.8% respectively) when forced to think about the subject thought there was a faux ami when there was not. This is evidence against the sub-hypothesis of this section.

Q3. Humidity

Students achieved good results on sentences a) and c) thus supporting the theory of CSL. Sentence b) resulted in a confusion of 'humid' (57/81 = 70.4% right attempts) with 'moist' (13/81 = 16%) and 'wet' (7/81 = 8.6%). This is another control sentence using the word when it is an ami loyal. Sentence d) was clearly one the students did not know the answer to: they did not know how to describe a cake as is clear by the way 15/84 (= 17.9%) gave 'damp', and 23/84 (= 27.4%) gave 'wet'. Only 8/84 (= 9.5%) gave the faux ami 'humid'. Therefore this sentence served more as a test of English than a test of the sub-hypothesis.

6. 'Density' is the mass per unit volume. The now outmoded concept of 'specific density' is the ratio of two densities, the density of water usually being taken as '1'.
Q4. Breathing and respiration

Sentences a) and d) gave no problems with faux amis, and are therefore evidence in favour of CSL.

Arguably in scientific English one can say as in sentence b) "to restore his respiration" but 'breathing' is better English, and 'respiration' is a faux ami which 18/87 (= 20.1%) used. More alarmingly for the level of English of the students, the majority (67/87 = 77%) chose 'breath' as an answer, which can be taken as a sharp reminder that faux amis are but a small part of the general question of English ability.

Despite sentence d) testing a phrase, 'artificial respiration'

French: 'respiration artificielle', 16/88 (= 18.2%) put artificial 'breathing' and 12/88 (= 13.6%) put artificial 'respiring'. The way that the students supposed a faux ami existed when in fact an ami loyal was required is evidence against CSL. It would have been interesting in retrospect to see if these same students had known the French phrase or not.

Q5. Passmark.

Though faux amis were not involved, this question tested the knowledge of students as to which words corresponded in English and French. Only sentence a) turned out to give useful results since b) and c) had several possible answers, and the number of students using the faux ami was small. Sentence d) brought out some of the confusion in that 10/85 (= 11.8%) thought that the 'mode' of an exam is variable, not the 'passmark'. Otherwise the evidence is inconclusive.

Sentence a) showed that while 53/88 (= 60.2%) knew about the term 'passmark', 16/88 (= 18.2%) chose the most common English translation of 'la moyenne' which is 'average', and 18/88 (= 20.5%) gave the actual French word 'moyenne' instead of an English word (though I wonder how many would have chosen to use the word 'passmark' if a free choice of words had been given). It is clear that students could not always handle these basic words.
Q6. Sensitive and sensible

Of all the questions, this is the one that gave the most difficulty. The faux ami 'sensible' was used for the English 'sensitive' in sentences a) b) and d) in 9/87 (= 10.3%), 42/89 (= 47.2%) and 24/87 = (27.6%) of attempts respectively. The faux ami 'sensibility' (French: 'sensibilité') was used instead of the English 'sensitive' in sentences c) and f) in 11/88 (= 12.5%) and 23/89 (= 25.8%) of attempts. In the control sentences e) and g) (in which the usage as an ami loyal was required) the faux ami 'sensitive' instead of 'sensible' was chosen by 17/89 (= 19.1%) and 10/89 (= 11.2%) of pupils respectively. All the results here are evidence against the sub-hypothesis.

4. DISCUSSION

Students were more confused by faux amis than they realised. This is shown for instance by the results for the question on humidity which on their own would be inconclusive. But later on in the questionnaire, 47/66 (= 69.7%) said that they knew of this faux ami and were not really confused by it. Students may not have been aware of the full range of use of the words tested here, and may not have been aware of their own lack of precision and knowledge in English.

The anthropological and linguistic context needs to be remembered when the sentences testing 'passmark' are considered. English speakers in a French system use French words in English without thought among themselves. It can happen that native speakers coming into a new situation abroad cannot understand the English used. The British and the Tunisian teachers all used words like 'moyenne'. A typical phrase might be, from a pupil, 'I didn't get the moyenne'. Native speakers of English usually know when they are speaking using a French word and can quickly change accordingly in a non-French speaking context. [7.]

The concept of the 'passmark', scarcely exists in Tunisian and French thought. The mark is always fixed at 10/20 or equivalent, though there

7. Force of long habit though can make one forget, and one can even be unsure if a word exists in the English of one's homeland or not. Foreign terms with no real equivalent in English such as 'stage' can be particularly irritating to translate.
is a way for students with 9/20 to pass if they do well in other subjects in the baccalaureate. In Britain the passmark for an examination can be any mark, either fixed in advance before the examination or fixed after the examination has taken place. Procedures vary and are complicated. See for instance the publication which explains how one English examination board sets and marks school examinations, in the reference AEB (1985).

Also, students in Tunisia do not study even the most basic of statistics until the seventh year. The 'pre-'O' level distinctions between mean, median, and mode, are not taught. This is explained further in the next chapter Section 3d Example 4.

This one question then, especially when considered in context, is considerable evidence against CSL at this point. If science teaching and words were constant, such basic terms would be fully understood, with no faux amis and the correspondences between words would be well known.

Whenever a faux ami was assumed instead of an ami loyal this is evidence against CSL because it is evidence of confusion on the part of the pupils. If CSL were valid then correct usage would be a matter of course.

5. SUB-CONCLUSIONS

a. Combining evidence from the sentence completion exercises with the scorings pupils gave as to how confusing they found some of the differences suggests that pupils may not always be fully aware of how little they know: they may be overconfident in their perceived grasp of faux amis.

b. While some examples of sentences show that pupils could clearly differentiate between French and English, others showed that faux amis are a problem. Some students even confused faux amis with amis loyaux. Therefore in general the sub-hypothesis is not supported: not only do faux amis exist in the language of science, but they were a problem to students at the English school.
D. FAUX AMIS OF PRONUNCIATION

1. INTRODUCTION

Scientific language is not just written. Scientists talk, and when they communicate in speech in a foreign language, there is the question as to how constant spoken scientific language is. It must be said that it is much easier for an Englishman in French because French has very clear rules about pronouncing written words and in writing spoken words. Therefore it is always possible for an Englishman hearing a new word to picture how it would be written. Also he can recognise the word from the spelling if not by the hearing. Owing to the fact that English is written with few consistent pronunciation rules, the reverse is much harder to achieve.

It is possible that the rules for pronouncing scientific English are stricter than those for pronouncing non-scientific English, and that the rules for this are international. The evidence though is probably against such a possibility. Johns and Dudly-Evans (1984 p146) write:

Sound-spelling correspondences. Many technical terms are international, and may be used in the student's first language in the same way as they are used in English. However the familiar term, while presenting no difficulty on the printed page, may be difficult to recognize when spoken.

Thody and Evans recognise that spoken scientific English is probably more difficult to understand than written scientific English. Also, such are the pronunciation problems in English that Défourneaux in both his books devotes many pages to it, and gives the pronunciation and the stress of words where necessary.

Occasionally the differences in pronunciation can give problems not just of understanding, but of also of actually getting the right equivalent word. The example will make this clear.

2. SUB-HYPOTHESIS

If CSL is valid then words that have similar spellings should be sufficiently similar when spoken, to be recognisable in another language.
3. RESULTS

While listening to sixth year chemistry lessons in French I came across a curious example of where a word said in French had a completely different meaning to me when I heard it in the English way. (T245). The French word sounded like an English word, and the context could, initially, have allowed either the English word or the real French word. The French 'alcyne' sounded like the English 'alkene'. [8.]

Daniel Jones' 'English pronouncing Dictionary (Jones 1989) does not list the word 'alkene', therefore to write the English in phonetics Gimson (1989) has been used as a guide. 'Alkene' in English is thus written phonetically as 'alkiːn'. In French Robert (1984) gives 'alcène' as 'alsen'. In contrast the French alcyne is given as written in phonetics as 'alsin' not 'alsiːn'. But, the introduction to Robert points out that (except for 'ε' in some words) the length of vowels in French is not used to distinguish between words, so vowel length has not been noted in the dictionary. (Robert 1984 page xxii). Therefore the correct transcription using the International Phonetic Alphabet (Gimson 1989) is probably 'alsiːn'.

Apart from the change of consonant from 'k' in in English to 's' in French, the vowel sounds are exactly the same for the English 'alkene' and the French 'alcyne'. Therefore an English word referring to a double carbon bond 'alkene' can be confused with the French word referring to a triple carbon bond, 'alcyne'.

This could be called a faux ami of pronunciation. When written there is no problem. French 'alcyne' = English 'alkyne', and French 'alcène' = English 'alkene'. But when the word 'alcyne' was first said I heard 'alkene'.

I had observed therefore a word with similar pronunciation which had a different meaning and spelling in the two languages. This is not the same as Maillot (1981 p51) who gives examples of words which are written the same way in two languages, but which are said in a different way and have different meanings, in the area of non-

8. 'Alkene' refers to carbon chains where double bonds exist, C=C, whereas 'alkynes' refer to triple bonds, C≡C.
scientific vocabulary. [9.] Maillot could not give any examples from science.

4. DISCUSSION

This is an important neglected area of CSL. It is important in ESP as much of science is communicated orally, in lectures and discussions. The example given above is an extreme one. No doubt more difficulties could be found if one looked. It is a fact of life that the pronunciation systems are different for English and French, English being particularly difficult owing to its non-phonetic script and the peculiar stress patterns and intonation which can be taught, but which are still very difficult for the non-native speaker to master. Further research is needed to identify exactly where the problem areas are, and in particular which ones are related to the assumption that science words will be mutually intelligible between two languages. Given the phonetic differences between English and French scientific words, mutual intelligibility must no longer be assumed, but be subjected to test.

5. SUB-CONCLUSIONS

One example has been found of a pronunciation difference for science specific words that is extremely misleading.

9. The examples given are:
   a. 'pour' French: /pu:r/ preposition meaning for,
      English: /pə/ verb meaning to cause to flow. (verser).
   b. 'ail' French: /aj/ garlic,
      English: /eɪl/ to suffer.
   c. 'an' French: /e/ year,
      English: /ən, an/ indefinite article.
   d. 'dire' French: /diʁ/ to say,
      English: /daɪə/ terrible.
   To which can also be added from my own observations:
   e. 'nous' French: /nu:/ we
      English: /nəʊ/ mind, reason, gumption, common sense
   f. 'ape' Italian: /aːpe/ bee, and a three wheeled vehicle
      used mainly for transport.
      English: /ɛxp/ a large semierect tailless or short-tailed Old World monkey (Longman).
   g. 'sale' French: /sɑːl/ dirty.
      English: /sɛl/ the act or instance of selling,
      selling of goods at bargain prices.
      Italian: /saːle/ salt.
   h. 'quel' French: /kel/ what, which.
      'quell' English: /kwel/ to squash, overwhelm.
E. SCIENCE AND SCIENTIFIC

1. INTRODUCTION

a. The subjects that can be called a science

'Science' in French is a broader term than its English equivalent.

- SCIENCE. Ensemble cohérent de connaissances relatives à certains catégories de faits, d'objets ou des phénomènes.
- SCIENCE HUMAINES, sciences qui ont pour objet de connaissance les différents aspects de l'homme et de la société, comme l'histoire, la sociologie, la psychologie etc. (Larousse 1984)

'Human sciences' in French refers to both the humanities such as history, and the human sciences such as psychology. Therefore 'sciences humaines' is a bigger term in French than its direct equivalent in English. 'Science' is also a much bigger word in French than in English and can refer to any subject studied systematically, and not just subjects accepted in English as 'sciences'.

Thody & Evans (1985) make a similar point under their entry "scientist". They point out that the Centre National de la Recherche Scientifique (CNRS)

... provides facilities for literary historians and philosophers as well as for microbiologists and nuclear physicists. Une revue à caractère scientifique is simply a learned journal, and may therefore possibly deal with literature or linguistics.(p129).

The word 'science' then can have a different, usually broader meaning in French than in English, as can 'human sciences'.

b. 'Science' and its opposites

According to the dictionary Robert (1984) the opposite of 'scientifique' is 'empirique'. Now whatever the opposite of scientific in English may be, it is certainly not seen as the polar opposite of empirical! Therefore further investigation is warranted.
To check that the French and the English mean the same by 'empirique/empirical', the dictionaries can be consulted.

EMPIRICAL. Originating in, based, or relying on observation or experiment rather than theory. (Longman 1985).

French and English dictionaries seem to agree that 'empirical' refers to experience rather than theory. But in French 'empirique' is the opposite of 'scientifique' (Robert 1984) as already stated. This implies that to be scientific is to be based solely on theory and reason. While several examples in Robert put theory and observation together as an essential part of the sciences (in the English sense of this word) the definition still tends to be towards equating 'scientifique' primarily with theory and reason rather than experience, experiment and observation. This statement is supported by the evidence that 'empirique' is taken to be the opposite of 'scientifique', and that the opposites of 'empirique' are given as 'méthodique', 'rationnel', 'scientifique' and 'systématique'. These opposites are summarised in figure 8.4 below. In English the opposites of 'scientific' would be 'non scientific', 'irrational', 'unsystematic' and 'unmethodical', not 'empirical'. Both the empirical and the theoretical are an essential part of science. (Hodson 1985, 1986b).

<table>
<thead>
<tr>
<th>Word</th>
<th>Opposites</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIENTIFIQUE</td>
<td>empirique, anti-scientifique</td>
</tr>
<tr>
<td>EMPIRIQUE</td>
<td>méthodique, rationnel, scientifique, systématique</td>
</tr>
<tr>
<td>SCIENTIFIC</td>
<td>non-scientific, Irrational, unsystematic, unmethodical</td>
</tr>
<tr>
<td>EMPIRICAL</td>
<td>theoretical</td>
</tr>
</tbody>
</table>

For instance Hodson (1986a) says that

... while it is apparent that no single, universally accepted view of science emerges from a consideration of the literature, there is a measure of agreement on a number of points relevant to the school science curriculum. (p216).
Among the nine areas of agreement, much of which "centres on the role and status of observation in science" (Hodson 1986b p382) the link between theory and observation is seen as an essential component of science. For instance,

Observations are theory dependent and theory often, though not always, precedes observation". (Hodson 1986a p216).

Science in English consists equally of empiricism and rationalism, and the interplay between these two approaches.

In non-scientific English, to be 'too scientific' means to be 'too intellectual'. 'Scientific' in this context is seen as the opposite of empirical. Yet, when one goes out and collects information or samples systematically, this is viewed as being 'scientific', i.e. a practical activity organised by careful thought and plans. So in non-scientific English there is more than one sense to 'scientific'.

Possibly the opposite of 'scientifique' in French is seen as mainly or only 'empirique' with no theoretical constraints. Just as in non-scientific English 'scientific' can be associated with both 'empirical' and 'intellectual' or both combined, so too in French. Both the intellectual and the empirical components exist in the French understanding of 'scientifique', but there is a possible change of emphasis. French tends to stress the intellectual more than the empirical in a way that would be unacceptable in English. The reasons for this are probably rooted in history with the French stress on reason in their culture, and may be linked with the importance of mathematics as a school subject (discussed further in Chapter 27 'The forces operating for and against CSL').

c. Sciences Naturelles

The way of dividing up the subjects of school science is different in English and in French. All except one of the Tunisian biology textbooks had for title, 'Sciences Naturelles', the exception being the final year book entitled 'Biologie', and concerned almost entirely with animal biology. [10.]
In contrast the teachers at the English school chose to use the title, "Natural Science", for only one book (the sixth year book).

The term also confused some teachers at the English school. In an introductory lesson for the first years at the English school TEC said,

T: what is natural science?
P1: . . . studies plants, rocks, and animals. (T12:6,7).

The reply by the pupil was accepted as correct.

'Natural Science' is not an English term: the teacher was using a phrase adapted from French. The equivalent in English would be 'natural history', as for instance in the title of a famous museum in London, the Natural History Museum.

The scope of the subjects is different. Significantly 'sciences naturelles' includes geology whereas in the UK this subject is usually studied as part of geography. By the origin of the word 'biology' meaning "the study of life" it is hard for someone in the Anglo-Saxon tradition to see how geology, which has nothing directly to do with life, has anything to do with biology. The situation in the UK may though be changing. Earth sciences are now being seen as part of the general science education of pupils and is taught by science teachers not geography teachers. (Notes 1991).

Larousse (1984) clearly states that,

| SCIENCES NATURELLES                      | NATURAL SCIENCES, Sciences of nature (botany, geology, zoology etc). |
| sciences constituées à partir de la nature | (botanique, géologie, zoologie etc) |

In contrast Harrap's Science (1985) fails to see any difference and calls 'natural science' 'sciences naturelles' and vice-versa.

French society has chosen to use this, the science of nature, as a basis for a subject, rather than the science of life, biology. Therefore there is a difference in the way of dividing up and classifying science subjects in French and in English. It was of
interest to find out the views of pupils in the French and English schools and to see how much they followed French customs.

2. SUB-HYPOTHESES

Dictionary definitions are not necessarily the ones held by people hence the question to the pupils. If CSL is valid, then from the British viewpoint pupils should see science as a combination of theoretical reasoning and practical activity. Any evidence that the scientific is mainly reason and excludes practical work, is evidence against CSL. The sub-hypotheses are therefore:

a. the meaning of 'scientific' will be the same in English and French, as studied through dictionaries. This has already been shown to be partially incorrect, in Section E above.

b. pupils at both schools will see 'scientific' as having the same sense involving theoretical reasoning and practical activity.

3. RESULTS

For details see Appendix 13. The majority of the students who replied at the English school, (reduced in number to students from three classes because of time pressures in a fourth), saw scientific as including theoretical reasoning and practical activity. The results for the English school were 25/53 = 47.2% and for the French school 17/89 = 19.1%. On the other hand more replies in the French school (67/86 = 75.3%) stressed the rational objective theoretical senses than in the English school (13/53 = 24.5%).

Four students at the French school actually stated that the opposite of 'scientifique' was 'empirique'. I have quoted their answers in full in Appendix 13. None of the students at the English school stated this.

The highest response to what was the opposite of scientific was 'literary': 19/53 = 35.8% in the English school and 23/89 = 25/8% in the French school.
4. DISCUSSION

It is not fair to argue that the French do not polarise Arts against the Sciences. While the polarisation between the Humanities and Sciences may be less marked in French than in English as Thody & Evans (1985 p129) assert, it still exists, at least in Tunisia.

Comparison with Durant's survey of the public understanding of science (1989) would have been interesting, but unfortunately the two largest groups in the results of his question, 'What does it mean to study something scientifically?' were 'Other answers 43.1%' and 'Don't know/Not answered 43.2%'. The few who mentioned theory construction or experimental method are too small in numbers to compare with these results from Tunis.

The dictionary Robert (1984) gave a clear explanation that the opposite of 'scientifique' is 'empirique' as discussed above. Even if the word 'only' is inserted, the opposite of scientific being empirical only, the weight is still to equate scientific with logic and reason, and practical activity with anti-science.

5. SUB-CONCLUSIONS

There was no consensus among the pupils, at both schools, that 'scientific' referred to both theoretical reasoning and practical activity, as stated in sub-hypothesis b. The pupils at the French school were more likely to follow the French dictionary definitions than the pupils at the English school.

Even if it is a question of degree not in kind, there is a clear difference in trends between the two schools. The evidence is against the sub-hypothesis. This is yet another example of how a word can encapsulate a whole different way of thinking and working.
F. CONCLUDING DISCUSSION

The assumption that scientific words will always have the same meaning in English and French has been shown to be untenable. Even basic words, at the heart of the division of science into disciplines, and at the heart of some of the inherent ways of proceeding in science, have been shown to have semantic fields that do not completely overlap.

When the material in Appendix 16 is also considered, it is clear that the question of faux amis is not an isolated case, but, as in other areas of language use in science they are a significant area of differences between English and French. This is especially true when the material presented here is considered along with the differences in 'Definitions', the subject of the next chapter. Also faux amis can be involved in instances where a one to one correspondence between French and English cannot be assumed such as French 'respiration' = English 'respiration, breathing'. When faux amis in scientific language are added to those known to exist in non-scientific language, a considerable area of re-learning is opened up for anyone desiring to be functional in both French and English. Regrettably, both Thody & Evans (1985) and Van Roey (1988) largely ignore even the basic faux amis of science.

Faux amis can cause difficulties even when they are known about. This was especially evident in the way pupils at the English school sometimes thought a faux ami was involved when there was not. Faux amis appeared even in the English translation of the 1989 physics baccalaureate examination paper given to the first group of students from the English school to take the baccalaureate.

The numbers of faux amis I have managed to collect and study, (and I am by no means confident that I have collected more than just a selection of those that exist), is a significant part of the case against the assumption that there is constancy of scientific language.
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1. INTRODUCTION

The subject of "definitions" was an early focus of the research. The British teachers TEA, TEG and TEH were surprised by the demand for definitions by the pupils when they first took up their posts in 1986. In the extensive periods of lesson observation 1987-89 in the French and English schools less evidence of this demand was found than expected. Instead, a study of definitions became but one part of testing the assumption of CSL. Inevitably there is some overlap between this chapter and others such as Chapter 8, 'Faux amis', since faux amis can appear as part of the wording of a definition. Where a faux ami is part of a definition it is considered here. Also included are the definitions involving symbols, such as the definition of a force.

Much of the chapter is derived from what I found in the schools, not just in textbooks. These definitions, and differences in them, gave real difficulties to teachers in the English school when they attempted to translate the French text and to stay as close to the French as possible while working in English.

2. SUB-HYPOTHESES

a. Where definitions are used, the content of these definitions will be the same in English and French. The scientific language of definitions will be international.

b. Where there are sets of inter-related words there will be:
   1) no ambiguity within a language.
   2) complete correspondence between English and French sets of inter-related words.
   3) no faux amis.

c. Where a choice of words is possible, for the same phenomena, the choice made will be the same in English and French, for the given level in the school.

1. See Chapter 6 'Procedures' Section 2 'Teacher interviews' for quotations. Also relevant is Section 3 'Lesson observation' b. 'Appraisal spring 1988'.
3. RESULTS

a. Examples from biology

Example 1, marne and marl.
The translation of this word was a real problem for the biology Teachers at the English school, and was an example I was given when I asked for definitions. 'Marne' in French refers to sedimentary clay and limestone (calcaire). The nearest equivalent in English, 'marl' is a wider word and covers soil which has a silt or clay base, with a layer of chalk on top.

The two words 'marne' and 'marl' have different definitions.

Example 2, biosphere and related words
There are several words related to biosphere which gave translation problems to the teachers at the English school. The sets of equivalent words are recorded in figure 9.1 below.

FIGURE 9.1 BIOSPHERE AND RELATED WORDS

<table>
<thead>
<tr>
<th>French Word</th>
<th>English Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>ecosystème général</td>
<td>biosphere</td>
</tr>
<tr>
<td>ecosystème (communauté)</td>
<td>ecosystem / ecosystem [2.]</td>
</tr>
<tr>
<td>biocénose</td>
<td>community</td>
</tr>
<tr>
<td>population</td>
<td>population</td>
</tr>
<tr>
<td>biotope (habitat)</td>
<td>habitat</td>
</tr>
</tbody>
</table>

(T31:15. TFA ,T99:6 TFA, 5FB92, handout D3 for English definitions.)

The dictionary Harrap's Science (1985) is misleading, giving the English for 'biocénose' as "biocenosis, biocenose", not 'community'. There is the problem too that the word 'communauté' exists in French, but it is not applied by Robert (1984) to animals though 'habitat' is. 'Biocénose' and 'biotope' are the preferred words in French, not 'communauté' and 'habitat'. From figure 9.1 above it is clear that the English 'ecosystem' has a narrower meaning than the French 'ecosystème'.

Each language therefore has a different set of terms, and there is not a complete correspondence between the two languages which at the same time avoids faux amis.

2. According to Henderson (1979) 'biosystem', the names 'biosystem' and 'ecosystem' are synonymous.
Example 3, Eurytherms and stenotherms

The Penguin Biology Dictionary (Abercrombie 1973), which was used by the teachers at the English school to check their translations, gives the following definitions.

**EURYTHERMOUS** Able to tolerate wide variations of temperature of environment of stenothermous.

**STENOTHERMOUS** Unable to tolerate a wide variation of temperature of environment.

The difficulty the teachers at the English school had was that while these terms exist in English they are not necessarily the words in current school usage in England.

The French textbook states,

> certaines espèces ne tolèrent que des variations limitées de température, elles sont dites sténothermes; inversement les espèces eurythermes tolèrent des variations de plus grandes amplitudes. (5FB151)

Similarly TFA defined 'animaux eurythermes' as

> qui sont capable à resister à de grandes variations en température. (T41:12)

This is fine so far, the definitions are the same as before. But Larousse (1984) defines STENOTHERME as

> se dit des animaux marins qui exigent une température à peu près constante de milieu. (1984)

The definition of 'Stenotherme' is therefore restricted in Larousse (1984) to marine animals.

TEB, in writing the fifth year biology textbook chose to use the Penguin definition in English when she wrote,

> Eurythermous species are able to tolerate wide variations of temperature. Stenothermous species are unable to tolerate wide variations in temperature. (5EB158).

The other possible words, poikilothermic (cold-blooded) and homeothermic (warm-blooded) were not used at this point, though by the time a later handout was written they were used alongside the
previous words eurythermous and stenothermous as in the extract below.

Remember that eurythermous are organisms able to tolerate wide variations of temperature of the environment and stenothermous are unable to tolerate such variations. The locust is stenothermous. Two other ways of grouping organisms depending on whether or not they maintain their body temperatures at constant, high levels. *Homoiothermic*, or *endothermic* or *warm-blooded* can maintain their own body temperature at constant levels by releasing large amounts of heat eg birds and mammals; whereas *poikilothermic* or *exothermic*, or *cold blooded* are animals whose body temperature is strongly influenced by the conditions of their environment. Reptiles and invertebrates are poikilothermic. (5EB160). [3.]

It is interesting that in the more up to date sixth year French biology book, the terms used were *homiothermes* and *poïkilo-thermes* (p57) without reference to 'eurythermous' or 'stenothermous'.

There is therefore ambiguity in French as to the meaning of the word 'stenothermous', which strictly speaking may be held to only apply to marine animals. 'Poikilothermic' and 'homeothermic' have similar meanings in English and French. 'Stenothermal' would be an unlikely choice of a scientific word in English at fifth year level.

Example 4, xerophyte, mesophyte and hydrophyte

According to Henderson (1979) these terms mean:

**XEROPHYTE**: a plant adapted to dry conditions, either having xeromorphic characteristics or being a mesophyte growing only during the wet period. alternative: xerophil, serophyte.

**MESOPHYTE**: a plant thriving in temperate climate with normal amount of moisture.

**HYDROPHYTE**: an aquatic plant living on or in the water.

The important feature to note here is that all three definitions refer to plants.

At the time these words were debated Henderson (1979) was not available to me or to the teachers at the English school. TEA though,

3. For once, it appears that most of the terms were given to the pupils, instead of giving them only the words which were closest to those used in the equivalent French textbook. The plethora of terms within English made for a lot of new vocabulary for pupils whose mother tongue was not even English.
having a degree in botany, insisted that (T75:6) 'phyte' refers to plants only, there being no term in English that includes animals. TEA and Henderson agree at this point.

According to the French text year 5 page 153-4: [4.]

La répartition des végétaux et des animaux est liée à la classification des êtres vivants, selon leurs besoins en eau...

Les organismes hygrophiles: ne peuvent vivre que dans des milieux très humides...A côté de plusieurs espèces végétales on trouve souvent des amphibiens adultes et des gastéropodes terrestres...

Les organismes mésophiles: Leurs besoins en eau et en humidité atmosphérique sont modérés. Ils peuvent supporter des alternances de saison sèche et de saison humide, c'est le cas d'un grand nombre d'espèces animales et végétales du Nord Tunisien et de la plupart des plantes cultivées.

Les organismes xérophiles: vivent dans des milieux secs.

The distribution of plants and animals is linked to the classification of living beings according to their needs for water.

The "hydrophiles" can only live in very wet environments ... alongside several plant species are often found adult amphibians and land gastropods [Henderson 1979: class of asymmetrical molluscs]

The "mesophiles": their needs for water and humidity are intermediate. They can tolerate alternating dry and wet seasons as is the case of a large number of species of animals and plants in the North of Tunisia and most cultivated plants.

The "xerophiles": live in arid environments.

The French text goes on to explain and give examples of animals and plants which are 'xérophiles' ie adapted to arid environments. The terms 'hygrophile' and 'mésophile' therefore includes animals as well as plants. This gave a problem in translation, given the pressure to conform to French usage. The teachers eventually came down on the side of the English usage.

Hydrophytes are plants which live completely or partially submerged in water: obviously they have no difficulty in obtaining water. Mesophytes grow in normal well watered soil: normally the water they lose by transpiration is readily replaced from the soil, and so they need no special way of conserving water. In contrast xerophytes live in dry conditions such as the desert: these are adapted to surviving drought in various ways. (5EB113).

4. The word 'hygrophile' is correct. The French word 'hydrophile' refers to a) something that absorbs water, and b) "insect coléoptère noir verdâture qui vit dans les eaux stagnantes" (Robert 1984).
The closest Henderson (1979) gets to using the '-phile' suffix is an entry under 'xerophilous' and even this is applied to plants only, not to animals.

There appears not to be a term in English covering the needs for water of both plants and animals as exists in French. The definitions of these related words in English and French are therefore significantly different.

Example 5. mutualism, symbiosis, commensalism

On 12.2.88 in a meeting the teachers discussed what 'mutualism' meant. (T39:1). Eventually the teachers agreed that 'mutualism' meant 'symbiosis' (explained below). TEA thought that while this word 'mutualism' did exist in English it was rare. According to this reasoning the translation of 'mutualism' ought to have been 'symbiosis'. But the pressure at the English school was to use terminology as close to the French as possible, therefore 'mutualism' was preferred.

TEA on 23.2.88 built up the following table on the board (figure 9.2):

<table>
<thead>
<tr>
<th>Parasitism</th>
<th>-</th>
<th>-</th>
<th>Where</th>
<th>+ benefit</th>
<th>- harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutualism (symbiosis)</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Commensalism</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>no effect</td>
</tr>
</tbody>
</table>

TEA explained how the two columns with plus minus and zero in them represented two organisms and their effect on each other, which way round they were being of no importance. (T49:5,6).

The translated English textbook used the heading "mutualism" not "symbiosis" (p99) despite 'symbiosis' being the more usual word in English.

The dictionary Harrap's Science (1985) equates 'symbiosis' with 'commensalism'.

Henderson (1979) gives the following definitions,

MUTUALISM: a form of symbiosis in which both parties derive advantage without sustaining injury.
SYMBIOSIS: living together of different species not necessarily only those of mutual benefit; the term is often used for an association of mutual benefit which is more properly called mutualism.

COMMENSAL: an organism living with another and sharing the food, both species as a rule benefiting by the association, or one benefiting and the other not being harmed.

The French textbook simply has five headings

Neutralisme, Compétition interspécifique, La symbiose ou mutualism, Le parasitisme, La prédation. (5FB200-216)

In the related lesson in the French school five headings were given (T90 5.5.88) "prédation, parasitisme, symbiose, commensalisme, antagonisme".

The definitions given by TEA agree with those given in Robert (1984).

<table>
<thead>
<tr>
<th>Source</th>
<th>Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Henderson</td>
<td>symbiosis</td>
<td>0 0 (strict)</td>
</tr>
<tr>
<td>(1979)</td>
<td>mutualism</td>
<td>++ (usual)</td>
</tr>
<tr>
<td></td>
<td>commensalism</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>0</td>
</tr>
<tr>
<td>TEA</td>
<td>symbiosis</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>mutualism</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>commensalism</td>
<td>0</td>
</tr>
</tbody>
</table>


symbiosis = commensalisme

5FB200 neutralisme 0 0

Robert mutualisme ++

commensalisme + 0

FIGURE 9.3 SUMMARY OF THE VARIOUS MEANINGS OF MUTUALISM AND RELATED WORDS.
The different meanings associated with the words can be summarised using the symbols of figure 9.2 in figure 9.3, where + means benefit, - means harm, and 0 means no effect.

There is therefore ambiguity in English, and the preferred word in English at school level is 'symbiosis' whereas the preferred word in the Tunisian biology texts was 'mutualisme'.

b. Examples from Physics

Example 1. a force

a) The distinction between 'direction' and 'sens'

In English, a force is characterised by its magnitude and direction. Thus when describing a force, the size and the direction of the force must be stated, or be clear from the context. In French, there are three essential features that must be described, direction, sens and valeur. (Many references, see for example 4FP89, or lesson T210).

The nearest English equivalents to the French 'direction' are, 'horizontal direction', or 'vertical direction'. A vertical direction can then have an upward or a downward sense.

In French physics both 'direction' and 'sens' must always be specified, whereas in English physics usually one word which combines both meanings will suffice, the word 'direction'.

When in English it is said that every force has an equal force of opposite direction, in French each force has an equal opposing force that has the same direction but opposite sense. (sens contraire T277:1).

In normal French usage, a phrase like 'sens unique' is used for 'one way street'. In contrast Van Roey (1988 p226) gives an example of the use of the French 'direction' where the meaning is clearly that of the English, including the 'sens'.

ils allaient dans la DIRECTION de Bruxelles

They were going in the DIRECTION of Brussels

(Translation Van Roey).
Therefore it is not possible to argue that in English direction always includes sense whereas in French direction can never implicitly include the meaning of sense. But when a force is described, the conventional definition in English has only 'direction' whereas French insists on 'direction' and 'sens' being specified. This subject was discussed several times between the physics teachers at the English school and myself. They insisted that in French physics 'sens' cannot exist without first specifying a 'direction'. (T230:3). My suggestion that the use of positive and negative direction could be used instead of 'sens' was not understood. (T230:5). [5.]

b) **Translation at the English school**

Because of the pressure to conform to the French way of explanation, several attempts were made to reconcile the two systems. 'Sens' was variously translated as,

- 'orientation' (4EP38),
- 'line of action' (4EP58,69),
- 'vertically upwards / downwards' (4EP75)
- 'direction' alone. (6EPI35),
- 'direction' and 'sense' (T211:10)

An example of the use of both 'direction' and 'sense' in a lesson is when TEM said,

T: The two forces have the same direction and value but not the same sense" (T211:10 TEM year 5).

5. Note that Whelan & Hodgson (1989) present three different definitions in the same textbook.
   a) In the context of current through a resistor, they do use positive and negative, for 'sense' (p390).
   b) On page 400 in the introduction to the 'magnetic force on a moving charge' they say, "We represent the magnitude, direction and sense of the magnetic field by the magnetic flux density B."
   c) A few lines later in explanation of a diagram they write, "the tangent to a field line at a point gives the direction of B at that point", the diagram having an arrow on it indicating the sense. While a tangent could have two 'senses' at 180° to each other, in practice the distinction between direction and sense is not usually made therefore in this case direction implied sense, though the arrow on the diagram made sense explicit.
c) Unit vectors

The 'unit vector' system of mathematics is used in France and Tunisia. Therefore force was defined using unit vectors, and these were invariably present whenever equations of forces were written. The unit vector system was used for the definitions, and also when calculations were done on the combining of forces. [6.]

The implications for the use of unit vectors in the writing of equations are considered in Chapter 21 'Equations'. Here, the definitions, both in verbal and symbol form, are of interest.

Force, when first introduced in the fourth year, was defined in terms of unit vectors. In symbols this was:

\[ F = F_1 F. \]

In words this means:

A force which is exerted on a moving body causes a change in the velocity vector of the centre of this body. (4EP31-2).

In English, the equations \( F = ma \) and \( F = \frac{mv^2}{2} \) are more likely to be used, without any reference at all to unit vectors.

The definition of a force at school level is therefore not the same in English and French, partly due to the French use of unit vectors, and partly due to the French distinction between 'direction' and 'sens'.

Example 2, speed and velocity

In English there is a distinction between 'speed', which is a magnitude, and 'velocity', which is a vector quantity. French has only one word, 'vitesse', which is generally equivalent to the English 'speed'. When one wants to emphasise the vector quantity in French, the expression 'vecteur vitesse' is used. Défourneaux (1980 p122) explains that, "vitesse (scalaire)" is speed, and "vitesse (vectorielle)" is velocity. He also notes that,

6. In contrast it is worth noting that the so called 'parallelogram rule' of combining forces which divides a force into two component directions and uses vector addition and subtraction to combine them, while existing in French, (Défourneaux 1980 p62 mentions it) was not taught in the Tunisian schools.
Le terme 'velocity' est très largement employé en langage scientifique même pour désigner la grandeur scalaire, l'inverse se produisant dans le langage courant.

The term, velocity, is used a lot in scientific language to mean speed, the converse being true in popular usage.

(translation IL).

To conform as closely as possible to the French, at the English school French 'vitesse' was translated as 'velocity' and 'vecteur vitesse' as 'vector velocity'. This is completely distorting English usage, and the teachers were aware of this, for it was they who first pointed out the example to me. Also, 'vector velocity' is tautologous. In English 'velocity' is already a vector quantity. (T208:11).

The English distinction between 'speed' ('vitesse') and velocity ('vecteur vitesse') exists in French, but is expressed in different words. 'Vitesse' cannot be equated with the nearest equivalent English word 'velocity'.

Example 3. momentum
Though technically not a question of definitions, momentum is included here as it follows on from velocity and force as another vector concept, and different terms are used in French and English for the same concept.

In French there is no single word for the English word 'momentum'. Harrap's Science (1985) gives three possible terms for momentum.  
force vive, force d'impulsion, quantité de mouvement
6FP63 has vecteur quantité de mouvement and proceeds to give the definition as the product of the mass times the velocity, as in English, so it is obvious that momentum is being referred to.

The teachers appeared to have been well aware of the English term, for the heading of one section is, "Momentum of a point mass". Two lines later though, the formula is given in the French way,

\[ \vec{p} = m \vec{v} \]

and the terms are defined as:

\[ p: \text{vector momentum at the time } t \]
\[ v: \text{velocity at time } t \]
\[ m: \text{mass of the point mass.} \]
Later in the same book (p94,95) the English term, momentum, is used correctly, and not the term 'vector momentum'. This latter term is in fact tautologous, for momentum is by definition a vector quantity.

French and English have therefore different terminology for the concept of momentum, a difference sufficiently great that the teachers found it difficult to translate from the French and stay close to the French usage.

c. Examples from Chemistry

Example 1, Normality
This is an outmoded concept in English, and has been replaced first by the term 'molarity' then 'mole per cubic decimetre'. A 0.1 M (molar) solution would be expressed as 0.1 mol dm⁻³. As early as 1972 the Association for Science Education could recommend that,

Strictly speaking, the word "molarity" (whose use carries the risk of confusion with molality) is now redundant, being only a synonym for concentration. I.U.P.A.C. recommends that it should not be used. (ASE 1972 p10 cp ASE 1985 p12-13).

The term 'normalité' was used in the fifth year French chemistry book (eg 5FC107) while the sixth year used moles per litre. The problem here is the equivalence of definitions when an old and a new terminology exists.

As long as definitions are changing, one international definition cannot exist, therefore scientific language is not functioning as a constant language.

Example 2, Definition of an acid: pH
The quantity pH is taken at school level in Britain as,

\[-\log_{10}\left(\frac{[H^+]}{\text{mol dm}^{-3}}\right)\] (ASE 1985 p19).

This means that pH is related to the concentration of H⁺ ions, pH being a measure of acidity.

In Tunisia in contrast, while an acid is initially defined in terms of H⁺ ions, pH is defined in terms of H₃O⁺ ions.

\[[\text{H}_3\text{O}^+] = 10^{-\text{pH}}\] (FC72,73,75).
A French source (Corrigés 1988 p34) gave the same definition as the one given in Tunisia. The definitions, both the mathematical form and the use of H\(^+\) ions in English and H\(_3\)O\(^+\) in French are different.

Example 3, Standard Pressure
ASE (1985) recommends that atmospheres be retained only for rough comparisons and that,

all calculation work should be based on the unit Pa and its multiples kPa, MPa, mPa, etc. (p12)

But many calculations in chemistry are made based on the "Standard Pressure for gases". This used to be one atmosphere, ie 101 325 Pa or 760 millimetres of mercury (760mmHg). In a change since the previous edition of ASE's 'Chemical Nomenclature' in 1979, IUPAC now apparently recommends that the standard pressure for reporting thermodynamic data be 10\(^5\) Pa, but that normal boiling points be reported assuming a pressure of 101 325 Pa as before. The chemistry teacher's guide for Nuffield advanced chemistry (Nuffield 1970 p57) defines standard temperature and pressure (s.t.p.) as "273K & 760mmHg" (p57) and goes on to say,

Students can be told that an average value of 22.4 cubic decimetres for the volume of 1 mole of gas molecules at s.t.p. is generally accepted. (p57).

Also, for convenience of doing calculations though it is not standard, a mole of gas at 293K (ie room temperature 20\(^\circ\)C) and 1 atm (ie 760 mm Hg or 101 325 Pa), occupies approximately 24 dm\(^3\) (ie 24 litres). The new pressure of 100 000 Pa means an unhappy approximation of 23.7 dm\(^3\) for 293K and 22.1 dm\(^3\) for 273K. Other correction factors to convert various tables of quantities, are noted in ASE (1985 p12).

A new 'Standard Pressure' means that two standards are operating under the same name. Scientific language and its definitions cannot be constant as long as two standards are in existence and when the two standards are not used in comparable circumstances in two languages.
d. Examples from mathematics

Example 1, a line.

The various definitions in French are:

i) La ligne est un ensemble infini de points". (1FM173)

ii) Par deux points distincts 

Through two distinct points

(1FM175)

iii) demi-droite.

lit: 'half a straight line'.

(1FM181)

iv) segment de droite.

lit: 'segment of a straight line'.

(1FM182-3)

In a similar way, the fourth year mathematics textbooks state:

... To define the velocity frame of reference at point A, we refer again to the case of rectilinear motion (fig 8) thus, we need only around point A, a part of the trajectory small enough to be assimilated to a segment line. This segment line has the direction of the trajectory tangent at point A. (4EP24).

We can assume B1B2 to be a segment line. (4EP26).

In only my second interview with the British teachers, on 12 October 1986, the question of the definition of a line was raised. At this time there was no mathematician among the British teachers. They were convinced that the term 'line segment' did not exist in English. (TEG, TEH). The term to them was tautological as a line is obviously a segment, unless qualified, for instance, as an 'infinite' line. (T3:31). To them a line joining two fixed points would be called a 'segment' (1FM186) or a 'droite' (Robert 1984) whereas in English this would be simply be a 'line'. [7.]

There is a distinction in French between a 'line' and a 'straight line'. In English a line is assumed to be straight unless there is indication to the contrary. In contrast in French, the short form of 'straight line', 'ligne droite' is 'droite'. In other words it is false to view the initial sense of 'ligne' as a 'straight line' for if the

---

7. Longman (1985) has 'segment' as "the part of a line between 2 points in the line. The important point here is that two British physics teachers took the view that a line joined two points.
French wants to stress that, the word 'droite' would be used. As Défourneaux (1980) says,

--- (ligne) droite
(straight) line

Lorsque le contexte ne permet pas de confusion, straight line est toujours abrégé en line, contrairement au français où ligne droite est abrégé en droite. On n'emploie donc straight que pour insister sur la forme rectiligne. When the context allows of no confusion, straight line is always shortened to line. This is contrary to French where ligne droite is always shortened to droite. Straight is therefore only used to stress the rectilinear form of the line. (p59 English translation IL).

In the Tunisian system, a line is taught as coming from infinity and going to infinity. Therefore it is possible to have the concepts of 'half a straight line' (ie from a point to infinity), and 'segment of a straight line'. A 'demi-droite' has a single point as an origin and passing through another known point, goes to infinity. A 'segment' or a 'droite' joins two fixed points. While 'segment' is possible in English, it is not the most usual word, and 'half a straight line' is clearly a nonsense.

The differences can be summarised in the figure 9.4 below.

**FIGURE 9.4 DIFFERENCES BETWEEN THE FRENCH AND ENGLISH SENSES OF 'LINE':**

<table>
<thead>
<tr>
<th>French to English</th>
<th>English to French</th>
</tr>
</thead>
<tbody>
<tr>
<td>ligne droite/droite</td>
<td>line</td>
</tr>
<tr>
<td>ligne</td>
<td>curved or straight line</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>demi-droite, segment de droite</td>
<td></td>
</tr>
<tr>
<td>droite</td>
<td></td>
</tr>
</tbody>
</table>

(p59 English translation IL).
Example 2. Linear and curvilinear.

In an early interview with the three British teachers my notes record:

Discussion of the concept of linearity. As far as TEG and TEH were concerned, 'rectilinear' and 'linear' were synonyms exact. The image conjured up by 'linear' was of a straight line graph. Therefore 'curvilinear' was a nonsense. (T3:32, 12 Oct 1986). [8]

The mathematics textbook states:

... The circular motion is a plane motion with a circular trajectory. (In the other cases the trajectory is a curve. The motion is said curvilinear (sic). (4EP2)

The most usual English view of 'linear' is that it is, or pertains to, a straight line. Longman (1985) gives only this type of definition, and does not mention curves, except when it defines 'curvilinear' as "consisting of or bounded by curved lines". James & James (1976, "motion") have "curvilinear motion, motion along a curve".

Rectilinear then serves to stress the fact that the linearity is of straight lines. The sense of 'curvilinear' is rare in English. This derives from the way in English 'line' is assumed to be straight, unless otherwise qualified, and while 'curvilinear' is possible, 'curvilinear' is not, for that would be a 'curve'. In French, as argued above, the word for straight line is 'droite'. The word 'ligne' can be curved or straight. Therefore there French needs a word like 'rectiligne' to stress the fact that the line is straight.

'Rectiligne' is in fact the adjective of the noun phrase 'ligne droite'. Robert (1984, under the entry 'rectiligne') states,

Mouvement rectiligne, Rectilinear movement,
qui se propage en ligne (movement) which propagates
droite '. itself in a straight line.

A suitable translation for 'rectiligne' would be 'linear' or 'rectilinear' hence 'rectilinear motion'. (Longman 1985).

8. Note: the translation of 'rectilinear' is not 'rectilinéaire' but 'rectiligne' (Défourneaux 1980 p59). According to Robert (1984) and Larousse (1984), 'rectilinéaire' is a word used in photography for lenses which give images that are not deformed on their edges. Clearly 'rectilinear' is a faux ami. But there is more here than faux amis involved, for the whole context of the definitions is different.
This information can be summarised in the figure 9.5 below.

**FIGURE 9.5. THE DIFFERENT MEANINGS OF 'LINEAR' AND COGNATES IN FRENCH AND ENGLISH**

<table>
<thead>
<tr>
<th>French to English</th>
<th>=</th>
<th>rectilinear</th>
</tr>
</thead>
<tbody>
<tr>
<td>rectiligne</td>
<td>=</td>
<td>or linear</td>
</tr>
<tr>
<td>rectiligne (ie along a straight line)</td>
<td>is the opposite of</td>
<td>curvilinear (ie along a curve)</td>
</tr>
<tr>
<td>curviligne</td>
<td>=</td>
<td>curve (not 'curviline')</td>
</tr>
<tr>
<td>English to French</td>
<td>=</td>
<td>rectiligne</td>
</tr>
<tr>
<td>rectilinear</td>
<td>=</td>
<td>(mathematics)</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>rectilinéaire</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(photography)</td>
</tr>
</tbody>
</table>

**Example 3, angle**

TEA reported to me (T3:33) she could not use the word 'angle', but instead must use 'opening of an angular segment.'

This perhaps derives from the primary definition of an angle which is, to cite Robert (1984) again,

Saillant ou rentrant formé Acute or obtuse angle
par deux lignes ou deux formed by two intersecting
surfaces qui se coupent. lines or surfaces.

It is not a question of the use of the French 'angle'. Quid uses 'angle' without qualification. (1985 p181c, 175b). Rather, the school was insisting that teachers followed the way students had been taught. The phrase 'opening of an angular segment' was the term the teachers of mathematics had decided upon for the French 'secteur angulaire saillant' (1FM224).

When 'angle' is combined with 'rectilinear', as in 'angle rectiligne' the translation in English cannot be 'linear angle' or 'rectilinear angle', as these terms are a nonsense in English.

The reason why the expression 'angle rectiligne' is possible in French derives from the definitions of a line and an angle. In
French a line is a set of points on a plane. Therefore 'angle rectiligne' simply means an angle between two straight lines. For, in the French system, an angle can be between two planes, or between two lines. The *rectiligne* is to emphasise that the angle is between two lines, not two planes.

In contrast, the context in English, not the terms, determine whether it is an angle between lines or an angle between planes.

In order to distinguish between 'angles between planes' and 'angles between lines', and also cope with lines that were themselves 'half lines', at the English school the English words had to be adapted to follow the French definitions of an angle. [9.]

Example 4, mean / *la moyenne*
British school children are taught, certainly by the fifth year of secondary school the difference between the,

MEAN: numerical average. (sum of components divided by the number of components)

MEDIAN: middle value, when the figures are arranged in ascending or descending order

MODE: most popular, most frequent class or group. (Definitions IL).

In addition English has the terms CLASS AVERAGE, and PASSMARK.

There are several problems. The concept of a variable passmark in examinations scarcely exists in Tunisia. I have never heard of a difficult paper in Tunis being moderated by lowering the passmark. Neither, in frequent discussions on this point in Tunisia, has this feature of British examining been understood, except as something done by British people, and not done in Tunisia.

9. Other related terms are: an acute angle, ie less than 90° is called *secteur angulaire saillant*, and an obtuse angle, measuring between 90° and 180°) is called 'secteur angulaire rentrant'. (1FM224).
The problem is perhaps best explained by the definition given by Robert (1984):

La moyenne then has two senses, the mean, and the passmark of fifty percent (or equivalent). The word is used in both senses where two are needed in English.

Défourneaux (1980 p50) also notes that the adjective 'moyen' can have several translations in English in particular 'middle' and 'medium', as in "Moyen Age, Middle Ages" and "d'un âge moyen, middle aged".

'Class average' is translated by 'la moyenne arithmétique'. This too can be called 'la moyenne' as for instance in T:9:22 when I was told that 'la moyenne' was 14 or higher for everybody in the school.

A student of mine at the University of Tunis, May 1990 said, "I didn't get the average". I have since given this sentence to over 150 of my students and asked them what was wrong with the sentence. To date no student has been able to correct the sentence, no one has suspected that the problem with the sentence was with the word 'average' and not with its grammatical construction.

Harrap's Science (1985) Dictionary translates 'mean' as 'la moyenne' without comment, gives only the adjective for 'median' ("median artery, artère médiane") omitting the noun form, and fails to list at all the 'mode'. (French 'le mode', Robert 1984). [10.]

10. Standard Arabic dictionaries such as Wehr (1979) are similarly weak. Doniach (1972) gives only 'average (mean)' as 'mu<ddal' and 'median' as munaSSif, not listing 'mode' or 'passmark'. Souissi (1968) in a comparative study of the Arabic and French vocabulary of mathematics suggests 'minwaal' for 'mode'. In Tunisia the general word for 'average' can have the whole range of French meanings, as in for instance in the phrase 'ma <ndik sh ilmu'ddl fil aHsaab?' haven't you got the average in mathematics?' (White sisters n.d.) where the average clearly refers to the passmark.

ما عندك في المعتل في الأساب؟
On consulting Robert (1984) it is clear that the definitions of 'le mode' and 'la médiane' are exactly the same as in English. The problem is that they are little used and understood if at all at school level. In England these basic distinctions would be taught before the end of the fifth year at secondary school. There is also one word in French, 'la moyenne' to cover 'mean' and 'passmark'.

4. DISCUSSION

A study of definitions has shown that there are significant differences between French and English. These differences are at the level of both words and symbols. If CSL was valid such differences would not exist. The differences are particularly striking when mathematics is involved. That such basic concepts as a 'line', an 'angle, and 'linearity' should be different in French is an important finding. Combined with the use of unit vector notation for the definition of a force, this suggests that mathematics in French has fundamentally different qualities to that in English. This is in striking contrast to the expected result that the constancy would be found especially in mathematics, with its higher reliance than other sciences on supposedly international symbols and logic. (B. Wilson 1981).

The differences noted are only a few of the simpler ones, no doubt someone with greater mathematical knowledge than this researcher possesses could find and explain other differences. The failure happens variously because of ambiguity within one language, a lack of one to one correspondence between terms in English and French, and sometimes because of faux amis. Where a choice of words is possible, for instance with 'mutualism', the preferred vocabulary is not always the same in English and French. The content of a definition can even change, such as with 'marne' and 'marle', 'stenothermous', '-phyte', and 'pH'.

The definition of a force is not the same in English and French for at least two reasons: the way French uses unit vectors, and the French needing to specify 'sens' and 'direction' where in English 'direction' will suffice. While fourth year students in England could feasibly accept the French distinction between direction and sense, it is highly unlikely that an English student would be able to cope with the unit vector
notation, therefore he would not be able to understand either the symbols or the words used in the French definition of force. While a force is the same phenomena studied in both languages, the linguistic expression of this, at school level in words and in symbols form, is completely different.

Similarly, there is a clear difference between English and French definitions in that *vitesse* means speed (magnitude) and *vecteur vitesse* means velocity (a vector quantity).

When it comes to the definitions associated with 'normality', even in English they are evolving: the scientific language is not stable. Similarly in Tunisia with the textbooks, the two definitions exist, and could be found alongside each other. It takes time to change conventions, and it cannot be assumed different languages and countries will be in step. Constancy cannot be expected in times of language change.

The different ways of defining pH, especially the French preference for a use of \([\text{H}_3\text{O}^+]\) instead of \([\text{H}^+]\) has repercussions for the writing of the formulae of acids. Thus the same Corrigés (1988 p33) has *l'acide chlorohydrique* as \((\text{H}_3\text{O}^+ + \text{Cl}^-)\), instead of the more usual in English, \((\text{H}^+ + \text{Cl}^-)\).

It will take time before the new Standard Pressure is fully accepted and used without exception, if it ever is. Given that there are changes being negotiated, CSL is not being maintained. Students and teachers alike could also be confused if they are not aware that there are currently two kinds of "standard pressure".

The word 'line' is a faux ami of 'ligne'. The basic working concept of a line is different between English and French. When the derivatives of the concept are considered such as the *demi-droite* and *segment de droite*, attempts to follow the French way lead to absurdities like 'half-a-straight-line'. This example illustrates well the difficulties of pursuing one system in another language. The constraint of conforming as close as possible to the French lead to a usage of words which is unusual in English.
Similarly 'rectilinear' is a faux ami, the French being 'rectiligne' not 'rectilinéal'. Usages of 'linear' and 'curvilinear' are different in English and French in part because of the different definitions of a line.

The concept of a variable passmark barely exists in French, therefore there is confusion for French speaking students of English between a class average and a pass mark. This word illustrates well the point that it is not only a matter of correct words, but of understanding how the systems are different in the French and English speaking worlds.

5. SUB-CONCLUSIONS

a. Definitions in science in English and French are not necessarily the same in form or content.

b. When several inter-related words are used in making definitions, the internationalness of definitions is not helped when there is ambiguity within a language, and the situation can be further complicated by faux amis and a lack of correspondence between related words in the two languages.

c. Given that a choice of words exists to define the same phenomena in English and French, it is not possible to assume that the same choice will be made in each language at school level.
SECTION III VERBALS
CHAPTER 10
DESCRIPTIVE LANGUAGE

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1. INTRODUCTION

The language of science has its own specialised vocabulary of qualification and description. The use of qualifiers is called 'collocation'.

When two or more words frequently occur together they make what is known as a 'collocation'. Examples are intense heat, dense system (of roots)... (Kennedy & Bolitho 1984 p65).

Or as Godman (1976) says

Collocation is the habitual association of a word in a language with other particular words in sentences. For example: a) a force acts at a point; b) a force acts in a given direction; c) chlorine acts as an oxidising agent. (p75).

In this chapter a few examples of collocation are studied, along with other descriptive words that differ between English and French. The chapter is relatively short as little time has been spent looking for these differences, but it is indicative, in that differences between English and French in the area of collocation in scientific language are shown to exist.

2. SUB-HYPOTHESIS

The descriptive language of science, and its collocations will be the same in English and French at school level. Names as such are not the point at issue but names that describe and add to the information of simple names.

3. RESULTS

a. Chemistry

Example 1, kinds of chemical formulae.

a) Data

FIGURE 10.1A TYPES OF FORMULAE

<table>
<thead>
<tr>
<th>I (CH2O)N</th>
<th>II C2H4O2</th>
<th>III CH3-COOH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV H O</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-C-C</td>
<td>-C-C</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H OH</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(After Défourneaux 1983 p25, numbering altered to suit the thesis)
The Tunisian text (6FC) used the terms in figure 10.1b below.

**FIGURE 10.1b TERMS USED IN THE TUNISIAN TEXTBOOK**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>formule brute</td>
<td>II</td>
<td>(p178)</td>
</tr>
<tr>
<td>formule semi-développée</td>
<td>III</td>
<td>(p124)</td>
</tr>
<tr>
<td>formule développée</td>
<td>IV</td>
<td>(p127)</td>
</tr>
</tbody>
</table>

The sixth year French biology text (p33-4) used as an example for kinds of sugars: "Leur formule brute est C₆(H₂O)₆" as in figure 10.1b above. The structures of three of them were also drawn out in a way called "formules développées" as in VI below.

**FIGURE 10.1c FORMULE DÉVELOPPEE**

It was by attending chemistry lessons in French and hearing these terms, that I was first alerted to a possible difference.

b) Lack of agreement in French

Défournieux (1983 p25) has the following names and translations. The numbering refers to figure 10.1a above.

**FIGURE 10.2a FORMULAE TERMS AS TRANSLATED BY DÉFOURNEAUX**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I = formule centésimale brute</td>
<td>empirical formula</td>
</tr>
<tr>
<td>II = centésimale</td>
<td>molecular</td>
</tr>
<tr>
<td>III = développée</td>
<td>condensed structural</td>
</tr>
<tr>
<td>IV = éclatée</td>
<td>structural</td>
</tr>
<tr>
<td>V = schématique</td>
<td>skeleton (sic)</td>
</tr>
</tbody>
</table>

As can be seen from figures 10.1bc & 10.2a the French text book and Défournieux differ in several respects. Firstly the textbook lacks the word "centésimale" and replaces it with the word "brute". Secondly the textbook lacks the word "éclatée" and replaces it with the word "développée". Thirdly the textbook adds the word "semi" and replaces "développée" with "semi-développée".
RESULTS: VERBALS Descriptive language 10.4

This does not even coincide with the simplified version that Défournéaux goes on to present (p25-6), saying that the distinctions between I & II, and III & IV, are rather academic, and that in practice the most current translations are as in figure 10.2b below.

**FIGURE 10.2b Défournéaux's Best Translations**

| I et II = formule centésimale | empirical formula |
| III et IV = formule développée | structural |

(After Défournéaux 1983 p26 numbering system adapted).

There is therefore inconsistency within French.

c) Lack of agreement in English

The English sixth year chemistry text on page five, in agreement with Défournéaux labels both III and IV as "structural". The translation follows Défournéaux's expanded list when it refers to C₃H₆O as "molecular formula". (p52-3).

The ambiguity really comes when one turns to the two sources of recommendations for schools in the UK: the Association for Science Education (ASE)'s "Chemical Nomenclature" (1985) and the Institute of Biology (IOB)'s "Biological Nomenclature" (1989). There is no disagreement for I, and II. Neither are we here talking about stereochemical formulae. The problems come with what the IOB report calls "displayed (or graphic) formula". (IOB 1989 p11).

This, the IOB states is also known as a "structural formula", and goes on to talk about a "full structural formula and a "shortened structural formula" such as "CH₂OH(CHOH)₄CHO" (p11), which is the III (condensed structural) of Défournéaux (1983) above. ASE (1985 p87-8) gives a separate list, and does not confuse "displayed formula (or graphic formula)" with the types of structural formulae. According to ASE (1985), IV above would not qualify as "full" since the hydroxide -OH is not drawn out in full, -O-H.

the criteria for a full structural formula... all the bonds between atoms are shown. (ASE 1985 p88).
That the bond between 'O' and 'H' is meant to be shown, is made clear by the example which is drawn out in full of 2-hydroxypropanoic acid. By the ASE (1985) definition, III is a 'shortened structural formula' not condensed.

I cannot find any use in the English translation of the expression "semi-structural" which would presumably refer to III above, as does the "semi-développée" of the Tunisian texts and classes.

There is therefore a lack of systematic agreement or standardised convention even in English.

Example 2. shapes of bonds
Défourneaux (1983) has the following information as in figure 10.3 below.

**FIGURE 10.3 DéFOURNEAUX ON SHAPES OF BONDS**

<table>
<thead>
<tr>
<th>[French]</th>
<th>[English]</th>
</tr>
</thead>
<tbody>
<tr>
<td>[C=C] plan; couches</td>
<td>planar; planar layers</td>
</tr>
<tr>
<td>\   /   \ planes</td>
<td></td>
</tr>
<tr>
<td>\   /   \ en trîlèdre</td>
<td>trigonal</td>
</tr>
<tr>
<td>\   /   \ tétraédrique</td>
<td>tetrahedral</td>
</tr>
<tr>
<td>\   /   \ rectilligne;</td>
<td>rectilinear</td>
</tr>
<tr>
<td>\   /   \ droit</td>
<td>straight</td>
</tr>
</tbody>
</table>

(1983 p29, numbering added)

The sixth year chemistry French text says, p132, for the reaction

RCH=CHR' + Cl₂ → Cl-CHR-CHR'-Cl

*Les carbones doublement liés passent de la structure trigonale à la structure tétragonale.* The carbons with double bonds change from a planar to a tetrahedral structure.
This means that the text refers to VII as "trigonal". TFF followed this usage and wrote on the blackboard, to distinguish between the carbons with double and triple bonds:

C:plane, trigonal, molecule spatiale,
C:tétragonal. (T248:6)

These words 'trigonal' and 'tétragonal' are not in Robert (1984) or Larousse (1984), but it is clear from the Grand Larousse (1971) that 'trigonal' refers to VII or VIII and 'tétragonal' refers to IX. While 'trigonal' does exist in English, the better word would be 'planar'. A similar word to 'tetrahedral' does exist in French but in Tunisia for some reason the preferred word was 'tétragonal'.

The equivalent in the English translation (6EBii:13) says,

The geometric form of the molecule has changed: from the plane (sic) molecule of ethene to the spatial (sic) molecule of 1,2-dibromoethane.

Here the teacher agreed with Dëfourneaux's (1983) translation of 'trigonal' as 'plane' (sic) [ie planar]. At the same time another word was introduced, 'spacial' (sic).

TEK describing another reaction, this time involving a C≡C bond becoming C-C, wrote on the blackboard, "from linear molecule to spatial one", (T255:5) and offered verbally the alternative for spatial as "tetrahedral". In contrast TEL for a similar reaction said, "carbon was digonal (sic) becomes trigonal". (T262:11).

The terminology in both languages therefore lacks systematic consistent agreement between sources, and equivalence of meaning cannot be assumed. This is particularly true for the French word 'trigonale' which can refer to a planar shape due to the double carbon bonds (alkene, VII above) or a planar shape due to another element such as nitrogen having a single bond with a carbon atom (VIII above).
Example 3, *sel interne*
There are various kinds of salt, such as 'rock salt' ('*sel gemme*') and 'sea salt' ('*sel marin*'). These, and other common names for the group of compounds called 'salts' belong to non-scientific language or to old terminology.

'Salt' as a scientific term can in French have at least three collocations. Two are the same: 'acidic salt' ('*sel acide*') and 'basic salt' ('*sel basique*'). A third salt has different words in English and French.

According to Longman (1985), a ZWITTERION is, an ion with both a positive and a negative charge.

According to Défourneaux (1983 p127) this is called a "hermaphrodite/*sel interne*" On page 101 he has the following,

\[ +\text{NH}_3\text{R-COO}^- = \text{sel interne} \quad \text{zwitterion/inner salt}. \]

The terms are not therefore the same and a noun with a collocation in French '*sel interne' has a separate noun in English 'zwitterion'.

b. Physics

**Example 1, positive and negative,**

(Cp Chapter 13 'Abbreviations' Section e. 'Mathematics' Example 1.)

Positive work = *travail moteur*
Negative work = *travail resistant* (5EP78)

'Positive' is translated as *moteur* and 'negative' is translated as *résistant*. [1.] Défourneaux (1983 p43) adds another difference,

Subzero temperature = *température négative*

In English, while one cannot have a negative temperature, one can have a temperature of minus so many degrees Celsius.

The word 'positive' is a faux ami in its own right in non-scientific language, as Van Roey (1988 p526-7) rightly notes, while missing the

1. 'Resistant' is a faux ami which is documented in Chapter 8 'Faux amis' Section 3 'Results c. Physics' Example 5.
differences in meaning in the scientific domain. It is interesting though to see how such a fundamental word in science can have differing usages and translations.

4. DISCUSSION

Further enquiry would no doubt reveal other examples of collocations and other descriptive terms that are not the same in English and French. The situation is not helped when there is a lack of clearly accepted and defined terms in one or both languages. It is possible for a noun in one language to be the equivalent of a noun plus collocation in another.

5. SUB-CONCLUSIONS

CSL assumes that the language of description will be the same and there will be consistency of terminology both in English and French. The examples above are sufficient to show that this is not always a valid assumption: the language of description is not necessarily similar between English and French.
SECTION III VERBALS
CHAPTER 11
LINKWORDS

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      5, ce qui signifie que...................................................9
      6, inversement............................................................10
      7, cadre.................................................................10
      8, vers.................................................................10
      9, both, as.............................................................11
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5. SUB-CONCLUSIONS................................................12
1. INTRODUCTION

Mathematics is an important science in its own right, and other subjects in science depend on mathematics and especially on its logical reasoning. Therefore the scientific language used in mathematics needs considering in any test of CSL. And one of the fundamental components of mathematics and logical reasoning are the linkwords, a term used to cover conjunctions, prepositions and logical connectives.

According to Longman, a CONJUNCTION is:

- a word (eg and or when) that joins together sentences, clauses, phrases or words.

While a PREPOSITION is:

- a linguistic form (eg by, of, for) that combines with a noun, pronoun, or noun equivalent to form a phrase with a relation to some other word.

Therefore prepositions are a subset of conjunctions.

Actually in English even the distinction between a preposition and a conjunction is not clear cut. For instance Thomson & Martinet (1980 p73) classify 'since' as a preposition, and go on to say that it can be used as a "conjunction of time" and can introduce other types of clauses such as 'since you don't trust him . . .'. Here 'since' can mean 'seeing that/as'. A word can function as a preposition and a conjunction. The heading 'Linkwords' covers all these uses of the word 'since', and the distinction is not necessary for the purposes of this thesis.

Dawe (1983) explains:

In the English language there are a group of words and phrases which serve to link propositions in reasoned argument. For example 'suppose', 'so that', 'but', 'either . . . or', 'if . . . then' and so on. Throughout the literature various labels are used to describe these words. (p331).

Dawe prefers the word 'logical connectives' after Gardner (1977). As the term 'logical connectives is clumsy this thesis uses the simpler term 'Linkwords'. (cp Ball 1986).
'Linkwords' then is a term covering prepositions, conjunctions and logical connectives. All are important in communication, and the question considered in this chapter is how much these linkwords when used in science are constant.

As will be shown later, linkwords are also an important part of reasoning ability in mathematics and of course in all reasoning. Therefore a test of linkwords is also a test of the opinion that mathematics is relatively culture free.

a. The viewpoint that mathematics is an easy subject to study through a foreign language

1) The English school

In my notes of my interview of the Head of the English school I wrote, (T9:13)

The consensus here (Head and other teachers) was that maths was the easiest subject to teach via English at the beginning as lots of symbols etc were used.

Some of these symbols represent linkwords. The implication was that these 'links' are used extensively, they cross languages, therefore a subject that relies on them is easier to study through a foreign language.

Similar reasoning was behind starting the teaching of computing in English in the first term of English, computing being taught at that early stage by the English staff. In the second term pupils were introduced to Logo, (a beginners computing language especially used in schools). So this assumption has already had the immediate practical application in the context of the English school, in that mathematics, and specifically computers, was the first subject taught in English, and this was during the first term of learning English by the pupils.
2) **Lakramti (1982)**

He reports an inspector as saying, [1.]

L'élève qui comprend ce que dit son professeur d'histoire ou de géographie comprendra, je pense, le français utilisé par son professeur de mathématiques, vue que les structures des expressions utilisées en histoire ou en géographie sont beaucoup plus compliquées que celles utilisées en mathématiques.

The pupil who understands what his teacher of history or geography says will, I think, understand the French used by his teacher of mathematics, given that the structures of the expressions used in history and geography are much more complicated than those used in mathematics.

Here the common view that language is more complicated in the humanities than in the sciences is stated. This argument can be used to justify the teaching of sciences in a foreign language rather than arts subjects. Actually the complication is seen in terms of the humanities using long complicated sentences rather than short precise sentences as in the sciences.

b. Some of the evidence against the view that mathematics is culture free.

1) **Roe (1977)**

Roe (1977 p11) confirms that the language of mathematics is deeply rooted in words.

An important point to note about the language of mathematical manipulation is that although it appears to be simply a mixture of words and symbols, with in some cases words representing only a very small proportion of the text, it is rigorously organised by the conventions of verbal realisations.

The language of mathematics is firmly linked to verbal conventions, and these need mastering if mathematics is to be mastered.

---

1. This was in Morocco. An inspector of what, and at what level is not specified. From the context it was probably an inspector of mathematics at secondary school level.
2) Dawe (1983)

Dawe worked with immigrant children in London and gave several tests to 53 Punjabi, 50 Mirpuri, 50 Italian and 50 Jamaican bilingual children who had been born in UK and a control group of 167 English monolingual children. [2.]

What is important here is that he used a test of deductive reasoning as part of his work. He concluded that deductive reasoning was at the core of mathematical understanding and logical reasoning, and deductive reasoning depended on logical connectives (linkwords). He is not so naive as to suggest that mathematics is concerned only with deductive reasoning.

Nevertheless, the ability of the child to reason deductively lies at the core of true mathematical understanding and is closely associated with the development of abstract thought. (p325)

His statement that an important part of deduction is mastery of 'logical connectives' (p331) is as follows,

There is general agreement among researchers as to their importance in reading comprehension, learning, and thinking. For example Strevens (1971 p 228-9) writes:

They are essential for expressing any kind of complex, abstract and especially recursively abstract ideas, whether scientific or not . . . they are vital not only to an understanding of science but equally to complex logical thought and verbalization in any field of discourse.

For evidence Dawe refers the reader to theses by Delahunty (1973) and Gardner (1977).

The results of Dawe's own work enables him to write,

It will be recalled that logical connectives are words in the English language which serve to link propositions in reasoned argument. The ability to use such words in English has been reported as an important variable in distinguishing high from low bi-lingual achievers on a test of deductive reasoning. A similar result was found for English mono-linguals. Knowledge of logical connectives was the single most important

2. Dawe's work tested, a) The 'threshold hypothesis' concerned with additive bi-lingualism. b) The 'developmental interdependence hypothesis' which predicts that the abstraction level of the mother tongue is important for mastering conceptual techniques connected with mathematics. c) The 'linguistic distance hypothesis' that the closer a second language and culture is to one's own, the easier it will be to function in that language and culture.
discriminating variable on the test of deductive reasoning, accounting for about 1/3 of the variance. (p348, italics mine).

In Dawe's work the superiority of English children (the control group) over the bilingual children on this variable: logical connectives, is reported to be quite marked. The implication Dawe draws is that this area needs special attention by teachers.

The implication drawn here is that if mathematics were to be totally culture free then all groups would have done equally well on the tests. Linkwords seem to be a good marker of proficiency in a language.

Also, given that monolingual children excelled significantly over their bilingual counterparts on linkwords, and that linkwords are very important in mathematics, then there are strong grounds for challenging the view that mathematics is an easier subject to study in through a foreign language than say history or geography. Dawe's evidence is the stronger because he controlled for 22 other variables. (p327).

2. SUB-HYPOTHESES

a. There will be a one to one correspondence between any two languages for the 'linkwords' used in scientific reasoning.

b. There will be no faux amis among them.

c. Mathematics, supposedly a symbolic language, will be least affected by changing the host language of teaching, will be one of the easiest subjects to teach through a non-first language, and will be largely a culture free subject.
a. Grammar books

English is blessed with works on French written in English which compare and explain the French language with respect to English. These books point out where English can be an ami loyal and where it is a faux ami; where similarities mean English is a help and where particular attention is needed because there are differences of meaning and usage to master. One such book is Byrne & Churchill (1956). In this grammar book most of the prepositions and conjunctions are systematically explained. But some of the expressions useful in science are missing. An example would be, 'since/because x is valid then y and z follows'. Byrne and Churchill fail to mention this frequently used construction in science, and thus fail to give its equivalent 'étant donné que'. The example illustrates another problem. When scientists, or science teachers, turn to the language experts, they not infrequently find the help singularly lacking just where it is most needed, in getting for instance the linkwords right.

Even worse, Byrne and Churchill in one instance make a mistake in the English when they translate both "à mesure que" and "à proportion que" (viewed as synonymous) as "in proportion as". Both linkwords are very useful in scientific reasoning. The former linkword would best be translated as 'to the extent that' and the latter as 'in proportion to'. 'As' would substitute for both of them. Byrne and Churchill should not have grouped together à mesure que and à proportion que implying that they are equivalent terms. (See below in this chapter, Section 3c. 'Défourneaux example 1' for a further discussion of these terms).

In another book of comparisons Astington (1980) devotes over fifty pages to linkwords and to sentence building devices, the markers of the stages of an argument. He, in common with other texts, neglects to give examples across the whole spectrum of knowledge, including the sciences, and no science specific examples can be found despite his extensive coverage of linkwords.
Maillot recognises the importance of prepositions. He states that in general, the prepositions have developed independently in each language and therefore there is rarely a fixed correspondence between the two languages. He argues that it is the most common prepositions which give the most problems, especially as the sense of such prepositions is often vague or neutral, such as in French, *de et à* or in English, 'for'. (p76-7). [3.]

'Si' is also identified as a problem word, though Maillot's discussion of this is not clear. (p103). Otherwise he has little to say about linkwords except that as a translator he makes the interesting point that English expressions such as 'not less than' or 'not exceeding' ought to be standardised to a form that would permit immediate algebraic expression, such as "*Inférieur ou égal à, égal ou supérieur à*". (p78).

Maillot also berates writers in French for lifting the expression 'and/or' and putting it straight into French as *'et/ou'*, as well as reproaching writers in English for using such a conjunction. What does it mean he asks. Does it mean a choice of, 'a alone, b alone, a and b,' or 'a and b, b alone'? To Maillot this is an example of bad English being transmuted into French.


In his book "Do you speak science" Défourneaux has a whole section listing and comparing linkwords in French and English. (1980 p81ff). He calls them "*locutions*" and has several lists. [4.]

3. Sastri (1968) also notes the importance of prepositions in his study of a small sample of 100 sentences from Chemical Abstracts. He states (p42) that the role prepositions play in a metallurgical text is significant, in that they often determine the meaning of the sentence.

4. There is one small mistake in the English. 'selon que *x > 0 ou < 0 (est positif ou négatif)*' is translated as "according as *x > 0 or < 0 (is positive or negative)*". A better translation would be 'when', and if the purpose is to say, 'when *x* is positive or negative', there is an alternative way of symbolising this, at least at school level: 'when *x* +ve or -ve'.
RESULTS: VERBALS: Linkwords 11.9

From looking at the lists clearly there are equivalent terms in the two languages, but they are not always using the same words, or root words, even when one might expect this. Seven of his examples are given below.

Ex 1, 'Dans la mesure où' does not become, 'in the measure that' or 'to the measure that' but, 'to the extent that'. (cp the discussion above in the introduction). In his other book (1983) he writes on this point,

En règle générale, on emploie as en anglais quand on peut employer à mesure que en français.

(Défourneaux 1983 p5).

Contrast this with his remark that when quand has the sense of à mesure que, 'as' is often used (Défourneaux 1980 p45). 'Dans la mesure où' is an example of a conjunction in one language being replaced by a preposition in another and how intertwined the possibilities are for an accurate translation.

Ex 2, 'Sous réserve que' is not 'under the reserve that' but 'provided that'. 'Réserves' is a faux ami within the linkword.

Ex 3, 'Il résulte de ... que' is not 'it results from ... that' but 'it follows from ... that'. 'Résulte' is a faux ami within the linkword.

Ex 4, 'D'où l'on tire (x > 0, que x est positif)' is not 'from where one pulls out (x > 0, that x is positive)' but 'which yields/gives (x > 0, that x is positive)'. [5.] Here I am not too happy about the English. The phrase "Which gives x > 0" reads well, though it does not exactly give the sense of the French, but the phrase "which gives that x is positive" does not work.

Ex 5, 'Ce qui signifie que x>0 (x est positif)' is not 'which signifies that' but 'which means that x>0 (x is positive)'. 'Signifie' is a faux ami within the linkword.

5. cp footnote 4, this chapter, Chapter 10 'Descriptive language' Section 3b. and Chapter 13 'Abbreviations' Section 3e. for further discussion of the word 'positive' and its abbreviation.
RESULTS: VERBALS: Linkwords 11.10

Ex 6, 'Inversement' is not 'inversely' but 'conversely'. One does not begin a sentence in English with 'inversely', instead 'conversely' is used.

Ex 7, 'cadre, dans le cadre de' is translated as 'frame, framework, scope, within the frame of'. Apart from the fact that 'within the framework of' would be a better translation, this word cadre is an example of a common French word that is used much more than its English equivalents. Harrap's (1978) gives examples of how many words can be used to translate this word or expression.

1. (a) Frame (of picture, door etc) casing (of ship's screw, etc) (b) Border (of map, etc.); setting (of scene); surroundings (of person). (c) Compass, limits, bounds, framework. DANS LE CADRE DES NATIONS UNIES, within the framework of the United Nations.

2. (a) Frame(work) (of bicycle, etc.). (b) Lit: Outline, plan, skeleton (of book, etc.).

In no way could the English be 'In the cadre of' for 'cadre' in English refers to "the permanent nucleus of an especially (sic) military organisation", or "a group of activists working for the Communist party cause". (Longman 1985).

A whole section is later devoted to the translation of prepositions and other expressions. (Défourneaux 1980 p151ff) Space does not permit reproducing the information in full. It will suffice to summarise saying that Défourneaux deals with de, à, en, par, sur, dans, entre, pour, selon, sous, vers, autour de, en fonction de, par rapport à et divers. One example, p164 (number 8 below), illustrates his material.

Ex 8, Vers is translated normally by "towards"(UK) or "toward"(US), or, with compound words, the ending "-ward" is used for instance 'VERS le haut' becomes 'upward(s)'. But in scientific language 'vers' is frequently translated by 'to'.

---de A VERS B, from A TO B,  
---x tend VERS 0, x tends TO 0,  
la série converge VERS the series converges TO une limite. a limit.

(Défourneaux 1980 p164).
Ex 9, 'Both'. Défourneaux (1980 p.13 cp also p.57) has a whole section on the use of 'both'. One of his examples explains that 'both' is used to translate *les deux* only in the sense of 'each one independently, (*l'un et l'autre indépendamment*), and never in the sense of the two working together. Hence:

- *des deux côtés de l'angle* — on both sides of the angle
- *les deux côtés forment un angle* — the two sides form an angle.

In his book, "Do you speak Chemistry" Défourneaux (1983) only mentions linkwords in passing. For instance, he has a section dealing with *en* and *quand* in causal relationships. The example of *'à mesure que'* has been dealt with in example 1) above. Other additional examples are given below.

Ex 10, *'Par rapport à'* can have the sense of 'to' i.e 'with respect to', as in the example which is from stereoisomerism.

\[ Y \text{ est en [position]} \]
\[ \text{cis, trans, cis, trans, ortho, meta, para par rapport à X.} \]
\[ (\text{Défourneaux 1983 p.34}) \]

This is an example where a conjunction in one language is replaced by a preposition in another. Note how 'vers' (example 8) above) can also be translated by 'to'.

Ex 11, While 'to proceed in parallel with' can be translated *'se dérouler en parallèle avec'* , 'to parallel' has the rather different translation,*'se comparer à'* lit: it is comparable to, it compares itself to. (Défourneaux 1983 p.110-111 English added IL).

4. DISCUSSION

Linkwords such as 'inversely' are very important in science and especially so in mathematics which, while being to a large extent involved with symbols, is not necessarily free from the influence of the host language. Mathematics relies heavily on linkwords, and these linkwords are a difficult part of any language. Therefore mathematics may actually be harder to study through another language than other subjects.
Linkwords are not easy to master, even in one's native language. Dawe found this was the one variable where monolingual children were superior to the bilingual children.

Maillot would like to standardise expressions such as 'not less than' and 'not exceeding' in a form that would permit immediate algebraic expression. This is an example of one of the pressures to make science an international language, in that a translator would like to see not only equivalence between languages, but also a standardisation of the wording so that a symbolic statement can be linked to this wording.

As conventional language books do not necessarily prepare students of other languages to meet the demands of working accurately with linkwords and especially their use in science, they are an important part of the curriculum for the language teacher to science students.

This chapter has not studied all the linkwords that exist. Enough evidence has been gathered to show that they are not necessarily constant. An interesting line of further research would be to identify which linkwords are important in scientific language, and in particular the language of logic and mathematics, and to compare them all with equivalents in French.

5. SUB-CONCLUSIONS

a. There is not always a one to one correspondence between linkwords in English and French. This is particularly true of those linkwords called 'prepositions', which are notoriously difficult to master in any language, yet upon which the whole meaning of an argument can depend. The problem of prepositions exists as much in the context of science as in their non-scientific contexts.

b. There are a certain number of faux amis in the area of linkwords.
SECTION III VERBALS
CHAPTER 12
PREFIXES AND SUFFIXES

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1. INTRODUCTION

Scientific language, it has been asserted, has a common stock of prefixes, suffixes, and root words deriving mainly from Latin and Greek. (Richards 1976 p xi, Strevens 1977 p153, Austin & Howson 1979 p169). There are also the further assumptions that the range of meaning will be the same when two languages are compared, and that minor spelling differences are small enough to make it possible to ignore them.

The word 'root' can be a misleading term. Applied to Greek it can be a prefix or a suffix, for the root is the part of a word upon which the rest is built. An example would be the word biology, composed of two roots, a prefix and a suffix respectively, 'bio-' and '-ology'. This chapter does not need a clear distinction between what is a root, and what is a prefix or suffix, collectively known as an affix. The assumption of CSL is that all are similar in the language of science in English and French.

There is a considerable amount of scientific language not using the Latin or Greek sources. If CSL were to be strictly valid, then even the non-Latin or non-Greek units would also be at least equivalent, if not the same, for they are used in the vocabulary of science.

In this chapter prefixes and suffixes are studied and compared. The primary interest is in roots of Latin and Greek origin, but others which have a meaning in science are also mentioned. Various examples are cited from Maillot, Défourneaux and other sources, and other examples given where there are differences in meaning between French and English. The results show that the assumptions mentioned above are not always valid.

2. SUB-HYPOTHESES

Ignoring minor spelling differences:

a) Scientific language, both words formed from a common stock of Latin and Greek roots, prefixes and suffixes, and those words formed from other language sources will be constant.

b) The semantic field, i.e range of meaning of a root is constant.
3. RESULTS


Larousse (1984) conveniently has lists of prefixes and suffixes of Greek and Latin origin. [1.] These total some 280 or so (depending on how one counts the variant spellings). The list, while large, cannot be considered to be complete, for the French suffix '-idd(s)', (Quill 1985 p139c ff) which is used for the level in taxonomy known as 'family', is not listed. By studying the lists in Larousse some spelling differences between English and French can be noted.

**Example 1, spelling differences.**

These spelling differences are: a) -coque for -coccus

b) -èdre for -hedral (eg dodécaèdre = dodecahedral)

b. Maillot (1981)

1) **Maillot's views**

Maillot (1981 p83) dismisses the subject of prefixes and suffixes as unimportant, since he as a translator is more interested in finding the equivalent of a term in another language and taking it *en bloc*, than in studying differences in meaning at the part-word level. He does though have a reminder that a prefix can have more than one meaning (eg 'dé- dés-' can mean separation, or be a negation). Also, he says there are in English combined words, without a Latin origin such as 'uptake' and 'pick-up'. These again he does not consider worth analysing since the equivalent in another language must be found as a whole.

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1. See Grevisse (1975) for massive detail on the uses of prefixes and suffixes in French, and the similar work for English by Quirk (1985).
2) Multiplier prefixes.

Concerning the *Préfixes multiplicateurs* Maillot makes several points (p86-7) which are summarised below. He points out that French and English have the same series:

- Latin: uni, bi, tri, quadri... multi.
- Greek: mono, di, tri, tétra... poly. [2.]

But English also has another two series which are part of the scientific vocabulary.

- single, two, three... multi/poly, (with a preference for multi-).
- double, triple.

The English examples given by Maillot are,

- "single-phase, two-phase, three-phase, multi-phase"
- "single-pole, two-pole, three-pole, multi-pole",
with also - 'double-pole'and 'triple-pole' in use for in the French 'disjoncteur bipolaire/ tripolaire'.

Maillot sees a nuance of meaning between 'two' and 'three', in the sense that such words stress the number, and 'double' and 'triple', which imply a narrower meaning as in the trip switch 'disjoncteur' which must cut two or three wires simultaneously. (p86-7).[3.]

c. Maillot on prefixes and suffixes in chemistry (p174-5)

Example 1. 'bi-' and 'di-'.

French uses 'bioxyde' for 'dioxide'. At this point French is using the prefix from the Latin series and English is using the prefix from the Greek series of prefixes.

---

2. There is one small difference. 'bi-' and 'tri-' in French can both have the extra letter 's' added eg 'bisannuel' for 'bi-annual' and 'trisannuel' for 'triannual'.

3. ASE (1985 p60) has a section marked as new since the previous edition, explaining the use of the multiplicative prefixes di, bi-, dis-; tri, tris-, tetra-, tetrakis-, indicating two series for labelling. The explanations given are limited, and this is getting into levels of complexity in labelling compounds that is beyond school use. But a change of practice in one language raises the possibility of a difference occurring between English and French.
Example 2. '−oxyde'

'−oxyde' sometimes in French gets substituted by 'anhydride' hence 'anhydride carbonique' for 'carbon dioxide' or 'anhydrique cuivrique' for 'copper (II) oxide'. 'Anhydride' can substitute for 'oxide' or 'dioxide'. This is also an example of how an adjective in French 'carbonique', can become a noun in English, 'carbon'.

Example 3. '−ure' and '−ide'.

'Chlorure de Sodium' becomes 'sodium chloride', the '−ure' becoming '−ide'. This difference is also noted by Défourneaux (1983 p81).

d. Défourneaux Do you speak science (1980)

Défourneaux has a whole section on terminations and prefixes p140-150. Unfortunately he leaves some work to do for the English reader, as he assumes a good knowledge of French and explains the English. He is though quite helpful, especially on the prefixes and suffixes from a non-Latin or non-Greek source.

Example 1. '−trice'
The suffix '−trice' is the feminine of −teur. Words with this ending are sometimes translated by '−trix', sometimes by '−tor' and other times indifferently, '−trix' or '−tor'. The examples given are: (p146)

<table>
<thead>
<tr>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>directrice</td>
<td>directrix [4.]</td>
</tr>
<tr>
<td>génératrice</td>
<td>generator</td>
</tr>
<tr>
<td>bissectrice</td>
<td>bissectrix or bisector</td>
</tr>
</tbody>
</table>

Example 2. '−able', '−ible'.

There is no rule for the correspondence between French and English, and all four possible variants exist: (p148)

<table>
<thead>
<tr>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>'−able'</td>
<td>'−able' eg measurable = measurable</td>
</tr>
<tr>
<td>'−able'</td>
<td>'−ible' eg négligeable = negligible</td>
</tr>
<tr>
<td>'−ible'</td>
<td>'−ible' eg divisible = divisible</td>
</tr>
<tr>
<td>'−ible'</td>
<td>'−able' eg expansible = expandable</td>
</tr>
</tbody>
</table>

4. A fixed curve in mathematics.
Example 3, *'sous-'* and *'sur-'*.

These common French prefixes with science specific meaning have different translations in English.

- **'sous-'** = 'under-' e.g. *sous-développé* = under-developed
- **'sur-'** = 'over-' e.g. *suralimentation* = overfeeding (nutrition)
- **'sub-'** e.g. *soustraction* = subtraction

*Example 4.*

<table>
<thead>
<tr>
<th>Prefix</th>
<th>English Meaning</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>'sous-'</strong></td>
<td>'under-'</td>
<td><em>sous-développé</em> = under-developed</td>
</tr>
<tr>
<td><strong>'sur-'</strong></td>
<td>'over-'</td>
<td><em>suralimentation</em> = overfeeding (nutrition)</td>
</tr>
<tr>
<td><strong>'sub-'</strong></td>
<td>'under-'</td>
<td><em>soustraction</em> = subtraction</td>
</tr>
</tbody>
</table>

D. Défourneaux, *Do you speak chemistry?* (1983)

Several examples are given but most have to do with remote names of minerals, and do not really belong to chemistry at school level. The *'ydé'* becoming *'-ide'* has already been noted under Maillot (1981) Example 3 above.

Example 1, *'ique'*

Adjectives ending in *'-ique'*, and derived nouns become *'-ic'*, in English. For instance *lonique* = ionic, *physique* = physics. (p1) This should cause little problem as the difference is consistent.

f. Other examples

Example 1, *'-phile'* and *'-phyte'*. In chapter 9 'Definitions' Section 3a. biology, Example 4, xerophytes, the suffix *'-phile'* is discussed. While this suffix *'-phile'* has the same form and meaning in English and French when used for having a liking for another people (francophile), or as in chemistry for a substance having a liking for another (an electrophile is a substance having an affinity for electrons), *'-phile'* does not accurately translate a word like *xérophile*. For this word the suffix *'-phyte'* is required. But *'-phile'* in French pertains to both plants and animals. The equivalent suffix in English *'-phyte'* pertains to plants only, not to organisms in general.

5. This last example, with the translation of *'sur-'* by *'super-'* was not given by Défourneaux, but was found by consulting the bi-lingual dictionary, Harrap's (1978).

6. 'Alimentation' is another faux ami, having a wider sense than the English "nourishing or being nourished" (Longman 1985) and meaning also for instance the supply of a town, or, mechanically, the feeding for instance of a boiler. (Harrrap's 1978).
An additional complication is the fact that the suffix -phyte does exist in French, and -phile does exist in English. Robert has "XEROPHYTES: Bot. Plantes xérophi les". and Henderson (1979) has 'xerophilous' as applying to plants only. This is an interesting case where each language prefers a different suffix, and for the lesser used suffix retains the usage of the main suffix.

The usage of -phile and -phyte is therefore different in French and English, though the core meaning, type of adaptation to the environment, is maintained.

Example 2. 'pluri-
In Tunisia a poster advertising a 'séminaire pluridisciplinaire' was seen. The prefix 'pluri-' exists in English, but the English translation here would use the prefix 'multi-' (multidisciplinary seminar). Yet the prefix 'multi-' also exists in French, eg 'multicolore'.

A 'perennial plant' is a 'plante vivace' (Harrap's 1978) or a 'plante pluriannuelle' (Robert 1984) in French. Here the French prefix '-pluri' is translated in English by the prefix 'per-'. French does have words which use the prefix 'per-' in the sense of lasting a long time, for instance a river that flows all year can be described as a 'source pérenne' and the noun 'pérennité' also exists.

The fact that the prefix exists in French and English does not mean that there is always an exact correspondence between English and French in their use.

Example 3, poly-
Newmark (1988) has the following sentence with translation:

La toxoplasmose et la maladie de Hodgkin ... caractérisées essentiellement par ... une polyadénopathie.  
Toxoplasmosis and Hodgkin's disease ... characterised primarily by ... generalised lymphadenopathy. 

(p250)
In his commentary on the translation (p251-2) Newmark points out the way that in his opinion the prefix 'poly-' is best translated by the word 'generalised'. His reasons are complicated, the point being here that the a prefix can be translated by a different word which is also an adjective.

Example 4, per-
An infusion is a continuous slow introduction of a solution, especially into a vein. A perfusion is when liquids are forced through an organism or tissue. The word also exists as a verb (to perfuse), a noun and an adjective. The prefix '-in' means 'within', 'into', 'towards', whereas '-per' means in this case 'through'. (Longman 1984).

In French the word 'perfusion' has both senses of 'infusion' and 'perfusion' in English, but only exists as a noun. 'Infusion' is restricted to the preparation of herbal tea drinks and has no medical meaning.

The prefix '-per' can, in both English and French, in chemical formulae mean 'di-' as in Hydrogen Peroxide, H₂O₂, but this nomenclature has long been superseded.

In the old nomenclature in French, it referred to an excess of the normal quantity of an element as in 'peroxyde'. (Robert 1984). But Robert also gives as an example of this "acide permanganique". In this case the definition does not fit the example for in the ion permanganate (MnO₄⁻) the element manganese is present not in excess proportion relative to the other elements, but with a high oxidation number. The new nomenclature dispenses with 'per-' and specifies the oxidation number [7.] instead. So the permanganate ion becomes manganate (VII) (ASE 1985 p45).

The French and English equivalents for the prefix 'per-' are therefore not necessarily equivalent.

7. For explanation and discussion of the oxidation number see Chapter 19 'Symbols' Section g. Example 5.
4. DISCUSSION

The semantic fields of affixes are not necessarily constant. In particular Maillot's evidence on multipliers suggests that it would be unwise to assume that two languages which have Latin and Greek multipliers in common always use them in similar ways and that these are the only sets of multipliers available. English for instance uses English multipliers in scientific words as well as the Latin and Greek ones.

Though the number of exceptions noted is relatively small, there are enough to show that the assumption that such words will always be constant is no longer tenable. It can also happen that an affix in one language has more than one possible translation in another language, therefore a one to one correspondence between languages cannot be assumed.

5. SUB-CONCLUSIONS

a. The affixes used in scientific language are not always constant between English and French.

b. Even when an affix exists in both English and French, the usage in combination with other word stems is not necessarily the same in English and French.
Abbreviations are an important part of the French and English languages. Unfortunately bi-lingual dictionaries tend to ignore them. Harrap's (1978) for instance presents a long list of specialised abbreviations used in the dictionary, but does not include general abbreviations in the main body of the dictionary. Another tendency to be deplored is that where abbreviations are mentioned and explained, the equivalent abbreviation in the other language, if any, is often not given though Harrap's (1978) does so, in two separate lists of abbreviations. Handbooks of French such as Batchelor & Offord (1982 p132ff) have begun to make up for this. Batchelor & Offord give about one hundred abbreviations, with the gender, explanation and nearest English equivalent abbreviation where that exists. The list is short, yet, a comparable handbook by Astington (1980 p8) has just a few abbreviations noted and explained, which is a pity as books like these aiming to supplement a course of French need to be strong where the dictionaries are weak. To its credit Harrap's Science Dictionary (1985)
has begun the job of including abbreviations in the body of the bi­lingual text and giving the French equivalent.

Note that to standardise, the modern convention of using letters without full stops is followed, except where quotations are used. Not infrequently there are differences between sources on the case of the letters, and the use of the full stop, therefore the usage of any one source cannot be taken as definitive.

2. THE SUB-HYPOTHESIS

Abbreviations in scientific language will be constant and international.

3. RESULTS

The results are presented in figures 13.1–4 below, with notes containing the references and comment.

Summary

Abbreviations that are the same in English and French
20/20 amino acids,
4/15 mathematical functions (figure 13.4),
8 except that the order of the letters changes,
2 despite a change of word order (AA & ADH notes 5 & 9).

Abbreviations that are different in English and French
11/15: mathematical functions (figure 13.4)
9 others listed in the figures,
7 do not exist in French,
2 do not exist in English.
FIGURE 13.1 ABBREVIATIONS: GENERAL AND BIOLOGY

<table>
<thead>
<tr>
<th>Reference &amp; Meaning</th>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. General</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[1.] Laboratory / laboratoire</td>
<td>lab</td>
<td>labo</td>
</tr>
<tr>
<td>[2.] Refrigerator / réfrigérateur</td>
<td>fridge</td>
<td>frigo</td>
</tr>
<tr>
<td>b. Biology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[3.] Nucleic acids</td>
<td>DNA, RNA</td>
<td>ADN, ARN</td>
</tr>
<tr>
<td>[4.] Rapport Nucléoplasmatique</td>
<td>-</td>
<td>RNP</td>
</tr>
<tr>
<td>[5.] Amino Acids / Acides Aminés Essentiel</td>
<td>AA</td>
<td>AA</td>
</tr>
<tr>
<td>[6.] amino acids abbreviations /</td>
<td>same</td>
<td>same</td>
</tr>
<tr>
<td>[7.] Protein Energy Malnutrition / la Malnutrition Protéo-Calorique</td>
<td>PEM</td>
<td>MPC</td>
</tr>
<tr>
<td>[8.] Respiratory Quotient / Quotient Respiratoire</td>
<td>RQ</td>
<td>QR</td>
</tr>
<tr>
<td>[9.] AntiDluretic Hormone / l'hormone antidiurétique</td>
<td>ADH</td>
<td>ADH</td>
</tr>
<tr>
<td>[10.] Endoplasmic Reticulum rough/smooth / réticulum endoplasmique rugueux/lisse</td>
<td>ER</td>
<td>RE</td>
</tr>
<tr>
<td>[11.] Cerebrospinal Fluid / le liquide céphalo-rachidien</td>
<td>CSF</td>
<td>LCR</td>
</tr>
<tr>
<td>[12.] Intra Uterine Device / dispositif intrautérin</td>
<td>IUD</td>
<td>DIU</td>
</tr>
</tbody>
</table>

1. Défourneaux (1983 p140) 'Fridge' in English has become a proper noun, and would probably no longer be considered an abbreviation. But according to Robert (1984), the French frigo is very definitely an abbreviation for réfrigérateur and both 'fridge' and 'frigo' are considered to be abbreviations by Défourneaux (1983).


3. 6EB15. This is the nucleoplasmic ratio, and is the volume of the nucleus divided by the volume of the cytoplasm. This ratio is, apparently, high in young cells and low in specialised, adult cells. In English this ratio is not known as an abbreviation.

4. English and French use AA for Amino Acids, though the word order changes in French, acides aminés. In addition 6FB85,87,88ff used 'AAE' for essential amino acids, acides aminés essentiel, which is not known as an abbreviation in English.

5. 6EB154,55. 6FB26, also Devlin (1986 p33). Each amino acid has a standard three letter abbreviation such as 'val' for valine. On comparison it becomes clear that in French and in English the abbreviations are the same. CSL is fully valid here.


7. 6FB261, Simpkins & Williams (1989 p91).

8. Curiously both English and French use ADH, even though the French word order would suggest that a different abbreviation ought to be used. The French is l'hormone antidiurétique.

9. 7FB20, Simkins & Williams (1989 p105).

10. 7FB20 and Simpkin & Williams (1989 p346).

11. 7FB275.

12. ---
FIGURE 13.2 ABBREVIATIONS: PHYSICS AND CHEMISTRY

<table>
<thead>
<tr>
<th>Reference &amp; Meaning</th>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. Physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[13.] Relative Humidity / humidité relative</td>
<td>RH</td>
<td>-</td>
</tr>
<tr>
<td>[14.] Alternating Current / alimentation en alternatif</td>
<td>AC</td>
<td>-</td>
</tr>
<tr>
<td>Direct Current / alimentation en continu</td>
<td>DC</td>
<td>-</td>
</tr>
<tr>
<td>[15.] Root Mean Square / moyenne quadratique</td>
<td>RMS/rms</td>
<td>fem</td>
</tr>
<tr>
<td>[16.] electro-motive force / force électromotrice</td>
<td>emf</td>
<td></td>
</tr>
<tr>
<td>[17.] potential difference / différence de potentiel</td>
<td>pd</td>
<td>ddp</td>
</tr>
<tr>
<td>[18.] Relation Fondamentale de Dynamique (Newton's second law of motion)</td>
<td>-</td>
<td>RFD</td>
</tr>
<tr>
<td>d. Chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[19.] Nuclear Magnetic Resonance / Résonance Magnétique Nucléaire</td>
<td>NMR</td>
<td>RMN</td>
</tr>
<tr>
<td>[20.] quantum number / nombre quantique</td>
<td>qn</td>
<td>nq</td>
</tr>
<tr>
<td>[21.] Standard Temperature and Pressure STP/stp</td>
<td></td>
<td>à t. et p. normales</td>
</tr>
<tr>
<td>[22.] Saturated Vapour Pressure à pression/tension de vapeur saturante</td>
<td>SVP</td>
<td>-</td>
</tr>
<tr>
<td>[23.] Thin Layer Chromatography chromatographie sur couche mince.</td>
<td>TLC</td>
<td>-</td>
</tr>
</tbody>
</table>

14. Défourneaux (1983 p127), Maillot (1981 p224). Note Harrap's (1978) is probably in error in giving the French abbreviation 'CA courant alternatif' with none given for direct current because neither Maillot nor Défourneaux give a French abbreviation and Maillot (p224) explicitly says that they do not exist in French.
15. Maillot (1981 p224) "Cette abréviation doit être traduite en français, donc en toutes lettres".
17. Défourneaux (1983 p127)
18. Newton's second law of motion is basically the equation $F = ma$, Force equals mass times acceleration, and equations derived from it. In French this law is referred to as la relation fondamentale de la dynamique, the abbreviation being R.F.A.. The name changes between English and French, and there is no equivalent abbreviation in English for this second law of motion. It is curious that in French Newton's second law should be described as 'fundamental'. This is discussed in more detail in Chapter 14 'Eponyms'. See also Chapter 21 for a discussion of the equations.
19. Défourneaux (1983 p38)
FIGURE 13.3 ABBREVIATIONS: MATHEMATICS

<table>
<thead>
<tr>
<th>Reference &amp; Meaning</th>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>e. Mathematics</td>
<td>&gt;0, +ve</td>
<td>&gt;0</td>
</tr>
<tr>
<td>[24.] Positive</td>
<td>＞0, ＋ve</td>
<td>＞0</td>
</tr>
<tr>
<td>Negative</td>
<td>＜0, －ve</td>
<td>＜0</td>
</tr>
<tr>
<td>[25.] Lowest Common Multiple / Plus Petit Commun Multiple</td>
<td>LCM</td>
<td>PPCM</td>
</tr>
<tr>
<td>[26.] Highest Common Factor / Plus Grand Commun Diviseur</td>
<td>HCM</td>
<td>PGCD</td>
</tr>
<tr>
<td>[27.] Application Numérique</td>
<td>—</td>
<td>A.N.</td>
</tr>
<tr>
<td>[28.] Computer Assisted Learning / Enseignement Assisté par Ordinateur</td>
<td>CAL</td>
<td>EAO</td>
</tr>
</tbody>
</table>

24. cp Chapter 10 'Descriptives' Section 3b. Défourneaux (1980 p36) gives, under the heading of 'inequality symbols', the examples, "＞0 positive, ＜0 negative", and fails to mention that there are two other abbreviations in common use in England for positive and negative, namely "＋ve" and "－ve". While such abbreviations as ＞0 and ＜0 were freely used in the French and English school, it is doubtful whether British pupils would be used to them. It is possible that an English pupil seeing the abbreviation '＞0 ' would read it as 'something greater than nought' rather than 'something positive'. On the other hand, no evidence could be found that '+ve' and '-ve' were used in Tunisia.

25. This can best be explained by an example. The lowest common multiple of 12, 18, and 24, is 72. English: LCM, French: PPCM Plus Petit Commun Multiple. (Défourneaux 1980 p32). 1FM95 and Quid (1985 p169c) have P.P.C.M. ie with full stops.

26. In a series of numbers such as 12, 18, and 24, the Highest Common Factor, is the highest number that will divide into them with no remainders or decimal places, in this case the number being 6. English: HCM, French: PGCD, Plus Grand Commun Diviseur, (Défourneaux 1980 p32), or, with full stops P.G.C.D. (Quid 1985 p169c).

27. The French have an abbreviation, A.N. to mean application numérique and is used at the end of a calculation involving algebra, when a numerical result is required. Hence the form A.N. = ££ units, where ££ are numbers. There is no equivalent in English to my knowledge. (Corrigés 1988 p167).

28. (T271:10).
### FIGURE 13.4 ABBREVIATIONS: TRIGONOMETRICAL AND LOGARITHMIC FUNCTIONS

<table>
<thead>
<tr>
<th>French</th>
<th>English (1)</th>
<th>English (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sin</td>
<td>sin</td>
<td>arccsin</td>
</tr>
<tr>
<td>cos</td>
<td>cos</td>
<td>arccos</td>
</tr>
<tr>
<td>tg or tan</td>
<td>tan</td>
<td>arctan</td>
</tr>
<tr>
<td>1/sin</td>
<td>csc</td>
<td></td>
</tr>
<tr>
<td>1/cos</td>
<td>sec</td>
<td></td>
</tr>
<tr>
<td>cotg</td>
<td>cot</td>
<td></td>
</tr>
<tr>
<td>arcsin</td>
<td>sin^{-1}</td>
<td></td>
</tr>
<tr>
<td>arccos</td>
<td>cos^{-1}</td>
<td></td>
</tr>
<tr>
<td>arctan</td>
<td>tan^{-1}</td>
<td></td>
</tr>
<tr>
<td>sh</td>
<td>sinh</td>
<td></td>
</tr>
<tr>
<td>ch</td>
<td>cosh</td>
<td></td>
</tr>
<tr>
<td>th</td>
<td>tanh</td>
<td></td>
</tr>
<tr>
<td>1/sh</td>
<td>cosech</td>
<td></td>
</tr>
<tr>
<td>1/ch</td>
<td>sech</td>
<td></td>
</tr>
<tr>
<td>coth</td>
<td>coth</td>
<td></td>
</tr>
<tr>
<td>log x</td>
<td>lg x</td>
<td>log_{10} x</td>
</tr>
<tr>
<td>ln x</td>
<td>ln x</td>
<td>log_{e} x</td>
</tr>
</tbody>
</table>

The following notes refer to all the abbreviations in figure 13.4.

29. Figure 13.4 is compiled from Défourneaux (1980 p42, 68), and Cores (1983). Note that there are two possible acceptable forms in some cases in English, and these have been noted in the third column. The list of circular and hyperbolic functions is not exhaustive.

30. Eleven out of the fifteen quoted trigonometric abbreviations are different in English and French.

31. Cores (1983 p93) gives the two English variants acceptable for the abbreviations of logarithms to base 10, and natural logarithms. Défourneaux (1980 p42) seems to get confused and gives "log x" as the English for both natural and common (base 10) logarithms.
4. DISCUSSION

The abbreviations used in scientific language in English and French are not always the same, and sometimes an abbreviation in one language will have no equivalent in another language. Against this trend are abbreviations which are the same in the two languages even though the word order of the full phrase may be different and may lead one to expect the abbreviations to be different. Apart from the amino acids a striking number of differences have been found. To put this in context, differences, not similarities, have been actively searched for, therefore it is probable that many more similarities than differences exist. Enough have been found though to render questionable the assumption that there is constancy in French and English of the abbreviations used.

What has not been considered in this chapter is the set of abbreviations common to both science and other subjects, such as AD ('apr. JC le 'après Jesus Christ') and BC ('av. JC') to express dates. It cannot be assumed that these are international, nor that they will be taught in language courses. For instance the commonly used "le" is not known in French. Instead "c.à.d." (c'est-à-dire) is used. Défourneaux (1980 p 85) lists a few such abbreviations but as he is writing for French people does not give the French equivalents for the English. It is good to see certain dictionaries like Longman (1985) giving extensive lists of abbreviations.

5. SUB-CONCLUSIONS

For the amino acids in the human body, the abbreviations are constant between English and French.

For other abbreviations, especially the trigonometrical and logarithmic functions in mathematics, they are not necessarily constant in English and French.
SECTION III VERBALS
CHAPTER 14
EPONYMS

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An 'eponym' is the term used for terms that use the name of a person.

There are dictionaries available listing eponyms, such as Beeching (1988), but the examples he chose were mostly irrelevant to this section as they did not cover many names of men of science.

It is thanks to TEF who first drew my attention to this topic. Maillot (1981) devotes a short chapter to it, while Défournéaux (1980, 1983) has nothing to say. Maillot (1981) is of the opinion that scientific vocabulary makes frequent use of the names of scientists to name laws which they have discovered, and their translation presents no difficulty. (p140).

It is possible that an equivalent might not exist. This does not seem to have occurred to Maillot. But Maillot is a translator not a teacher, and if one is interested in translation then an equivalent can be made with relative ease. But the teachers at the English school, in trying to stay as close to the French as possible, at times had to use a French eponym in English, when the eponym did not previously exist in English. It is also conceivable that French and English use different eponyms to label the same item or phenomena. In Maillot's opinion such exceptions are rare but do exist. He says:

D'une façon générale, on remarque une unanimité presque complète dans la façon dont les différents pays honorent ainsi les grands savants quelle que soit leur nationalité, ce qui semblerait confirmer le caractère international de la science. Toutefois, on voit dès le début apparaître certaines discordances.

Generally speaking it is noticeable that there is an almost complete unanimity in the way that different countries honour scientists, whatever their nationality. This seems to confirm the international character of science. However, from the beginning certain discordances can be seen to appear. (Maillot 1981 p140-141).

It is not so much the different countries doing the honouring, so much as the scientific community in each country. That aside, Maillot does see this unanimity of names as evidence for the supranational nature of science.
Newmark (1988) on the other hand is not so optimistic that eponyms are as rare as Maillot states they are.

... the authenticity of the discoverer may be implicitly disputed (‘Arnold's fold’ - Valvule de Krause; Desnos's disease' - maladie de Grancher), or more commonly, replaced by a technical term (Röntgenographie - 'radiography'; 'Hitchinson's angioma' - angiome serpigineux'). In this category there is a tendency for eponyms to be gradually replaced by descriptive terms (‘Davy lamp' - lampe de sécurité (de mineur)). (p199).

Clearly when the same names are used in different languages, this will make it easier for a learner to switch between languages and the language of science will be constant. This chapter sets out to find as many differences in the eponyms of scientific language as possible, in order to test how constant eponyms are between English and French.

2. SUB-HYPOTHESES

The sub-hypothesis is that whenever the names of famous people are used as part of the vocabulary of science, then these names will be the same in both languages. This sub-hypothesis can be made more precise as:

a) An effect or a label, when it bears a famous name, will always do so.

b) The choice of a famous name will always be the same.
3. RESULTS

a. Summary

**Figure 14.1** SUMMARY OF THE RESULTS ON EPONYMS

<table>
<thead>
<tr>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Biology</td>
<td></td>
</tr>
<tr>
<td>1. l'indice d'aridité de Martonne</td>
<td>---</td>
</tr>
<tr>
<td>2. Quotient pluviothermique de Emberger</td>
<td>---</td>
</tr>
<tr>
<td>3. échelle de Braun Blanquet</td>
<td>---</td>
</tr>
<tr>
<td>4. le milieu de Knop</td>
<td>---</td>
</tr>
<tr>
<td>5. le milieu de Sach</td>
<td>---</td>
</tr>
<tr>
<td>6. axone géant de Seiche/Calmer</td>
<td>giant nerve fibre of squid.</td>
</tr>
<tr>
<td>7. follicule de De Graaf</td>
<td>ovarian follicle</td>
</tr>
<tr>
<td></td>
<td>(Graffian follicle)</td>
</tr>
<tr>
<td>c. Physics, Maillot</td>
<td></td>
</tr>
<tr>
<td>1. La loi de Mariotte</td>
<td>Boyle's law</td>
</tr>
<tr>
<td>2. courants de Foucault</td>
<td>eddy currents</td>
</tr>
<tr>
<td>3. pertes Joule</td>
<td>$1^2R$ losses</td>
</tr>
<tr>
<td>4. les marques de franco-bord</td>
<td>plimsoll marks</td>
</tr>
<tr>
<td>5. tension</td>
<td>Voltage</td>
</tr>
<tr>
<td>6. démagnétiser</td>
<td>to de-gauss</td>
</tr>
<tr>
<td>7. henrymètre</td>
<td>inductance meter</td>
</tr>
<tr>
<td>d. Physics, Tunisia</td>
<td></td>
</tr>
<tr>
<td>1. Tube à croix mobile</td>
<td>Maltese Cross Tube</td>
</tr>
<tr>
<td>2. Baromètre de Vidi</td>
<td>aneroid barometer</td>
</tr>
<tr>
<td>3. La relation fondamentale de la dynamique</td>
<td>Newton's 2nd law of motion</td>
</tr>
<tr>
<td>4. La loi de Laplace</td>
<td>no name, equation used $F = BQv \sin \theta$</td>
</tr>
<tr>
<td>5. Théorom de Huygen</td>
<td>moment of inertia</td>
</tr>
</tbody>
</table>

b. Commentary on the biology results

**Examples 1, 2, and 3, indices**

See Chapter 19, 'Indices' for further details. What is relevant here is that the following indices which were difficult to translate, had the name of a scientist attached.

Index of Martone
Rainfall and temperature quotient of Emberger.
Braun-Blanquet scale.
In that these scales were not known, nor could TEA or myself find any reference to them, it is probable that these eponyms do not exist in English. Even if the indices do exist in English, they were not known at school level in Tunisia.

Examples 4 and 5, *le milieu de Knop et de Sachs*

'Le milieu de Knop' is the name given to a solution containing nine elements, which are sufficient for the growth of plants. 'Le milieu de Sachs' is a similar liquid, but with the elements provided by different combinations of salts and which shows that the actual chemical form of the element is not important. Standard school biology texts such as those by DG Mackean (1969), though mentioning similar solutions give no eponym to them.

Example 6, *axone géant de Seiche ou de Calmer* (7FB39,42)

This, according to the Encyclopaedia Britannica (1976 12 p974) is the giant nerve fibre of squid, beloved of neurophysiologists for being a large axon and amenable to studies of for instance the action potential. There is no eponym attached in English.

Example 7, *follicule de De Graaf* (7FB263)

In English this is called the 'ovarian follicle'. (Simpkins & Williams 1989 p464). There is no eponym attached in English at school level, though it used to be called the 'Graffian follicle' (Oxford 1989).

Example 8, Grave's disease = *la maladie de Baselow*

Maillot (1981 p142) gives this as the sole example where he regards the problem of eponyms as most acute, in the domain of the names of diseases. He doubts the utility of eponyms when words are used to multiply words, for instance "Negativisme sexuel de Hirschberg" meaning simply "frigidité". Where simple words can be used instead of a long label including a name then Maillot is of the opinion that clarity may be best served by dropping the use of such names.
Note, Maillot, while writing in French, and comparing mostly French with English, also considers other languages notably German and Russian. These languages are beyond the scope of this thesis. From the information he gives though, seven items, which are relevant to the school situation are worth citing.

Example 1, Boyle's Law = La loi de Mariotte
This example is quite important: Boyle's Gas laws are fundamental and basic. Défourneaux merely notes the difference (Défourneaux 1983 p47) but Beeching (1988) explains,

Boyle's Law is also known as Mariotte's Law from the French physicist Edme Mariotte (1620?-84) who confirmed Boyle's principle quite independently of the British scientist.

Example 2, Eddy currents = courants de Foucault
This was first mentioned to me by TEJ. (Dec 89). In the English translation both terms are given, the English being adapted to "Foucault currents". (6EP1187, 6FP269).

Example 3, $I^2R$ losses = pertes Joule
These losses are of energy due to resistance in a wire. French gives them an eponym, English does not.

Example 4, Plimsoll marks = les marques de francobord
The example belongs to general knowledge, that ships have a series of lines to indicate their depth in the water and to avoid overloading them with cargo. This is an example where England has honoured someone and other countries have not, preferring a label.

Example 5, Voltage = tension
Maillot asserts that the term 'voltage' exists only in English, except in the name of an electricians trade union, Syndicat des Fabricants Français d'Appareils à bas-voltage. The root "volt" does though exist in two French terms, survolteur (step up transformer) and dévolteur (step down transformer). (Translations into English of these terms are not given by Maillot but were found in Harrap's 1978).
Example 6, to de-gauss = démagnétiser
English is the only language apparently to employ a verb derived from Gauss, meaning to de-magnetise, as for instance with ships to protect them from magnetic mines. This is despite the existence in both languages of 'Gauss' as the unit of magnetic induction when a system pre-dating the SI system was in use, the cgs system. [1.] Both languages also refer to the normal distribution in statistics as the 'Gaussian distribution' ('distribution de Gauss' Harrap's 1978). In fact, the verb '(se) gausser' exists, but it has a different, sixteenth century origin and means "to poke fun at someone, to sneer at someone" (Harrap's 1978).

Example 7, inductance meter = henrymètre
In this example both French and English use the name "Henry" for the unit of inductance. But French also uses the name in the name of the measuring instrument, while English uses the name of the effect being measured.

d. Physics examples found in Tunisia

Example 1, the Maltese Cross tube = tube à croix mobile. [2.]
In a classical experiment in schools, to show that rays of electrons travel in straight lines, a form in the shape of a Maltese Cross is put inside an evacuated tube, and the experiment arranged to project the image of this cross, onto a small fluorescent screen at one end of the tube. When this experiment was done in Tunisia, in the sixth year physics classes, it was called simply the 'Expérience de la croix'. The tube is called the 'Tube à croix mobile' not the 'Maltese Cross tube'. Yet the picture in the physics book (6FP92) clearly showed a maltese cross. The English translation (lacking for this year a British teacher in the team of teacher-translators) simply avoided the question and did not give a special name to the experiment or the tube. (6EPi:63-5). Yet the Maltese Cross ('croix de Malte') exists as a name in French.

1. The unit Gauss, symbol G, has now been replaced by the tesla. 0.00001 T = 1 G (Quid 1985 p222b). The abbreviation 'cgs' means 'centimetre - gram - metre' and was a system widely used before the SI system based on the metre kilogram and second.
2. 'mobile' meaning movable, or in motion.
Example 2, Baromètre de Vidi = aneroid barometer
5FP121 describes the baromètre de Vidi and it is quite clear from the
description and the diagram that the aneroid barometer is referred to.
In the English text the teachers chose to retain the eponym and wrote
"Vidi barometer".

Example 3, Newton's second law of motion, or, la relation fondamentale
de la dynamique [3.]
Newton's second law of motion states that,
The rate of change of momentum of a body is proportional to the
resultant force that acts on it. (Whelan & Hodgson 1989 p34b).
The law is perhaps more well known as expressed in the formula \( F = ma \)
(Whelan & Hodgson 1989 p36b).

In French this law is known as la relation fondamentale de la
dynamique (Corrigés 1988 p61) and does not have Newton's name attached
to it. The sixth year French physics textbook also abbreviated it to
R.F.D. and assumed knowledge of its meaning to the extent that a chapter
heading used the abbreviation, "Application de la R F D au système
isolé" (p125).

It is curious that Newton's second law in English is regarded as the
fundamental law In French, Bullock & Stallybrass (1977) under the
heading "Newtonian mechanics" state that "The basic principle is . . .
acceleration = force \( \div \) mass". Therefore in French the second law is
viewed as more basic. The reason for the first law having priority is
probably for historical reasons. Asimov (1987 p804ff) shows how
historically the first law was derived before the second law by
Stevinus then Galileo. English therefore gives precedence to history,
and French gives precedence to physics.

The English text initially gave both, but later stayed with the French
usage, inventing the term "the fundamental relation of dynamics".
(6EPi48).

3. Cp Chapter 13 for the abbreviation, and Chapter 21 for the equations of
this law.
Interestingly the law of gravitation does have Newton's name attached in English and in French: 'Newton's law of gravity'/'loi de Newton (gravitation universelle)'. (Corrigés 1988 p82, Whelan & Hodgson 1989 p169, 4FP86).

Example 4, *La Loi de Laplace* $F = BQv \sin \theta$

This is the name given to the equation for magnetic force on a charge moving in an electric field. Whelan & Hodgson (1989 p400-1) have no special name for this formula, $F = BQv \sin \theta$, where $F$ is the force, $B$ the flux density, $Q$ the charge and $v$ the particle velocity. In French, the equation is called 'la loi de Laplace' and the force 'la force de Laplace'. In the English translation the teachers chose to use Laplace and to refer to "Laplace's Law" and "Laplace's force". (6EPII22).

Example 5, *Théorème de Huygen* = moment of inertia

In French the eponym 'Huygen' is used for moment of inertia. The English translation used the eponym, (6EPI104). Whelan & Hodgson (1989 p57) do not use the eponym, and neither does the Encyclopaedia Britannica. Both of them though do have 'Hugyen' attached to light waves in optics. (Whelan & Hodgson 1989 p106; Encyclopaedia Britannica 1976 V p230a 'parallel axes theorem').

4. DISCUSSION

English sometimes uses an eponym where French does not. French sometimes uses an eponym when English does not. Sometimes different men are chosen. Whatever the reasons, the existence of differences generates difficulties for translators and anyone attempting to follow one language while using another.

5. SUB-CONCLUSIONS

It does not always and invariably happen that when a famous name is used as a label in one language it will be so used in another language, nor that when an eponym is used, the same eponym will be chosen in both languages. Eponyms are not necessarily constant.
SECTION III VERBALS
CHAPTER 15
DISEASES

1. INTRODUCTION
It is not the purpose of this thesis to venture into medical science therefore examples mentioned below are ones found while studying in the secondary schools. Due to the relatively small amount of biology studied in the two schools, few diseases were mentioned, and therefore few examples could be found of differences.

2. SUB-HYPOTHESIS
If CSL is valid then the same names for diseases will be in use in both languages, especially where there is only one name in use in each language.

3. RESULTS
Example 1, Anaemia
6FB:32 mentions 'drépanocytose'. This in English is 'sickle cell anaemia' or, rarely, 'drepanocytosis'. Even an undergraduate medical textbook like the BDS Textbook of Physiology (1980) uses the common name, not the Latin name.

Example 2, Rickets
6FB:74 has 'rachitisme'. Harrap's Science Dictionary (1985) was unhelpful, but Harrap's (1978) had the entry, meaning 'rickets'.
Example 3. Whooping cough.

Whooping cough, also known as pertussis is called in French 'coqueluche'. The Latin name 'pertussis' does not exist in the French Dictionaries Robert (1984) and Larousse (1984) and even the Grande Larousse (1971) does not give any Latin name.

4. DISCUSSION

Further work needs doing to see if these examples are isolated ones or if many more examples of differences exist. In English teaching to scientists a few rare differences can probably be ignored, but if a lot exist then the scientific English will need teaching, as it can no longer be assumed that knowledge of terms in one language can transfer easily to another.

There is an additional factor which also works against CSL in that the pressure in England at school level is to use common names rather than Latin or Greek terms.

Whenever possible English terms should be used in preference to Latin and Greek terms. (IOB 1989 p29).

In examples one and two above, the common names are listed in the Institute of Biology report (IOB 1989), but not the Latin names. Therefore scientific language based on the use of Latin names cannot necessarily function at school level because the Latin names may not be in common use at that level.

In example three, English has two names, common and Latin, whereas French has only one. Therefore once again constancy based on the use of Latin names cannot function.

5. SUB-CONCLUSIONS

Differences between English and French do exist for the names of diseases, therefore scientific language is not fully constant in the area of names of diseases. The extent and significance of these differences has not been studied sufficiently to make a fair assessment of them.
1. INTRODUCTION

'Systematics' is the study of biological classification, and 'taxonomy', strictly speaking refers to the principles of organising taxa into hierarchies, and looking for evolutionary links. Therefore in purist terms, this chapter should be headed 'systematics'. But in conformity with the Institute of Biology's report on Biological Nomenclature (IOB 1989) the term 'taxonomy' will be used.

The roots of modern taxonomy go back to Linnaeus of the eighteenth century who established, but did not originate the binomial naming system. (Savory 1953 p137). The binomial naming system, by which every organism is known by its genus and its species name (written in italics or underlined) was one of the earliest attempts at an international language. As a system of naming it has become widely and internationally recognised and used.
Given the fundamental importance of the classification of species is to biology, as important as the periodic table is to chemistry, it might be expected that the systems of classification would by now be well worked out and agreed internationally: most of the world's species would be described, given an international name, and classified in a scheme that is fixed and unchanging. Scientific language would be constant, with few if any exceptions, and those exceptions would be newly discovered organisms, or to clarify obscure details. While specialists might argue over a few relatively unknown organisms, certainly those referred to in school texts would have internationally agreed names and classifications. At least in the domain of taxonomy at school level, CSL would be completely valid.

For professional taxonomists, the picture is somewhat different from that of the popular view. Taxonomy cannot by its nature be completely international as its main task includes refining and developing ways of classification (which means that it is constantly changing as new data is added). The place of any given creature in that classification can be and is changeable. Taxonomy is a good example of a discipline where the professional reality and the popular view can differ widely.

One can though, at least at school level, expect a consistency in the superstructure, and in style such as the use of suffixes. The comparison between French and English is made more difficult by the modern trend to do very little taxonomy, or classification of species, in British schools. Therefore this chapter relies heavily on material from outside the schools.

2. SUB-HYPOTHESES

a. The binomial species naming system is international.
b. The suffixes of the Latin names used are international.
c. The system of classification is international.
3. RESULTS

a. The binomial naming system

According to the Institute of Biology's report on Biological Nomenclature (IOB 1989) published for schools, 

... family, genus and species [names] are governed by strict internationally agreed conventions called Codes of Nomenclature. (p14).

The report notes that there have been changes in recent years, most of which are irrelevant to secondary school level pupils. Some of the more common changes are mentioned in figure 16.1 below.

FIGURE 16.1 RECENT CHANGES IN GENUS

<table>
<thead>
<tr>
<th>Example</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>rabbit</td>
<td>Lepus</td>
<td>Oryctolagus</td>
</tr>
<tr>
<td>dogfish</td>
<td>Scyllium</td>
<td>Scyliorhinus</td>
</tr>
<tr>
<td>lion</td>
<td>Felis</td>
<td>Panthera</td>
</tr>
</tbody>
</table>

So apart from minor changes, at school level the binomial naming system is constant.

b. The suffixes of the Latin names

It is clear from a comparison of various sources such as Quid (1985) Stacey (1980) and Henderson (1979) that the Latin suffixes used are constant between English and French except for the level of family. In each case the last vowels are simplified to an 'é'.

For animals English -idae = French -idé
For plants English -aceae = French acé

This could be considered to be but a minor spelling difference.
c. The systems of classification

Traditionally in schools, systems of classification based on divisions between animals and plants or vertebrates and invertebrates have been used particularly for the early years of secondary school. These are now out of favour. (IOB 1989 p17).

In recent years, the five kingdom system has enjoyed wide acceptance. But, as the IOB (1989) report points out, One of the major problems of systematics is to decide how to divide the living world into kingdoms. While the traditional dichotomy into plants and animals is adequate for non-scientific purposes, it is not consistent with current understanding. (p17).

The division into kingdoms is a disputed issue. Even given the five kingdom system, which the report recommends, [1.] there is disagreement in classification of living things at the higher levels of phylum class and order. [2.]

The report says,

Systematics is subject to personal opinion and no two textbooks are likely to be in agreement. . . . However, in many cases the situation is rather different. Kingdom, phylum, class and order are subject to an author’s whim— even to their renaming—but family, genus and species are governed by strict internationally agreed conventions called Codes of Nomenclature. (IOB 1989 p14).

1. The five kingdoms are, Procaryotae ie bacteria etc, Proctoctista ie one celled organisms, Fungi, Plantae and Animalia. For the details Margulis and Schwartz (1988) is recommended. See also Margulis & Guerrero (1991). Their work apparently is based on Whittaker (1959) but nowhere is this reference given in full in the IOB report, though the book by Margulis & Schwartz gets mentioned twice, in a footnote (p17) and in the bibliography. I first thought that Whittaker (1959) could be a misprint, for Hutchinson (1979) has ‘Whittaker (1969)’. When I raised the question with the Institute of Biology I was sent an extract of a letter to them by Colin Hutchinson, which states that “The reference in the report could either be to Whittaker, RH (1959) Quart. Rev. Biol. 34, 210 or be intended as a reference to the 1969 paper that I refer to in my article with a misprint. I would guess that the former is more likely. . . . In any case it is the same Whittaker and the same scheme essentially in all cases”. (IOB 1991). The date used in the bibliography of this thesis is 1969.

2. For some interesting examples of this, and an early outline of the five kingdom system proposing and arguing its acceptance in schools, see Hutchinson (1979) where he refers the reader to Whittaker (1969) for a short critical review of other classification systems.
It will take time for the changes recommended in the report to work their way through into schools. Viruses cannot apparently be fitted in to the system proposed.

Also, in the changes, the divisions can be changed. For instance, a class can become a phylum.

Attention is drawn to the fact that the classification does not use two traditional phyla, Protozoa and Tracheophyta, because the classes which belong to these phyla have been exalted to phylum status. (IOB 1989 p17).

So while international agreement exists for lower levels, no such agreement exists for higher levels, and what belongs to which level can also be changed.

In 1990 Woese proposed a radical new classification system based upon the genetic make-up of species rather than their physical characteristics. Bown (1990) reporting this in the New Scientist anticipates that,

The new Tree is likely to establish itself quickly in schools and colleges because it provides a simple arrangement of species and has great explanatory power. (Bown 1990 p30).

Yet, as Bown admits later in the report,

... the new Tree is still in its infancy, with many branches and even kingdoms still to be sorted out (1990 p30).

As the new classification system has still to be worked out, its acceptance at school level is questionable, but proposals to introduce it at school level illustrate the point made in the Introduction that taxonomy, by its nature, must develop, and not stay as a fixed system of classification.
4. DISCUSSION

As changes are from time to time made to the binomial names, it cannot be assumed that these changes have been implemented in all languages. So taxonomy is not necessarily fully constant between French and English. The method of using a binomial name as an international standard is well established among professional scientists. As such the binomial system is much more fixed, in French and in English, than is the system of higher classifications. These higher classifications are subject to changing opinion, not only for the names of any individual species, but also for their very structures, and what belongs where at what level.

Professionally taxonomy is in a state of flux and the scientific language is not completely constant despite the expectation at school level that some measure of stability exists. At school level the scientific language of taxonomy is not completely constant. School level taxonomy is neither completely international in superstructure, nor in names of organisms.

5. SUB-CONCLUSIONS

a. The binomial naming system (genus and species) is constant with a few changes occasionally being made.
b. The suffixes of the Latin names used are constant.
c. Divisions of Kingdom, phylum, class and order are not necessarily constant, or even national, though there seems to be broad agreement on the five kingdom system, and the seven levels. Even this five kingdom system is being challenged by other systems.
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CHAPTER 17
CHEMICAL TERMINOLOGY

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5. SUB-CONCLUSIONS ................................................15
1. INTRODUCTION

In both the French school and the English school the IUPAC rules for naming organic substances were mentioned. Teachers stressed in the course of their lessons how the naming in organic chemistry was international, and the system used in class was according to IUPAC rules. It came then as a surprise to discover that there appears to be two versions of IUPAC for organic chemistry, a French version and an English version. This made it difficult for the teachers in the English school who were obliged to follow French as closely as possible. They decided in the case of chemical names to use the English system in its entirety, since anything less would have resulted in a nonsense. [1]

There is a whole world of chemical substances, perhaps little known to students and translators, but there nonetheless. This is the world of stains, reagents, and tests. The teachers, particularly in biology, faced problems translating them. Part of the problem was the inadequate monolingual documentation available in Tunis. Even my experiences as a science teacher in England left me with the impression that information is sometimes hard to come by, and has to be sought in technicians' handbooks. Unfortunately even the otherwise excellent "Henderson's Dictionary of Biological Terms" (1979) is strangely weak and unhelpful in this area. Along with constancy of scientific language goes the culture, the methods, the techniques used which are also assumed to be similar. What is important for this chapter is not only the constancy of the substance names, but also how international the use of substances in common experiments such as testing for the components of foods.

1. Right up to the last moment one of the teachers was uncertain what the English system was. A copy of the ASE (1985) report on "Chemical Nomenclature" had not at that time arrived. I was able to show TEK the advice in Buttle et al (1981) which I had found in the British Council library in Tunis. This I literally handed to TEK a few minutes before he was due to teach. "Afterwards, TEK said the notes were timely as he was in two minds right up to the last minute what system to teach". (T233:16) He also earlier had referred to this, publicly acknowledging my help in front of the class, maybe to reinforce the authoritativeness of what he was teaching (T233:14). This is a good example of the benefits of actively seeking to help the teachers in the course of my research.
In England, ever increasing pressures of safety have forced changes in standard procedures for food tests. As accepted practice has changed, so too has the accompanying vocabulary. These pressures for safety are not the same in every country. Neither are the desired substances always available. In this small area alone then, the actual science may not be the same.

Where there are changes happening over time in the actual science done in schools, the science a pupil learns in one country will not necessarily be the same as that learned by their counterpart in another country. When such people subsequently meet, at say degree or postgraduate level, there will be areas where they will not share a similar body of language or culture.

This chapter then tests several related and important areas of the naming and use of chemicals, to see how international they are.

2. SUB-HYPOTHESES

The broad hypothesis is that the names of the chemicals are the same in French and English. But this is too vague for the purposes of analysis. Therefore I have subdivided names of chemicals into:

a) Names of elements

b) Inorganic chemistry

The names for inorganic chemicals will be the same in English and French, at least when ignoring any differences in word order. But this to make three assumptions which are questionable:

1) The nomenclature for chemicals which, at least at school level, have been known about for decades or more, is fixed and not changing, in both languages. Or if it can be shown that there is evolution taking place then:

2) The state of development is the same in both languages.

3) There is only one, consistent, acceptable system.

c) Organic chemistry

The names and the order of putting the words together will be the same in English and French. Here the sub-hypothesis must include component order, because the grammar of the host
RESULTS: VERBALS Chemical Terminology 17.4

language does not impose a word order as it does in inorganic chemistry (chlorure de sodium instead of Sodium Chloride).

d) Reagents and tests
If CSL is valid then not only will the names of these reagents, stains and tests be the same in English and French, but the same tests and reagents will be used in comparable circumstances. For instance, food tests are part of the biology of nutrition. Tunisia has them in the curriculum just as England does. One would expect then that the same tests would be used if science is the same in different countries.

e) Enzymes
f) Vitamins and nutritional minerals
g) sugars
h) Amino acids

3. RESULTS

a. Names of the elements

| 68 names exactly the same including 14 with extra accents in French | 34 names which are different explained in figure 17.1b below |

Fourteen names have extra accents in French, without otherwise changing the spelling. If these are counted with the names without any spelling differences, then out of 102 elements, sixty-eight have the same name.

Of the thirty-four names with differences, the details are given in figure 17.1b. It can be seen that seven names are totally different: azote (nitrogen), fer (iron), cuivre (copper), argent (silver), étain (tin), or (gold), and plomb (lead). An English person knowing the symbols will quickly grasp that Fe = fer (iron), Cu = cuivre (copper), Ag = argent (silver) and Pb = plomb (lead). That leaves only nitrogen, tin and gold as the names that do not have any similarity between French and English, even when the symbols are known.
### Results: Verbals Chemical Terminology 17.5

#### Figure 17.1b. Classification of the 34 Elements Which Are Different in English and French [2.]

<table>
<thead>
<tr>
<th>Difference</th>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>'-e' -&gt; '-um'</td>
<td>lanthane</td>
<td>lanthanum</td>
</tr>
<tr>
<td></td>
<td>molybdène</td>
<td>molybdenum</td>
</tr>
<tr>
<td></td>
<td>tantalé</td>
<td>tantalum</td>
</tr>
<tr>
<td></td>
<td>plantine</td>
<td>platinum</td>
</tr>
<tr>
<td>'-e' -&gt; '-um'</td>
<td>chrome</td>
<td>chromium</td>
</tr>
<tr>
<td></td>
<td>titane</td>
<td>titanium</td>
</tr>
<tr>
<td></td>
<td>tellure</td>
<td>tellurium</td>
</tr>
<tr>
<td></td>
<td>praséodyme</td>
<td>praseodymium</td>
</tr>
<tr>
<td></td>
<td>néodyme</td>
<td>neodymium</td>
</tr>
<tr>
<td>'-yum' -&gt; '-ium'</td>
<td>baryum</td>
<td>barium</td>
</tr>
<tr>
<td></td>
<td>silicium</td>
<td>silicon</td>
</tr>
<tr>
<td>'-ene' -&gt; '-en'</td>
<td>hydrogène</td>
<td>hydrogen</td>
</tr>
<tr>
<td></td>
<td>oxygène</td>
<td>oxygen</td>
</tr>
<tr>
<td></td>
<td>tungstène</td>
<td>tungsten</td>
</tr>
<tr>
<td>halogènes -&gt; '-ine'</td>
<td>fluor</td>
<td>fluorine</td>
</tr>
<tr>
<td></td>
<td>chlore</td>
<td>chlorine</td>
</tr>
<tr>
<td></td>
<td>brome</td>
<td>bromine</td>
</tr>
<tr>
<td></td>
<td>iodé</td>
<td>iodine</td>
</tr>
<tr>
<td></td>
<td>astatate</td>
<td>astatine</td>
</tr>
<tr>
<td>Similar roots</td>
<td>césium</td>
<td>caesium</td>
</tr>
<tr>
<td></td>
<td>bore</td>
<td>boron</td>
</tr>
<tr>
<td></td>
<td>carbone</td>
<td>carbon</td>
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<td></td>
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<td>sulphur</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>antimoine</td>
<td>antimony</td>
</tr>
<tr>
<td></td>
<td>mercure</td>
<td>mercury</td>
</tr>
<tr>
<td></td>
<td>lutétiurn</td>
<td>luteclum</td>
</tr>
<tr>
<td>Totally different, French relates to symbol</td>
<td>Fer</td>
<td>Iron Fe</td>
</tr>
<tr>
<td></td>
<td>cuivre</td>
<td>copper Cu</td>
</tr>
<tr>
<td></td>
<td>argent</td>
<td>silver Ag</td>
</tr>
<tr>
<td></td>
<td>plomb</td>
<td>lead Pb</td>
</tr>
<tr>
<td>Totally different, French has no relation to symbol</td>
<td>étain</td>
<td>tin Sn</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>gold Au</td>
</tr>
<tr>
<td></td>
<td>azote</td>
<td>nitrogen N</td>
</tr>
</tbody>
</table>

2. Figure 17.1b takes no account of American spellings, or proposed changes. For instance the Royal Society of Chemistry is to move from 'sulphur' to 'sulfur' in its main journals, four decades after IUPAC first recommended this. Americans still tend to use 'cesium' /sɪˈziːəm/ for the English 'caesium' (same pronunciation) and 'aluminium' /əˈljuːmɪnɪəm/ for 'aluminium' /eɪˈluːmɪnɪəm/ (Feedback 1992). This information provoked the witty question as to whether or not this change would also affect the notation used for hydrogen ion concentrations. "Is pH going to become "p"? (Hannant 1992).

3. Défournéaux (1983 p80) asserts that nitrogen belongs to the group 'êne' -> '-en'. The French for nitrogen is azote not nitrogène. The mistake may be due to the fact that in his previous book (1980 p135) he listed the four elements in English with the '-en' ending together.
Example 1, the suffix for the halogen ions.
The suffix for the halogen ions, in French is '-ure' and in English '-ide'. Chlorure de X becomes 'X chloride' in English.

Example 2, the names of elements existing as molecules: dichlorine
Chlorine has the symbol 'Cl' in French and in English. But, the atomic form 'Cl' does not normally exist in nature. Chlorine when it is found, is found as a molecule, Cl₂. The English for this is simply 'chlorine' or 'chlorine gas'. Anyone working in science in English is expected to know the fact that certain elements exist as molecules. In French there are two ways of labelling Cl₂. Either 'dichlore' (5FC66), or 'molécules de chlore' (5FC27). The examples of other similar elements are hydrogen, oxygen, nitrogen and the other halogens. Not for the first time French is being more precise in its use of words than English. The teachers at the English school, when they translated 'dichlore, dioxygène' (4FP68) in a table of densities, used the words 'dichlorine, dioxygen'. (4EP45). While these words exist they are not those most commonly used. [4.]

Example 3, word order
The biggest apparent difference between English and French in Inorganic chemistry is the word order. English has a type of binomial system that follows the order in the formula,

{positive charged ion} {negative charged ion},

ie {cation} {anion}.

eg sodium chloride.

French reverses this order when using words, thus 'chlorure de sodium'.

4. In a recent article in the New Scientist (Leigh 1990) the word 'dinitrogen' is used several times. "Air consists of four-fifths nitrogen, or, more correctly, dinitrogen gas (N₂)." (p55a). When a labelled equation was given, the label included 'dinitrogen' and 'dihydrogen', possibly because the author wants to discuss the splitting of the 'di-' bond. However, as the symbol for an electron is repeatedly given as 'e' not 'e-' one has reason not to trust the New Scientist as a standard setter. ASE (1983 p14) for instance uses 'e-' to represent an electron, and does not use the 'di-' prefix in the way Leigh and the French language use it. There is also a world of difference between an expert using newish terminology, and the permitted use by school students.
Example 4, old terminology

Biology may use old names that are not used in chemistry. This in fact was happening at the French school. The fifth year French Chemistry text was using the modern system, (e.g., 5FC117, sulfate de cuivre II CuSO₄) while the biology fifth year French book was using the old system (e.g., 5FB21 oxyde cuivrique CuO instead of oxyde de cuivre II). [5.] The language in French is still evolving, and not necessarily at the same rate as in English.

c. Organic chemistry [6.]

1) Spelling differences

As Défourneaux explains (1983 p.92), there is very little difference between the words used in organic chemistry, except for a few changes namely,

a) Elimination of the accents (hardly surprising)

b) Elimination of some of the final e's, in particular with the 'ylé' ending ('methylé' becomes 'methyl').

c) Replacement of 'ique' by '-ic'.

d) The French cètone, cètène becomes 'ketone, ketene' with a 'k' in English.

These differences are small. The problem lies more with the order of writing the names.

2) The order of the component parts

Défourneaux (1983 p.93) makes little fuss about the order of the component parts of a name, and he gives only one example of the difference. This difference is used to illustrate point b) below, in figure 17.2b.

In practice the differences were far more confusing to myself and to the teachers at the English school than Défourneaux's single example would lead one to expect. Therefore, included in

---

5. For a further study of old and new names in English and French, Défourneaux (1983) and ASE (1985) are good starting points.

6. Much of the material of this section came from class observation, and in particular was written by teachers on the blackboard, thus facilitating the research.
the questionnaire were six items designed to test how confusing these differences were to the pupils (see Chapter 18 'Chemistry questionnaire').

a) Sometimes the words and numbers are exactly the same as for instance in figure 17.2a.

FIGURE 17.2A. ORGANIC CHEMISTRY EXAMPLE SHOWING EXACT SIMILARITY BETWEEN ENGLISH AND FRENCH

| French:    | monochlorométhane (6FC:100) |
| English:   | monochloromethane (T229:11). |

b) Other times the words stay exactly the same, but the location of the numbers changes. In French the numbers are put to the right of the relevant component, whereas in English they are on the left, as in the figure 17.2b below.

FIGURE 17.2B. ORGANIC CHEMISTRY EXAMPLE SHOWING POSITION OF NUMBERS

| French:    | triméthyl-2,2,4 pentane |
| English:   | 2,2,4-trimethylpentane |

c) In French dashes and spaces are used to separate the numbers from the words, the dash implying that the numbers are linked to that component, a space separating each radical from the stem. In English the dash serves the same function, to link the numbers to the appropriate component, but this time the component is on the right of the numbers. Figure 17.2c illustrates these points.

FIGURE 17.2C. ORGANIC CHEMISTRY EXAMPLE TO COMPARE DASHES AND SPACES

| French:    | dibromo-1,2 méthyl-3 butane. |
| English:   | 1,2,-dibromo-3-methylbutane. |

English does not use spaces where numbers are involved, a dash being used as the separator. As such the dash does not necessarily imply linkage of a number to the name. Numbers always go with what follows in English, therefore the dash of
linkage and the dash of space can be distinguished from the context. [7.].

Note how in English there is no break between the 'methyl' and 'butane' in 'methylbutane'.

d) English also uses numbers to break up components like octyne, whereas French keeps such words together placing the numbers after the words. Examples of this are given in figure 17.2d below.

FIGURE 17.2d. TO SHOW HOW FRENCH DOES NOT BREAK UP COMPONENTS LIKE ENGLISH DOES

<table>
<thead>
<tr>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>butène-2</td>
<td>but-2-ene.</td>
</tr>
<tr>
<td>diméthyl-3,6 octyne-4.</td>
<td>3,6-dimethylocta-4-yne.</td>
</tr>
</tbody>
</table>

An early attempt to see how confusing this was to pupils was made in the questionnaire, (chapter 18) and a presentation of the results is given there. As far as the nomenclature is concerned it is clear that there are major differences between English and French concerning word order and punctuation of names in organic chemistry.

d. Reagents and tests

Example 1. lugol solution
The French textbooks states, solution de lugol ... (le lugol est une solution d'iode dans l'iodyre de potassium). (6FB144)
The English book, at this point translating directly from the French states, ...

lугol solution (= solution of iodine and potassium iodide) (6EB17).

Here the teachers at the English school used the name as in the French book and that is what it is known as in Tunisia. But lugol solution is widely and more simply known in England as 'iodine solution'. Apparently it exists in English (Turner 1991), but it is not in current use.

Example 2. *bleu de toluidine-éosine* and *bleu de toluidine phéniqué.* These are stains to show the chromosome behaviour in binary fission in plant root tips in a technique known as mitosis squash preparations. The sixth year English text adroitly avoided translating these stains by saying "look at the slides you are given". Devries (1976), a science dictionary not available in Tunisia has these equivalents: 'toluidine blue' and 'carbol toluidine blue' respectively, not 'toluidine eosine blue' and 'phenol toluidine blue' as might be expected.

Example 3. *biuret test*  
In Tunisia the biuret test (6FB24) was used to test for the presence of protein. [8.] The biuret test is known in England but is now little used.

Example 4. *la reaction xanthroprotéique.*  
For this test nitric acid is added to a sample which is then heated. This causes the sample to produce a white precipitate which on continued heating turns yellow verging on orange. The test was given the name "xantoproteic test" in the English book (6EBI57). At the English school the teachers had to make an intelligent guess as to what it is in English. The test is unknown in modern English schools and is now not used.

Example 5. *growth solutions for plants*  
There are two liquid growth media for plants (5FB10-11) called a) "*milieu de Knop*" and b) "*milieu de Sachs*". *Le milieu de Knop* is a solution containing nine elements needed for the growth of plants showing that an artificial growth medium can be made. *Le milieu de Sachs* is a similar liquid, but with the elements provided by different combinations of salts showing that the actual chemical form of the element is not important.

Only something similar to "Knop's solution" is known and used in English, without a special name.

---

8. In the biuret test adding first sodium hydroxide solution then copper sulphate solution to a protein solution gives a blue colour, which when shaken becomes a violet colour.
Example 6, litmus
In French the terms used are 'papier de tournesol', 'tournesol rouge', and 'tournesol bleu', for 'litmus', 'red litmus', and 'blue litmus' respectively. 'Litmus' is not the name of a man as such, but according to Longman (1985) is linked with the old norse for a type of herbs used in dyeing. Harrap's Science Dictionary (1985) gives another eponym 'Kubel-Thiemann's solution', and 'litmus solution' is known as 'tinture de tournesol'. The substance is the same, but the name is not, with the word 'solution' being replaced by the word 'tinture'.

e. Enzymes
At the low level of biology studied in Tunisia, no examples of differences between English and French for enzymes could be found.

f. Vitamins and nutritional minerals

Example 1, group names
The important nutritional elements in English are called simply 'minerals'. Other elements needed are called 'trace elements'. The division in French is between macrominéraux and "microminéraux ou oligoéléments". (6FB45).

Anyone trying to say any of these three French words in English would not be understood. 'Macrominerals', 'microminerals', and 'oligoelements' are not English words.

Example 2, the vitamin B complex
It can be seen that at one time different numbers were used for niacin and pantothenic acid within English. Also that biotin normally has no number, but Henderson (1979) gives it the number B4. Pantothenic acid is also given the number B4 in French. The French labelling of B12 as 'cyanocobalamine' agrees with the English (Henderson 1979, though no mention in Mervyn 1984).

There are therefore differences in the group names for the nutritional minerals, and in the names and numbers of some vitamins belonging to the B group.
### FIGURE 17.3 SUMMARY OF THE NAMES AND NOMENCLATURE OF THE VITAMIN B GROUP IN ENGLISH AND FRENCH WITH VARIANTS NOTED

<table>
<thead>
<tr>
<th>English (Mervyn 1984 p26-7, 148,155)</th>
<th>French (Quid 1984 p1394c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>thiamine</td>
<td>B₁</td>
</tr>
<tr>
<td>riboflavin</td>
<td>B₂</td>
</tr>
<tr>
<td>nicotinic acid</td>
<td>B₃ (USA and now)</td>
</tr>
<tr>
<td>or niacin</td>
<td>B₅ (old: Europe)</td>
</tr>
<tr>
<td>pantothenic acid</td>
<td>B₅ (USA and now)</td>
</tr>
<tr>
<td>or niacin</td>
<td>B₃ (old: Europe)</td>
</tr>
<tr>
<td>pyridoxine</td>
<td>B₆</td>
</tr>
<tr>
<td>biotin</td>
<td>no number (B₄) (Henderson 1979)</td>
</tr>
<tr>
<td>folic acid</td>
<td></td>
</tr>
<tr>
<td>B₁₂.</td>
<td></td>
</tr>
</tbody>
</table>

#### g. Sugars

The evidence is from 6FB32-5. 6EBi57-8 with example six from 5FB21. Note that the English system is followed in full in the English translated textbooks.

### FIGURE 17.4 EXAMPLES OF NAMES OF SUGARS THAT ARE DIFFERENT

<table>
<thead>
<tr>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. les glucides</td>
<td>carbohydrates</td>
</tr>
<tr>
<td>2. les oses ou sucres simples</td>
<td>monosaccharides</td>
</tr>
<tr>
<td>3. les diholosides</td>
<td>disaccharides</td>
</tr>
<tr>
<td>4. les polyholosides</td>
<td>polysaccharides</td>
</tr>
<tr>
<td>5. amidon/la fecule</td>
<td>starch</td>
</tr>
<tr>
<td>6. lévulose</td>
<td>fructose</td>
</tr>
</tbody>
</table>

Most of these differences are to do with the group words, rather than the individual name of a sugar.

---

9. This last name for nicotinic acid, vitamin B₇, is either an error or is so old that it is no longer used at all, as Mervyn (1984) has no mention of this.
h. Amino acids

Standard names and abbreviations for amino acids exist in English and in French. In the human body there are only twenty amino acids which are used. When these twenty are compared between English and French it becomes clear that apart from the odd accent and a change in word order required by the French, ('l'acide aspartique' instead of 'aspartic acid') the names and the standard three letter abbreviations are the same.

4. DISCUSSION

a. Names of elements

Superficially there is a lot of agreement between French and English. But, of the elements having exactly the same names and spellings with no accents (54/102), twenty are elements in the lanthanide series (numbers 58-71) and the actinide series (numbers 90-102). These elements are rare, and mostly of interest to nuclear scientists. When these are excluded that leaves seventy-five elements to be considered, of which thirty-four have exact equivalence, and another nine have only accents as the difference. Thus 34/75 elements have significant differences, ie almost half of those considered.

At school level usually only elements 1–36, plus silver, tin, iodine, tungsten, platinum, gold, mercury and lead are considered, some 44 elements. Of this 44, some 21 have differences in their names, a marginally higher number (48% as against 45% for 34/75).

So the area of agreement between French and English upon examination proves to be only slightly more than half. The names of the elements cannot therefore be regarded as fully international.

b. Inorganic nomenclature & c. Organic nomenclature

The most obvious difference between English and French for inorganic nomenclature is the word order, but as the basic content stays the same, and these changes are bound to the differing rules
of grammar in French and English: the difference is not that important and says little about the internationalness of the inorganic nomenclature. It is clear that the terminology has been changing: both languages are moving towards a modern 'systematic' naming system. But even this modern system is not yet fully international. For instance there is the change of suffix for the halogen ions, and the name change for molecules existing in nature in diatomic form. The changes are not happening at the same rate in different subjects, countries and languages. There is a trend towards growing agreement, but full agreement used consistently has yet to happen.

The differences in organic chemistry names are mainly to do with punctuation and the order of the components in the name. In the questionnaire an attempt was made to see how difficult pupils found these changes. (See Chapter 18 'Chemistry questionnaire').

d. Reagents & e. Enzymes
Most of the stains used in the schools in Tunis had similar names in English and French, with only the minor difference existing of a reversal of word order, as in inorganic chemistry. With enzymes, there is the limitation that few were studied in the school courses. It is possible that examples of enzymes which differ in name between English and French can be found, especially those used in 'A' level biology which is higher in level and broader in scope than the biology of the 'Bac C' or the biology studied in Tunisia.

f. Vitamins and nutritional minerals, & g. Sugars, & h. Amino acids
It was interesting that for sugars and for minerals it was the group words which changed most between English and French. For the vitamins the biggest area in which differences were found was in the vitamin B complex. Not only are there differences within a language, especially English, but also there are differences between English and French. The amino acids in contrast is an area where both symbols and names are fully constant between English and French, ignoring accents and word order.
5. SUB-CONCLUSIONS

a. Names of elements
   A third (34/102) of the names of the elements have differences between English and French, therefore they are not international.

b. Inorganic chemistry
   This sub-hypothesis has not been adequately tested. There is though sufficient evidence to show that the sub-hypotheses can fail: differences between English and French do exist. The state of progress towards a more international system is not necessarily the same in English and French.

c. Organic chemistry
   There is little difference regarding the names of the component parts, but the order, and the punctuation differs. There is also a major difference in the way French specifies that hydrogen (and similar elements) is a molecule of two hydrogen atoms, \((\text{dichlore})\) whereas in English this is normally assumed, and chlorine is assumed to be \(\text{Cl}_2\) unless there are specific indications to the contrary.

d. Reagents and tests & e. enzymes
   1) The names of reagents dyes and stains are not necessarily international.
   2) The same standardised tests and stains are not always used in comparable circumstances.
   3) There was no evidence to test the sub-hypothesis for enzymes.

f. Vitamins and nutritional minerals & g. sugars & h. amino acids.
   There is some ambiguity concerning the labelling of the vitamins of the B group. The numbering system for the B group is not completely international. The classification labels (group names) for minerals and trace elements are not international. Some common names for sugars are the same, but not the French for starch or levulose. The group words are different. For amino acids, apart from accents and word order, the language is constant for both words and symbols between English and French.
SECTION III VERBALS
CHAPTER 18
CHEMISTRY QUESTIONNAIRE

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1. INTRODUCTION

The differences in organic chemistry nomenclature between English and French have been discussed in the previous chapter 'Chemical Terminology'. The methods used, and how the questionnaires were administered has been presented in the Chapter 6 'Procedures'.

This chapter is an attempt to see how significant the observable differences between English and French are. In effect there were three groups of pupils, at the English school with some reading of French, at the English school without French, and at the French school.

In the questionnaire, the precaution was taken of asking the French school pupils if they had read anything or studied anything about organic chemistry in English. Each class had some who reported they had had one short lesson by their English teacher. Whole classes were affected even though only some recalled and mentioned this. Therefore the French group has not been split into those who professedly have or have not done any organic chemistry in their third language as has been done for the English school.

In accordance with accepted practice in linguistics, the second language has been labelled L2, and the third language has been labelled L3. All the students spoke Tunisian Arabic as their first language L1, with French (L2) and English (L3) being spoken at the French school, and English (L2) and French (L3) being spoken at the English school.

2. SUB-HYPOTHESES

a. If CSL is valid, then on an exercise in reading formulae and correctly drawing their structure there will be the same number of mistakes between:
   1) The French and English test at the English school
   2) The French and English test at the French school
   3) The French and English test at the English school for the group who have read French and the group who have not, ie the fact of reading some French material should make no difference, and give no advantage.
b) If CSL is valid and if the French and English groups are equivalent populations with the sole significant difference being the language of instruction then the number of mistakes in the French school should be identical to the number of mistakes in the English school.

c) If CSL is valid then when students are asked to re-write a formula in the style of the other language, there will be no mistakes. [1.]

3. RESULTS

As a control, class three at the French school was given the exercise in L2 only. Their results were: eighteen pupils, with eight mistakes out of 108 questions. This is comparable to those classes who did the exercises in L3 then L2.

FIGURE 18.1A. ENGLISH SCHOOL 'DRAWING FORMULAE': STUDENTS WHO REPORTED STUDYING CHEMISTRY IN ENGLISH ONLY (incorrect ans = incorrect answer, nos = numbers)

<table>
<thead>
<tr>
<th>Class</th>
<th>pupil nos</th>
<th>L3 (French)</th>
<th>L2 (English)</th>
<th>L3/L2 Fr/Eng</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>incorrect ans</td>
<td>incorrect ans</td>
<td>ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nos   %</td>
<td>nos   %</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>19/48 39.6</td>
<td>5/48 10.4</td>
<td>3.8</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>7/42 18.7</td>
<td>2/42 4.8</td>
<td>3.5</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>12/30 40.0</td>
<td>1/30 3.3</td>
<td>12.0</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>2/30 6.6</td>
<td>0/30 0.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>40/150 26.7</td>
<td>8/150 5.3</td>
<td>5.0</td>
</tr>
</tbody>
</table>

1. Note, this test I gave almost as an after thought to some at the English school only after the second time the students had done the chemistry questionnaire (English version) and after the students had had exposure to the French style. Time was too short at the French school to even consider giving a similar test there.
FIGURE 18.1b. ENGLISH SCHOOL 'DRAWING FORMULAE': STUDENTS WHO REPORTED STUDYING CHEMISTRY IN FRENCH AND ENGLISH

<table>
<thead>
<tr>
<th>Class</th>
<th>Pupil nos</th>
<th>L3 (French)Incorrect ans nos %</th>
<th>L2 (English)Incorrect ans nos %</th>
<th>L3/L2 Fr/Eng ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>17/78 21.8</td>
<td>5/78 6.4</td>
<td>3.4</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
<td>8/78 10.3</td>
<td>4/78 5.1</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>19</td>
<td>22/114 19.3</td>
<td>4/114 3.5</td>
<td>5.5</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>6/102 5.9</td>
<td>6/102 5.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>53/372 14.2</td>
<td>19/372 5.1</td>
<td>2.79</td>
</tr>
</tbody>
</table>

FIGURE 18.2 FRENCH SCHOOL 'DRAWING FORMULAE'

<table>
<thead>
<tr>
<th>Class</th>
<th>Pupil nos</th>
<th>L3 (English)Incorrect ans nos %</th>
<th>L2 (French)Incorrect ans nos %</th>
<th>L3/L2 Eng,Fr decimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>14/90 15.6</td>
<td>8/90 8.9</td>
<td>1.75</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>18/132 13.6</td>
<td>7/132 5.3</td>
<td>2.57</td>
</tr>
<tr>
<td>4</td>
<td>19</td>
<td>15/114 13.2</td>
<td>6/114 5.3</td>
<td>2.5</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>15/120 12.5</td>
<td>8/120 6.7</td>
<td>1.88</td>
</tr>
<tr>
<td>Σ</td>
<td>76</td>
<td>62/456 13.6</td>
<td>29/456 6.4</td>
<td>2.14</td>
</tr>
</tbody>
</table>
FIGURE 18.3 SUMMARY OF FIGURES 18.1A, 18.1B AND 18.2

<table>
<thead>
<tr>
<th>Pupil nos</th>
<th>L3 numbers %</th>
<th>L2 numbers %</th>
<th>L3/L2 decimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>English school 'English only'</td>
<td>25</td>
<td>40/150 26.7</td>
<td>8/150 5.3</td>
</tr>
<tr>
<td>English school 'French &amp; English'</td>
<td>62</td>
<td>53/372 14.2</td>
<td>19/372 5.1</td>
</tr>
<tr>
<td>French school</td>
<td>76</td>
<td>62/456 13.8</td>
<td>29/456 6.4</td>
</tr>
</tbody>
</table>

FIGURE 18.4 GRAPH TO SHOW THE SUMMARY RESULTS OF 'DRAWING FORMULAE'

Incorrect answers (%)
FIGURE 18.5 TABLE OF RESULTS AT THE ENGLISH SCHOOL OF RE-WRITING CHEMICAL FORMULAE IN FRENCH

<table>
<thead>
<tr>
<th>Class</th>
<th>Pupil nos</th>
<th>Number of questions answered</th>
<th>Totally right</th>
<th>Almost right</th>
<th>Totally wrong</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>66</td>
<td>7</td>
<td>40</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>78</td>
<td>8</td>
<td>53</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>54</td>
<td>0</td>
<td>34</td>
<td>20</td>
</tr>
<tr>
<td>Total (percent)</td>
<td>33</td>
<td>198</td>
<td>15</td>
<td>127</td>
<td>54</td>
</tr>
</tbody>
</table>

(The 'almost right' answers were those in which the word order was right but the other details were wrong)

FIGURE 18.6 GRAPH TO SHOW THE RESULTS AT THE ENGLISH SCHOOL OF RE-WRITING CHEMICAL FORMULAE THE FRENCH WAY
4. DISCUSSION

a. 'Drawing formulae'.

Despite the limitations of a small sample and the fact that though difficult chemical formulae were chosen the error rate was low, making distinctions difficult, the following statements can be made:

1) There was a greater number of errors in the third language of students, than in their second language. This was true for the English school and the French school. If CSL were to be valid then this difference would not exist at all. [2.]

2) At the English school, the 'English only' group made 27% errors in L3, compared to 14% for those students who had confessedly some contact with French.

3) The French school made less errors in their third language than the English school did in their third language. This result is unexpected. Maybe the lesson the students had on organic chemistry had helped, maybe students were more sure of themselves in French because they had not had two languages confusingly floating around, therefore being sure of one, they could reason more clearly in the other language.

4) Both schools got base levels of scores for L2 that were close, 5.1% for the English school compared to 6.4% for the French school. This is evidence supporting the assumption that the two schools are similar populations of pupils.

2. All the tests were given in the third language before the second language. To do half the classes in L2 then in L3 would have been to further divide the population to unacceptably low sizes. In no case did the errors in the second language exceed those in the third language. It is possible that errors are lower for L2 because of prior exposure to the questions in L3. In the English school this was minimised by separating the two tests by a time interval of weeks. In the French school the tests had to be administered an hour apart. Both schools received the test in the L3 L2 order, therefore valid comparisons between the schools can be made.
b. English school 're-writing formulae'

The students who attempted this section did so because they had time, it was an optional extra. It was not attempted before the other questions had been completed. Therefore the result is significant that though the majority had grasped the idea of the change in syllable order between English and French, and were able to achieve high scores on recognition, only 7.6% of questions were answered correctly when it came to re-writing the formulae the French way. The result shows how difficult it is to change between languages when something as essentially simple, yet practical, as re-writing a formula is demanded. Science may be international in that differences are sufficiently minor to make recognition an insignificant problem, but correct usage in another language is another, more difficult skill. Minor differences that do not affect recognition can become major differences when correct usage is demanded.

c. General comments

The sub-conclusions must be drawn with caution, as the numbers of pupils, though almost all the population, were small, and the number of errors was so small in the tests that the figures are less convincing than otherwise. Also, the French school clearly did better than the English school 'English only' group when tested in L3, showing that differences between schools can easily affect results of tests like these. The results though are indicative. In particular, the exercise requiring the re-writing of formulae, which was testing an active skill not just recognition, points to a serious failure of CSL.

5. SUB-CONCLUSIONS

a. More mistakes are made in L3 than in L2.
b. Rewriting a formula in another language proved particularly difficult.
SECTION IV NON-VERBALS

CHAPTER 19

SYMBOLS

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1. INTRODUCTION

A major argument of those in favour of CSL is that the symbols used in science are assumed to be international, particularly because there exists the international system (SI) of units, supposedly one of the most fully international systems in use in the modern world. Widdowson, as explained in chapter 28 also regards symbols as a kind of interlanguage. If there are major differences between English and French in this important area of symbols, it follows that CSL is not valid in one of the more important areas.

"La conférence Générale et du Comité International des Poids et Mesures" (CGPM) has been in existence since 1889. (Maillot 1981 p221). It is this body which adopted the SI, the International System of units, based upon seven base units, the metre, kilogram, second, ampere, kelvin, candela and mole. (ASE 1981 p 1). Because the UK has adopted the metric system (based upon the metre, litre and kilogram) one would expect few problems now between French and English, especially when units are used by scientists.

In the SI system, a distinction is made between 'quantity' (grandeur) and 'unit' (unités). Quantity, is a dimension, or a measure, such as the length, breadth or height of an object. All three of these quantities, length, breadth and height, have a symbol for them in italics. (l, b, and h). But the 'unit' for all three of them is the metre. The metre has the symbol 'm', written with an upright character. [1]

In handwritten material italics cannot be used, therefore underlining must be substituted. Whether this is done in British or French schools I am in no position to say. I can though report that the underlining of the symbols of quantity was not routinely done in the classes I observed in Tunisia. With printed material on the other hand, it is not always easy to see whether any individual letter is in italics or not,

1. There is according to Maillot (1981 p220-1) a tendency in English to use the symbol of the unit instead of the more correct quantity symbol. The example is given of "rated kVA", i.e rated at so many kilovolt-amps. The correct way is to give a quantity (in this case, watt, symbol W) not the units for a power rating.
therefore this distinction is very much left in the domain of accepted knowledge that a student at this level of science should have. Both the symbols for the quantity and the symbols for the unit are included in the SI system.

2. SUB-HYPOTHESES

The following will be the same in English and French, both in form and in usage at school level:

a. Conventions for expressing vector quantities.
b. Symbols for units.
c. Symbols for quantities.
d. Punctuation and orthography.
e. Symbols in biology.
f. Symbols in physics.
g. The non-SI symbols in chemistry.
h. Symbols in mathematics.

3. RESULTS

a. Vector quantities

Some quantities have both a size and a direction. Such quantities are called "vector quantities". This is the case for instance with force. Force in English is characterised by both quantity (size) and direction of action.

If CSL is valid then the conventions for stressing that a quantity is a vector quantity will be the same in English and in French.

In French vector quantities are indicated by is made by writing a right facing arrow above the quantity eg $\vec{F}$

According to the Association for Science Education, the convention by which symbols for vector quantities may be printed in bold face type has, in accordance with common present day school practice, not been followed in these lists. (ASE 1981 p18).
So an alternative convention does exist for indicating a vector quantity, by using bold print, but it is apparently not accepted UK school practice (ASE 1981 p18).

Whelan & Hodgson (1989 p17b) follow the convention that the symbol is printed in *bold italic*, unless we refer to magnitude only.

This is fine for books. Whelan & Hodgson give no suggestions as to how this can be written by hand, or even, how to cope when the typewriter will not handle bold printing. The ASE (1981 p17) suggest that when a system is wanted for handwriting, the bold type of printing be replaced by underlining with a wavy line, which is in accordance with the recommended system of correcting manuscripts (Writer's 1992 p482).

When it comes to indicating unit vectors, Cores (1983 p94) gives 'a', a bold symbol with a circumflex, as "unit vector in the direction of 'a' ". This is not the same as anything else mentioned so far and is little used in Physics. French uses vector \( \vec{1}, \vec{j}, \) and \( \vec{k}, \) as explained in Chapter 21 'Equations' where their use in physics is studied. Conventions for representing vectors exists, but they are little used in English school science, and certainly nowhere near the extent that the French symbol for a vector is used. [2.]

---

2. The French convention of using right pointing arrows to indicate that the symbol represents a vector quantity is not the same as the symbol \( \vec{A} \) above a line segment \( AB \) which means "The vector represented in magnitude and direction by the directed line segment \( AB \) " (Cores 1983 p94). The terminology in Cores (1983) refers to the use of lines with a certain direction, the length of the line representing the size, and the direction representing the direction of a vector quantity. This terminology was not used in Tunisia and must not be confused with the right pointing arrow over a symbol or symbols, indicating vector quantity.
b. Units

**Example 1, the ohm**
The international ohm symbol $\Omega$ is apparently little used in English according to Maillot (1981 p216), the English preferring to write out the unit in full, though the symbol does exist.

**Example 2, the kelvin**
In the Tunisian French texts, (up to 1988) the $^\circ$K for degree kelvin is used, though TFC (T237:11) told students at the French school to no longer use the degrees symbol, as it had been changed in French, but had yet to appear in the new textbooks. In fact, Maillot (1981 p218) reports that the thirteenth *Conférence Générale et du Comité International des Poids et Mesures* (CGPM) (1967-8) replaced the 'degree kelvin' by the 'kelvin'. In 1983 (p43) Défourneaux could still write $^\circ$K. The changes sometimes take a long time to work through. I can remember in my school days (pre-1976) being taught not to use degrees Kelvin. France perhaps changes slower though the current editions of Anabac do use 'kelvins', not 'degrees kelvin'.

**Example 3, the degree Celsius.**
This is an interesting unit when it comes to language change. Défourneaux as late as 1983 (p43) could write, in the French column, "20 $^\circ$C = 20 degrés centigrade and in the English column "20 [degrees] centigrade/Celsius *abbrev.*: 20 C". ie no degree symbol at all. There are several points here.

a) In the last few decades there has been a change in the name of the unit, from centigrade to Celsius. At the time Défourneaux wrote he clearly thought centigrade was in use in France, and both centigrade and Celsius were in use in English. In fact the ASE (1981) required the use of Celsius without thinking this was worth commenting on. Maillot (also in 1981) does not even mention centigrade. It is unwise to draw conclusions on what was acceptable from Défourneaux alone. What this does illustrate is that standards have been changing in recent years.
b) Défourneaux evidently thought the degrees symbol was optional in English for Celsius (it is not: cp ASE 1981 p22) and Fahrenheit when he used words in full, and omitted it altogether when he recorded the symbols. I find it puzzling that he should do this and still get degrees kelvin wrong. It is possible that he was influenced by America since he often refers in his books to British and American differences. Défourneaux is clearly in error here. [3.] Maillot (1981 p218) says,

Quant aux Américains, ils adoptent souvent une solution simpliste en supprimant le signe °, ce qui revient à exprimer les températures en coulombs ou en farads, selon qu'il s'agit de degrés Celsius ou Fahrenheit''.

There is potential for ambiguity here, the problem being of science incorrectly written down. Any language can be subject to carelessness, and students of science need to be able to cope with it, while making sure that they themselves maintain the international standards.

c) As Maillot (1981 p218) points out there is confusion in French over how to write the unit, eg is it 5° C or 5 °C ? The latter is apparently preferred by UIPPA (Union Internationale de Physique Pure et Appliquée) and is viewed as the reasonable solution since the two symbols go together and it is normal to separate the numerical value and the symbol of the quantity. The British though resolve the problem by eliminating the space and writing in one go, 5°C as did Tunisian books (eg 4FB21). This question is not even mentioned in ASE (1981) or in other publications that might be expected to deal with it, such as ASE (1985) or IOB (1989).

3. Défourneaux (1980 p111) is not always right. He gives for instance for the French tonne "metric tonne (UK, ancien) / ton (UK et US)". Actually, as Longman (1985) correctly explains, under the entry UNIT, a 'tonne' refers to the metric tonne, of 1000 kg. 'Ton refers to the old English ton, of 2240 pounds. They are approximately the same.

4. 20C means literally 20 coulombs, a coulomb being the unit of electric charge, and 20F means literally 20 farads, a farad being the unit of capacitance.
Example 4. the speed of rotation
As ASE (1981 p25) explains, in common use, but 'non-SI' is the unit rev/min (recommended up to 16+ in age with r/min also possible) and rev min⁻¹ (for beyond 16+). Here Maillot (1981 p219) reports that there are major language differences. He cites German and Russian as having problems, and says that the French is 'tr/min. (ie tour par minute). Défourneaux (1980) only gives the English abbreviation, RPM (revolutions per minute) for the French 'tours/minute' and RPS (revolutions per second) for 'tours/seconde'. (p113). Défourneaux (1980) then does not agree with ASE (1985) but Défourneaux is not particularly writing for people at school level. The official SI unit for speed of rotation is radian per second, 'rad s⁻¹', but, like the unit of pressure, the pascal, it is an inconvenient unit. It is used though by the sixth year French Physics textbook.

The official SI unit for rotation, 'rad s⁻¹ ' is international, but in English 'rev/min' and in French 'tr/min' are commonly used.

Example 5. the minute
The symbol for minute, 'mn', is, according to Maillot (1981 p218) used with 'min', in France, even though only 'min' is technically correct. Tunisia seems to have followed the same indifference. ASE (1981 p19) reports that 'min' is not part of SI, but is in general use.

Example 6. the units of pressure.
This is one area where the units are difficult, and where recent changes are still being implemented.

The problem is a historical one. Medicine has used millimetres of mercury, where 760 mm Hg = 1 atmosphere. Chemistry has used either mm Hg or, simply, atmospheres. Physics though defines the quantity of pressure in terms from the seven basic units of the SI system. Pressure then has the units 'newtons per square metre', Nm⁻². The
The unit of pressure is the pascal, Pa. So 1 atm = 760 mm Hg = 101.325 kPa. Meteorologists use the bar, which ASE (1981 p22) says is "not a recognised unit, but still in use". [5.]

Tyre pressures add to the confusion, with various units such as the old pounds per square inch (easily converted to atmospheres assuming 14.5 lb/in² = 1 atm), and the almost SI unit of kg cm⁻². All these are in current use. The Institute of Biology (IOB 1989 p4) recommends that the pascal and the kilopascal be used, while admitting that millimetres of mercury is still in use in medical practice. This has caused problems for textbook writers. Whelan & Hodgson (1989) state that while they used the SI system,

Non-SI units have been given in addition where it is anticipated that the SI system may not be adopted in the near future.

So Whelan & Hodgson (1989) give blood pressure in both units (eg p163) and some measures, like the partial pressures of gases, are given only in millimetres of mercury. (eg p153).

The situation gets worse in chemistry, where the quantity 'Standard Pressure' exists. (See Section c. below, also the topic of blood pressure in Section c. Example 3).

Example 7, the Angstrom Å
This is a unit of length equal to 10⁻¹⁰m and, as Longman (1985) says, is "not now recommended for technical use". But this unit was used in Tunisia. The unit is obsolete, so obsolete that ASE (1985) does not even comment on it. The whole SI system beyond 1000 or 0.001 is based upon multiples of three. The nearest unit to the Angstrom is therefore the nanometre, nm. While the Angstrom for a time was a unit used in both French and English it is no longer used. So the example here is one of an old unit in both languages still being used in Tunisia.

5. According to ASE (1981 p22) 1 bar = 100 Pa. The conversion rate given is incorrect, one bar actually equals 100 000 Pa as is noted correctly in ASE (1985 p12). What was probably meant was that one millibar equals 100 Pa, since the pressure readings given as part of weather forecasts, in UK, Tunisia and France, are usually in millibars.
Example 8, the calorie and the joule
The modern unit of energy is the joule. The old unit was, in certain circumstances, the calorie. The unit is a particularly difficult one to change as it has come into common use for giving the energy content of foods, and in terms such as the 'thousand Calorie diet'.

Interesting to note then that the French school biology text (5FB44) uses kilocalories, and the translation used kilojoules for the energy derived from sugar by different types of respiration, aerobic and anaerobic. Similarly 6FB47ff used kcal. The translated text defined both (6EB164-5) but elsewhere continued to use "Kcal" instead of kJ, and incidentally writing a capital K instead of the small k just like the French textbook did. It is quite clear from ASE (1985 p6) that the metric prefixes for all values below mega should be written in the lower case.

So old units are still in use especially in French.

c. Quantities

Example 1, standard pressure
Many calculations in chemistry are based upon the 'standard pressure for gases'. This used to be one atmosphere, or, since the time when the pascal was the recommended unit of pressure (ASE 1985 p12) the equivalent in pascals: 101 325 Pa. IUPAC now recommends that the standard pressure for reporting thermodynamic data be fixed at 100 000 Pa, but that 'normal boiling points' (ASE 1985 p12) should continue to be reported at 101 325 Pa as before.

The 'standard pressure for gases' is particularly used when combined with temperature: 'standard temperature and pressure (stp)'. The 'stp' is used in calculations in 'A' level chemistry upwards. This used to be in English schools 298.15K and 1 atm (ie 25°C, and 760 mm Hg = 101 325 Pa) (ASE 1985 p14). At stp one mole of a gas occupies approximately 24 dm³ (ie 24 litres), which is convenient for calculations. The new unit of standard pressure gives a more difficult approximation of 23.7 dm³ as well as meaning that in
English two standards for pressure in thermodynamic data exist at the same time.

In French the standard temperature and pressure are defined as at 0°C (273.15K) and 1 atm. ("les conditions normales" 4FB107, 5FC77, 6FC81). This would mean one mole of a gas would occupy 22.4 dm³ and if 100 000 Pa were used, a mole of a gas would occupy 22.1 dm³.

A different standard temperature and pressure is therefore used in Tunisian schools compared to the new 'stp' recommended by IUPAC. Two 'standards' exist within IUPAC.

Example 2, subscripts and superscripts
On this subject Maillot (1981 p216-7) has little to say. He does though raise an interesting point, without exploring it, that the way of labelling diagrams can differ in the use of superscripts and subscripts.

a) Thus German can write $i_k$ for a short circuit current, (meaning Kurzschluss) whereas French would use $i_{cc}$ for court-circuit.

b) The "ionic product for water $K_w$" whose units are mol²dm⁻⁶ (ASE 1985 p10) is the "produit ionique de l'eau" symbol "$K_e$" in French. (5FC94,95,96).

Therefore here is an area where CSL is not necessarily valid. At school level it is not possible to explore this subject further, other than to comment how this is yet another small area where differences exist between English and French.

Example 3, blood pressure
In the French system, in daily life and in the textbooks (eg 7FB206) blood pressure is routinely measured in centimetres of mercury, not millimetres. While the school textbook did give units when referring to blood pressure, to state the units when a pressure is given orally, in either language, is unusual, therefore this can be confusing when changing languages. At least the custom of expressing the systolic pressure before (ie above) the diastolic is the same in
French and in English. An additional complication is that orally, in French situations, only the systolic pressure is usually given, whereas in English both the systolic and the diastolic pressures are given.

The units, and what is often measured, are different in English and French.

**Examples 4, miscellaneous**

Section 2.4 of ASE (1985 p 11-20) has more details about chemical symbols and quantities that have changed since the previous report in 1979. These include

a) molar entropy $S_m$

b) standard molar Gibbs energy change $\Delta G_m$

c) molar mass $M$

d) molar enthalpy change $\Delta H_m$ standard

For these and other changes too detailed and complicated to be discussed here the reader is referred to the ASE (1985) report.

d. Punctuation and orthography

One of the areas which can cause difficulty, even for those working within one language, is the question of punctuation. It is a fiddly detail, and can give particular problems to examiners who may have to decide what is right and wrong. Also lack of clear agreed punctuation can lead to ambiguity.

**Example 1, The decimal point and the thousands grouping**

a) **Different practices**

Traditionally the decimal point has been in England a dot at the mid-point eg '3.7' read as 'three point seven'. Increasingly, the dot on the line has been used: '3.7'. Thus ASE (1981) could write,

It is now the official CGPM recommendation for scientific work that the decimal point should be written on the line... and we endorse this practice for school use (p16).

The accepted practice in France is to use the comma to indicate a decimal, thus '3,7' read as 'trois virgule sept'. The old English
habit, which is still in wide use, is to use a comma as a spacing into three of large numbers. The newest advice is to use a half space, (which does not exist on many computer & printer setups but does exist on some old typewriters).

A reason given for abandoning the use of commas is that,

By abandoning the traditional commas it is hoped to reduce the risk of confusion with the Continental use of the comma as a decimal sign. (ASE 1981 p16).

This advice becomes even firmer with ASE (1985):

Commas should not be used to separate groups of three digits. (p24).

The fact remains that the use of the comma for dividing up threes used to be current practice. The British teachers and Tunisians I worked with, while knowing that the decimal point could be written 'on the line' in English, were not aware that the comma as a spacing symbol was now outmoded.

The use of a dot on the line can also lead to ambiguities, because this symbol also means, in French and in English, 'multiplied by'.

The French continue to use the comma for a decimal point and now that its use as a number divider has been removed, I would not be surprised if the English go over to the use of a comma as the decimal symbol in the foreseeable future.

b) The pupils at the English school

When the pupils at the English school were asked about coping with the different practices, out of sixty-six who replied, forty-four said they knew about this difference and were never confused by it, as against three who said they knew about it and were always confused.
c) Styles of reading numbers aloud

It is well known that there are different styles of reading group numbers. For instance, with telephone numbers, not only are they traditionally grouped in three's in English [6.] and in two's in French, they are also read in a characteristic way, in groups of three but using the single digit names. [7.] [8.] The French will usually pronounce a telephone number in groups of two treating each group as a complete number.

Not so well known perhaps is that the same practice happens after the decimal point. This practice I observed many times, and I also saw it carried over into English at the English school. For instance in lesson T46:7 a pupil said "sixty-two point thirty-three grams" for '62.33'. This happened frequently.

Example 2, orthography of numbers

For scientific language to be international, the way of writing the symbols and numbers must be the same. In fact, the French and the English, while having the same printed styles, do not have the same styles in handwriting. Défourneaux (1980 p3) from the French perspective, describing English says (English translation mine):

- le 1 en un seul trait" 1 as a single line
- le 2 parfois très déformé 2 often very deformed
- le 4 fermé 4 closed
- le 7 sans barre transversale: 7 without cross bar (beware of the confusion with the <<1>>)
- le 9 droit 9 with a straight back

In turn, I often found my seven was read as a four, until I started barring my sevens. The seven in English is rarely crossed, and can

6. Commonly in Tunisia where the basic currency, the Dinar, is divided up into one thousand millimes, telephone numbers can be written in threes and said, even in French, in threes.

7. This leads to classic mistakes of comprehension, for instance 90 is read in French as 80 10 (quatre-vingt dix) and can easily be mistaken for two couplets, not one, only a slight pause differentiating the couplet 80, 10 from the number 90.

8. There is at least one exception to the groups of three rule in English: the date 1992 is almost always read as 'nineteen ninety-two', though in general use (not dates) 1100 can be read as either 'eleven hundred' or 'one thousand one hundred'.

---

1 1 as a single line  
2 2 often very deformed  
4 4 closed  
7 without cross bar (beware of the confusion with the <<1>>)  
9 9 with a straight back
look like the French one, or, if the top half is written like the top of a curved Y, it can be taken for a four. A crossed seven in English is understood, though perhaps regarded as odd. I am often confused by their ones, which become like \[ \text{\textbackslash} \] ie close to a seven, their open four I also confuse with a seven, and the nine can be confused with an eight if the tail bends too much or a one if the circle is not kept big enough. The four is never written in French in a closed format as in the printed 4, but is much more open and can be taken by English readers for a seven. My written closed fours (in English both closed and open forms are possible) cause hesitation for Tunisian readers, but rarely error. Nine is commonly written in English with a straight stem, whereas in French it is curved. Because of this, any tendency to flatten the circle means it can be taken for a one. But as the tail of a curved stem nine can so often curl too much, a French nine can be confused with an eight.

These possible confusions are summarised below.

**FIGURE 19.1 HANDWRITTEN NUMBERS**

<table>
<thead>
<tr>
<th>English number</th>
<th>French eyes</th>
<th>French number</th>
<th>English eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>letter 'l'</td>
<td>1</td>
<td>seven</td>
</tr>
<tr>
<td>7</td>
<td>one or four</td>
<td>4</td>
<td>seven</td>
</tr>
<tr>
<td>9</td>
<td>one</td>
<td>9</td>
<td>eight</td>
</tr>
</tbody>
</table>

These variants are not just 'bad habits'. Some of them are clear stylistic differences which need to be recognised. In handwriting, numbers which are the very basis of scientific communication in symbols, are not international in form.

It was interesting that on the questionnaire, a few students, when asked for differences between English and French, gave the example of the way of writing numbers.
Example 3, orthography of letters.
Here is not the place to compare styles of cursive writing between English and French. What is of concern at this point is the ways of writing isolated letters which are symbols in formulae and equations, where precision is vital. In a piece of prose, the context will often provide clues as to the identity of a mis-shaped letter. In equations, every letter is significant and vital, there is no redundancy of information.

In the course of my research I looked for letters that confused me, in real contexts, such as teacher or a pupil writing on the blackboard, or among the written responses to the questionnaires. There was one letter which was persistently written in such a way that I found it hard to identify. This was the letter $x$. Sometimes $x$ was used as a symbol of multiplication as in English, in which case it was always written with two strokes of the pen. In the classes I observed the written isolated symbol $x$ was always written in one stroke, rather like a curvy $y$ followed by a $c$.

Example 4, organic chemistry.
In the results (Chapter 17, 'Chemical Terminology') it has already been shown that the punctuation used in the names of organic compounds is not the same in English and French.

Example 5, position of the unit symbol in the figures
I saw in one lesson (First year, T46:6 TEC) that 3.6 kg was written, "3 kg 600 ". This was not an isolated example. Ketteridge (1983 vol 1 page LXXXH) writes:

La denomination des poids et mesures, qui est généralement placée en français entre le nombre entier et la fraction; ainsi $1^{\text{m},25}$, $0^{\text{m},25}$ suit les chiffres en anglais; ainsi $1^{\text{m},25}$, $0^{\text{m},25}$ ou $0^{\text{m},25}$.

The unit, in French is generally placed between the whole number and the fraction thus $1^{\text{m},25}$, $0^{\text{m},25}$. In English on the other hand the pattern is $1^{\text{m},25}$, $0^{\text{m},25}$ or $0^{\text{m},25}$.

Even if this is a dying French custom, it is still a significant difference between English and French.
RESULTS: NON-VERBALS Symbols 19.17

e. Biology

Example 1, osmosis
10B (1989) makes some significant remarks on this subject. Apparently the terminology of osmosis and therefore its symbols are still being worked out and standardised at school level, therefore only limited advice could be given.

Despite several attempts to produce a coherent and rational system of units terms and notation applicable to water relations studies in plants and animals, the Working Party concluded that the time was not yet right to make common recommendations. (p23-4).

Therefore the terminology and symbols are not even standardised in Britain, let alone internationally.

When formulae were used in the French text, the teacher working on the translation chose to avoid the problem when it came to symbols by not giving the equations and symbols at all, concentrating on a simple verbal description of osmosis.

Example 2, genetics.
When drawing genetic pedigrees the system exists, which is the same in English and in French, of using a circle to represent the female, and a square to represent the male, with filled in shapes to represent an affected individual. Also the labelling of blood groups is the same.

In French and English allele pairs are represented by a capital letter for the dominant and a lower case letter for the recessive. But in French the allele pair is represented as a fraction, except where statements of proportions of a cross are used, in which case square brackets round the horizontally written pair were used (7FB286). The same pattern was followed for sex linkage. Subscripts are used instead of superscripts. These differences are summarised in figure 19.2 below.
f. Physics

One particular area of symbols belonging to physics is the electrical symbols. This is not the place for a detailed comparison, only the differences from the school material I studied will be noted. ASE (1981 p13) and the 1990 Physics 'A' level syllabus (AEB 1988 p277) refer to the British standards Institution publication BS 3939 as the standard for schools.

Example 1. The resistor symbols

The three possible symbols are as in figure 19.3 below, with a descriptive name added, to facilitate discussion.
The new standard is the rectangle (ASE 1981 p13).


The French sources Anabac (1988b) and Corrigés (1988) both use the rectangle. The Quid (1985) uses the zig-zag and the snake. (for both on one page, in two separate diagrams see Quid 1985 p198a).

The Tunisian French textbooks seem to reflect the ambiguity in French, using all three symbols, (eg 'snake' 4FP224, 'rectangle' 4FP227, and 'zig-zag' 6FP344). The situation was similar with the English translations with perhaps a preference for the rectangle. (eg 'zig-zag' 6EPii126, and on the next page 'rectangle' 6EPii127, and 'snake' 4EP162, 163, 139).

Example 2, capacitors

The standards in Britain (ASE 1981 p13, 5EP90, cp Symboles 1986) and both Tunisia and France (Anabac 1988a p110, 6EPii138) are shown in figure 19.4 below. The standards are clearly very different.

FIGURE 19.4 BRITISH AND FRENCH CAPACITOR SYMBOLS

<table>
<thead>
<tr>
<th>TYPE</th>
<th>BRITISH</th>
<th>FRENCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>capacitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>polarised capacitor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example 1, symbols of the elements

A comparison of the symbols used for the elements will show that they are identical in French and English. This is in contrast to their names, which are not all alike, as is shown in Chapter 17 'Chemical terminology' Section 3a. 'Names of the elements'.

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RESULTS: NON-VERBALS Symbols 19.19
Example 2, state symbols

These are symbols used in chemical equations to represent the state of the substance in the reaction. They are not considered to be abbreviations as such, since they are used in equations. These symbols are the subscripts as in figure 19.5 below.

FIGURE 19.5 STATE SYMBOLS

<table>
<thead>
<tr>
<th>English (ASE 1985 p85)</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>(s) solid state</td>
<td>&lt;solide&gt;, s, sd</td>
</tr>
<tr>
<td>(l) liquid state</td>
<td>&lt;s&gt;, (solution), aq</td>
</tr>
<tr>
<td>(g) gaseous state</td>
<td></td>
</tr>
<tr>
<td>(aq) dissolved in water.</td>
<td></td>
</tr>
</tbody>
</table>

If CSL was valid then these state symbols would be the same in French. Corrigés (1988 p3) has,

Tous les ions sont hydratés en solution aqueuse, mais la notation ne fera généralement pas apparaître ce phénomène.

Effectively then the question of the state symbol for aqueous is avoided partly by assuming solutions are of water. When necessary eg p20, the subscript '<solide>' is used, and, confusingly, '<>' is used to denote solution (p21 etc). Dursupthy (1989), a textbook from France on chemistry for the C stream of the baccalaureate gives no special symbols for states other than <solide> or aq. Rather, symbols such as those in figure 19.5 are used.

The French book has (6FC57): \( \text{NH}_3 + \text{HCl} \rightarrow (\text{NH}_4^+, \text{Cl}^-)_{\text{s}} \)

When I asked TFC if it was a printing error, that the state symbols lacked the brackets, I was told the book was correct. (T237). Similarly 5FC51 has the symbol 'aq' after an ion, without brackets and strangely p48,128 had '(sd)', a symbol signifying 'solid', this time in brackets, after various chemicals. But again, unusually by British standards, the state symbol is used only on one side of the equation. Where state symbols were used at all, and they were used rarely, formulae like the following would be

9. I can also remember using (pr) for precipitate, but this is clearly not one of the recognised symbols.
common: \( \text{Pb}^{2+} + 2\text{Cl}^- \rightarrow \text{PbCl}_2(\text{aq}) \) (5FC121).

Frequently, instead of state symbols, other symbols were used as in Figure 19.6 below.

**FIGURE 19.6 OTHER KINDS OF STATE SYMBOLS IN FRENCH**

<table>
<thead>
<tr>
<th>Example</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) ( \text{PbCl}_2 )</td>
<td>In context, means precipitate. (5FC82)</td>
</tr>
<tr>
<td>b) ( \text{Cl}_2 )</td>
<td>Gas given off, this symbol was frequently used along with variants like example c) below.</td>
</tr>
<tr>
<td>c) ( \text{Cl}_2 )</td>
<td>Variant of b)</td>
</tr>
<tr>
<td>d) ( \text{NH}_3 \uparrow + \text{HCl} \rightarrow \text{NH}_4\text{Cl}\uparrow )</td>
<td>Meaning gaseous (6FB14 = 6EB128)</td>
</tr>
<tr>
<td>e) ( \text{QR} = \frac{\text{Volume de CO}_2}{\text{Volume de O}_2} = 1 )</td>
<td>The upward arrow means expelled or rejected. The downward arrow means absorbed.</td>
</tr>
</tbody>
</table>

**Example 3, ways of writing the charge on ions**

In old textbooks in English one sometimes sees something frequently met here in Tunisia, but which is no longer accepted practice in British school books, namely, the use of two or more pluses or minuses for the charges on ions instead of using the number, then the sign. For instance, 5FC30 "0--" instead of "0^-", and, 5FC119 has "SO_4^2-" instead of SO_4^2-. Even TEK who was usually so precise and careful in these matters once used SO_4^2-. (T247). In lesson T255:1, when the teacher mentioned Hg^{++} was said as, 'H, G, plus, plus' instead of the more usual 'H, G, two plus'.

---

10. This is included here because the symbols indicating state are used, though with a slightly different sense (6FB261 = 6EB11:37). 'QR' is the respiratory quotient, i.e RQ in English.
Example 4, dot and cross diagrams
These are a well known teaching aid for the structure of molecules. Usually two different kinds of elements are involved. In one element the electrons in the outer energy level (also called shells in the outmoded valency theory) are represented by a dot, in the other element the electrons are represented by a cross. Thus HCl can be diagramatised as in figure 19.7a.

![Figure 19.7A. Dot and Cross Diagram, Britain](image)

The problem is that the Tunisian texts used dots only, (5FC29,30,36 etc) and on page 30, added in the charge symbols, giving:

![Figure 19.7B. Dot and Cross Diagram, Tunisia](image)

Adding symbols of charge is not accepted practice in English. Neither is it in French if Défourneaux (1983) is to be believed, for he gives (p20) dots and crosses, but with a small box round the free electrons. In both languages it is possible to combine two dots as a line, though this is not recommended British practice for schools.

Example 5, oxidation number
There is no agreed notation to express 'the oxidation number of B'. This is confirmed by the ASE who suggest "Ox(B)". (ASE (1985 p95).

In the Tunisian French text just words were used here, while retaining the ASE (1985) advice to use small capital roman numerals (where needed) to express the size of the oxidation number.
Mathematics

Example 1. The division sign.

In English this is ' \div \'. Quid (1985) has the French as ' : ' and Longman (1985) has ' \div ' and ' : ' and ' / ' but Cores (1983) does not include the symbol ' : '. The symbol ' : ' was used in the first year Tunisian French Mathematics text. Défourneaux (1980 p31) notes the symbol ' : ' and gives the English translation without seeming to notice anything strange. Note that calculators sold in Tunisia have the ' \div ' sign. The other two symbols for division are constant: \[ \frac{a}{b} \]

In England the ' : ' sign means "is to, the ratio of". The French simply use the solidus ' / ', but this can lead to ambiguity. There is a huge difference between \( \frac{1}{4} \) and 1:4. To use the traditional cake analogy when discussing fractions, \( \frac{1}{4} \) implies that a cake has been divided into four equal parts and one of them has been taken to eat. But to divide a cake up in the ration of 1:4 implies fifths are involved, and the cake is divided into two parts, of one fifth, and four fifths respectively. 'One to four' means '1:4', but 'one in 4' means \( \frac{1}{4} \). It is easy to confuse fractions with ratio.

The differences between English and French are summarised in figure 19.8 below.

**FIGURE 19.8 THE DIVISION SIGN**

<table>
<thead>
<tr>
<th>French symbol</th>
<th>French meaning</th>
<th>English symbol</th>
<th>English meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>/</td>
<td>fraction ( \frac{1}{4} ) or ratio 1:4</td>
<td>/</td>
<td>fraction: one divided by four</td>
</tr>
<tr>
<td>:</td>
<td>fraction ( \frac{1}{4} )</td>
<td>:</td>
<td>ratio: one to four</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+</td>
<td>fraction: one divided by four</td>
</tr>
</tbody>
</table>
Example 2, the algebraic value $\parallel \parallel$ and the absolute value $\parallel$.

There is a symbol used in French and Tunisian textbooks, to make a distinction not usually made in English. This is the $\parallel \parallel$ symbol. It means, 'numeric value of'. It is used for vector quantities which have both size and direction, to stress the fact that the size is being talked about not the direction. The example of force will make this clear.

**FIGURE 19.9a FRENCH SYMBOLS FOR NUMERIC AND ALGEBRAIC VALUE**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning in French</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F$</td>
<td>valeur algébrique</td>
</tr>
<tr>
<td>$\parallel F \parallel$</td>
<td>valeur numérique. (T232:1c, TFD).</td>
</tr>
</tbody>
</table>

In a teachers meeting at the English school it was explained to me that for the symbols below it is the size which is being considered, not the direction.

$\parallel F \parallel = a$ number, and is simply a way of stressing the fact that the force now has a value. It is read as 'the value of $F$ equals'. (T208:5).

The symbol $F$ alone, without vector or magnitude symbols attached means 'algebraic measure' of $F$. This is to make a distinction not usually made in British schools, but which comes easily to the students in Tunisia due to the kind of mathematics they have learnt. The distinction has to do with the unit vectors, and is studied in Chapter 21 'Equations'. In England, unit vectors are not used in physics, therefore the concept would take a lot of explaining if ever English pupils were to read the English texts of Tunisia. It would be understood more easily by students doing for instance the AEB's pure or applied mathematics 'A' level.

When TFD was asked why he thought they made the distinction between algebraic and numeric values, he said,

La même notation ne doit pas indiquer deux choses différentes. The same notation must not indicate two different things.
Note, this is not the same as the distinction made in ASE (1981 p7ff) between 'quantity algebra' and 'number algebra'. In quantity algebra the letters stand for both the quantity and the unit. Units also need stating for everything in a formula, and are stated throughout the manipulations, whereas in number algebra the units are stated at the end. ASE (1981 p7) and for example Whelan & Hodson (1989 p10b) both state that quantity algebra is to be preferred in schools, though it leads to more writing of symbols that might be considered cluttered. [11.] In both French and English the units of any numerical answer are usually stated.

The $| |$ symbol is known in English, Longman (1985 symbol) has it listed as "the absolute value of" or "the modulus of", ie if the sign of the number is negative or positive, the number is still read as positive. In Tunisia it means 'valuer absolue'. (Quid 1985 p173). Cores (1983 p92, in a list headed 'operations') defines it as "the modulus of", without explanation. The symbol $| |$ would appear then to have a similar meaning in English and French.

But Cores (1983 p94) also has this symbol round a letter in bold type indicating a vector. This would be the equivalent then of the French $||$ indicating that the size of a vector is being considered.

English therefore has one symbol: $| |$ to indicate either the operation 'the modulus of' or the magnitude of a vector quantity, where French has two: $| |$ and $||$ respectively. The former means in both languages the positive value of, but in English can also indicate, when placed round a vector quantity, that the size is being referred to, whereas Tunisia insisted on $||$ for this. Figure 19.9b below summarises the situation.

11. The distinction in practice may not be that clear. It is also common practice to specify units of initial quantities, and then to omit units in the calculation until the final statement (as in number algebra) and then to specify the units as in quantity algebra.
RESULTS: NON-VERBALS Symbols 19.26

FIGURE 19.9b FRENCH AND ENGLISH MEANINGS OF \|\| AND |||

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning in French</th>
<th>Meaning in English</th>
</tr>
</thead>
<tbody>
<tr>
<td>| |</td>
<td>Positive value of</td>
<td>Positive value of,</td>
</tr>
<tr>
<td>| |</td>
<td>Magnitude of a vector quantity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is worth noting that while the second use in English for \|\| (the magnitude of a vector quantity) exists, it is rarely used, whereas in French \|\| is used routinely in school physics along with vector and unit vector notation.

Example 3, identical to, \equiv
This symbol in English means "is identically equal to" (ASE 1985 p24) or "is identical to" (Longman 1985). But Quid (1985 p173) has the French meaning "congru a" ie "congruent to". Longman (1985) has though a different symbol for congruent to, and gives ' \approx '. Cores (1983) has the symbol ' \equiv ' meaning both, and reserves another explanation for ' \approx ', "is isomorphic to". (p91), meaning "a one to one correspondence between two set, which preserves algebraic structure". (Race 1990). The symbol ' \equiv ' can also mean in English, 'represents', as for instance in a list of definitions of symbols used in a formula, and is used this way elsewhere in the thesis.

Example 4, equivalent, similar, in the order of. \sim
Longman (1985 symbol) explains this as "equivalent, similar" which agrees with Cores (1983 p91) which also give the extra meaning, for \sim p as "not p". Quid (p172a) gives the French for \langle\langle non P\rangle\rangle as

\neg p or \bar{p}.

Both symbols could well exist in English, but are not in any list I can find. That these extra symbols exist is not of interest here. What is at issue, is that the symbol \sim does not have any meaning in the French system.
How much less meaning would exist then, for a third sense of ~, in the order of, the same magnitude as. This use was given to me, maybe unofficially, when studying physics to 'A' level, 1974-6, and Race (1990) informed me that it was so used at undergraduate level. [12.]

The reason I could not find any symbol for this despite asking in the two schools is probably quite simple, and is the reason I was given many times. Approximation is not taught in Tunisia, therefore there is not any use for the distinction between 'approximately' and 'in the order of'. When I put the term 'order of magnitude' in the questionnaire, I was warned that the pupils would not recognise it from their work in class. This turned out to be quite true.

Example 5. therefore and because
Extremely commonly used in English are two symbols, ' ' and ' ' meaning 'therefore' and 'because' respectively. Longman (1985) gives only the former, Cores (1983) gives neither, though both are in use in Britain. These symbols are not used in French. The symbol ‘’ would probably be used for 'therefore'. The symbol ‘’ exists in English with the sense of 'implies'. (Cores 1983 p91) as in French 'implique'. (Quid 1985 p173).

Example 6. the angle
In English this can be written x&y or <xay. The second style, or more simply <a is more common. The first year French mathematics book in Tunisia used, (p229) xay. Défourneaux (1980 p65) has the French as Â and the English as <a. Longman (1985) gives the symbol ‘’ and Cores (1983) has no reference. To my knowledge the ' ' format is rarely used in French whereas it is very common in English.

12. Another sign we used was c. for 'circa'. Ewer & Latore (1969) give the meaning of c. as "approximately".
Example 7. The set of rational numbers \( \mathbb{Q} \) and positive integers \( \mathbb{N} \)

Both French and English use the symbol \( \mathbb{Q} \) to represent the set of rational numbers, and \( \mathbb{N} \) to represent the set of positive numbers. But the variants are not the same. There is the question of whether or not zero is included, and with \( \mathbb{Q} \) how to make the set to mean positive numbers only. Figure 19.10 is compiled from Cores (1983 p90), and Quid (1985 p173) and gives the differences in detail.

**FIGURE 19.10 RATIONAL NUMBERS AND POSITIVE INTEGERS**

<table>
<thead>
<tr>
<th>symbol</th>
<th>French meaning</th>
<th>English meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \mathbb{N} )</td>
<td>with zero</td>
<td>with zero</td>
</tr>
<tr>
<td>( \mathbb{N}^* )</td>
<td>without zero</td>
<td>without zero</td>
</tr>
<tr>
<td>( \mathbb{Q} )</td>
<td>with zero</td>
<td>with zero</td>
</tr>
<tr>
<td>( \mathbb{Q}^+ )</td>
<td>with zero positive only</td>
<td>without zero positive only</td>
</tr>
<tr>
<td>( \mathbb{Q}_0^+ )</td>
<td></td>
<td>with zero positive only</td>
</tr>
<tr>
<td>( \mathbb{Q}^{**} )</td>
<td>without zero positive only</td>
<td></td>
</tr>
</tbody>
</table>

Particularly ambiguous is the notation \( \mathbb{Q}^*_1 \), which means two different things in French and English.

It is not simply a question of whether the notation exists in two languages, but a question of who uses it. Given the lesser part that mathematics plays in education in UK, the notation here is not fully international as it is not used in UK to the same extent. It would not have been understood by counterparts in Britain.

In contrast, as an example of the use of \( \mathbb{N}^* \) in a lesson, (sixth year physical science), in which they were discussing the alcohols, a pupil wrote on the blackboard, " \( C_n \text{H}_{2n+1} \) avec \( n \in \mathbb{N}^* \). (T276). This was well understood by the class and was not questioned. In fact, the notation is introduced from the first year in Tunis, unlike Britain where it would be reserved for the last two years, and for those doing 'A' level mathematics. (See 1FM16, 104 104 etc).
4. DISCUSSION

Upon investigation it has been shown that symbols are not necessarily constant between French and English and that even where they are, it does not imply that if pupils in one language know and use them that their counterparts in another language will be similarly knowledgeable.

With the SI system, the problem is not that as a system it is failing, but that in certain areas such as pressure, and units of rotation, there is a failure to implement it completely. When there is this failure, each language may have a different notation.

The differences between French and English do not only come from different verbal expressions of a concept, but also from different accepted practices. There is also the problem of standards not being strictly maintained. Like it or not, scientists need to be able to cope with lax standards, and where lax standards differ between French and English CSL is failing. CSL also fails in assuming that symbols and standards are fixed and are not changing. Even here, in the topic of symbols which is at the heart of CSL, it is clear that the standards are still being set, and even when they have been set, their general acceptance in science education is still being negotiated.

To use Zylbersztajn's framework, a symbol may be internationally recognised at the level of 'science for the scientist'. But if pupils in one language at a similar stage in learning do not use this symbol, then the symbol is not international at the level of 'science for the student', because it will not be understood by the counterparts in another language.
5. SUB-CONCLUSIONS

a. Vector quantities
There are different ways of representing vector quantities in English and French. In addition, in French at school level, a vector quantity is always indicated as such, whereas in English no indication is routinely given. Therefore symbols and distinction are not fully constant.

b. Units
The SI system is intended to be an international system, but its implementation at school level may not be. Non-standard units such as the calorie in both their name and their measurement symbols appear to be the same. Some differences exist which indicates that constancy has yet to be achieved. Some recent changes for example in what is standard, for pressure and temperature, will take time to work through even in English.

c. Quantities
Symbols for quantities are not necessarily constant. Changes in chemical quantities, (relevant to 'A' level chemistry but at too high a level for students in the Baccalaureate system in Tunisia to know about), are currently proposed, therefore are unlikely to be international as yet. Blood pressure in French is routinely expressed in centimetres of mercury with systolic pressure alone given, not millimetres of mercury with both systolic and diastolic pressures given as in English.

d. Punctuation and orthography
Punctuation in science is not necessarily constant. Several differences between French and English have been noted, including the decimal point, the 1000 grouping symbol, the handwriting of numbers and the punctuation of formulae in organic chemistry.
e. Biology
A standard system of notation for osmosis has yet to be worked out, therefore any in current use cannot be confidently regarded as international. Not all the symbols used in genetics are international, but the basic symbols of genetic pedigree are.

f. Physics
Not all the electrical symbols used in school physics are constant.

g. Symbols in Chemistry
The symbols for chemical elements are without any doubt the same in English and French. State symbols, and dot and cross diagrams are not constant between English and French. Old systems for representing charge on ions are still being used in French. A system for oxidation numbers has yet to be agreed therefore there cannot yet be any symbolic representation that is international.

h. Mathematics
Several symbols in French and English have different meanings and uses. The distinction between numeric and algebraic value is not normally made in English, while in French it is routinely made. The same symbol is used for both in English, therefore symbols and distinctions are not (in practice) constant.

To summarise, the SI system of units and the symbols of the elements are completely constant in English and French. Some quantities, and some symbols of physics, chemistry, biology, and mathematics are not constant.
SECTION IV NON-VERBALS
CHAPTER 20
INDICES

1. INTRODUCTION

When I asked the teachers early in my investigation about differences between the two languages I was pointed to the indices for the distribution of organisms. (T26:16). This chapter investigates the small topic of indices and considers some examples of where they are not constant.

2. SUB-HYPOTHESES

The indices will be the same in two languages. This means the same:

a. names
b. definition
c. way of expressing the index.
3. RESULTS

Example 1. L'abondance, La dominance, L'abondance-dominance, La sociabilité, La fréquence

The French biology textbook (5FB89-90) defines these as in figure 20.1a below.

FIGURE 20.1A ECOCOLOGY INDICES, ACCORDING TO THE FRENCH TEXT

A) L'abondance (A):
L'abondance d'une espèce est le nombre relatif des individus qui la représentent dans un relevé.

B) La dominance (D):
La dominance (ou degré de recouvrement) d'une espèce est l'étendue relative recouverte par cette espèce.

C) L'abondance-dominance ou échelle de Braun Blanquet (AD): cette échelle combine l'abondance et la dominance d'une espèce dans son milieu.

D) La sociabilité (S): Elle concerne la manière dont sont disposés les individus de la même espèce les uns par rapport aux autres.

E) La fréquence (F):
C'est une notion statistique. Elle est égale au rapport du nombre de relevés dans lesquels figure l'espèce au nombre total relevés.

These indices gave many problems to the teachers at the English school. Effectively TEA thought that 'l'abondance' was the same as 'la fréquence'. When the English textbook was written the "abundance" was ignored and simply not put in the text. The English textbook defined the "species frequency" as

... the probability of an individual of a particular species being present in a randomly placed quadrat. (5EB55)

TEA maintained that 'la dominance' did not exist in English as such, and that if density was meant she did not see how a density could be expressed as a percentage instead of a decimal.[1]

1. Density in physics is mass/volume, units kg/m³. This is in three dimensions. The density considered here is in two dimensions, therefore has different units. Either way it is defined, density cannot be expressed as a percentage unless a standard density is set up and results expressed as a percentage of the standard. It is possible to express the degree of ground cover of a plant species as a percentage of the area, but this is arguably not density as such.
Longman (1985) defines density as,
the average number of individuals or units per unit of space. <a population density>.

Once again, a decimal not a percentage. Therefore the English textbook has,

SPECIES DENSITY. This is the number of individuals of a particular species per unit area. (5EB55)

L'abondance-dominance ie the Blaun-Blanquet index was explained as "species cover" as in the translation quoted below in figure 20.1b.

FIGURE 20.1b THE BRAUN-BLANQUET SCALE, ENGLISH VERSION

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>rare, it covers less than 5%</td>
</tr>
<tr>
<td>1</td>
<td>abundant but covers less than 5%</td>
</tr>
<tr>
<td>2</td>
<td>very abundant, covers between 5% and 25%</td>
</tr>
<tr>
<td>3</td>
<td>covers between 25% and 50%</td>
</tr>
<tr>
<td>4</td>
<td>covers between 50% and 75%</td>
</tr>
<tr>
<td>5</td>
<td>covers more than 75%</td>
</tr>
</tbody>
</table>

According to the teachers, this scale does not exist in English.

As for 'sociabilité'. The nearest equivalent word in the sense meant above is "gregariousness" and at the time none of us could think of this word. [2.] This could be considered a faux ami but here it is more relevant as an example of another scale or index that is not known to exist in English, and even if it does exist somewhere, is not used at school level.

The teachers at the English school just ignored this word 'sociabilité' and neither the word nor the index was translated for the English text.

2. Thanks to Madame Jamoussi (TFG) for the suggestion.
RESULTS: NON-VERBALS

<table>
<thead>
<tr>
<th>French</th>
<th>Possible English equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>abondance</td>
<td>frequency</td>
</tr>
<tr>
<td>dominance</td>
<td>density (as a decimal not, percentage)</td>
</tr>
<tr>
<td>abondance-dominance</td>
<td>species cover (not used in English)</td>
</tr>
<tr>
<td>sociability</td>
<td>gregariousness (not used in English)</td>
</tr>
</tbody>
</table>

So only 'abondance' has a direct English equivalent, and it is not a scale as such in English.

Example 2, l'indice d'aridite de De Martonne
The French and its English translation are given in full in figures 20.2ab below.

**FIGURE 20.2a ARIDITY INDEX OF DE MARTONNE IN FRENCH**

\[
I_a = \frac{P}{T + 10}
\]

P = pluviosité annuelle exprimé en mm.
T = température moyenne annuelle en degré celcius.

On voit ainsi que plus la région est sèche plus \( I_a \) est faible. Cet indice donne également la répartition phytogéographique:

- \( I_a < 10 \): Végétation désertique
- \( 10 < I_a < 20 \): Steppe
- \( 20 < I_a < 30 \): Prairie naturelle
- \( 30 < I_a < 40 \): Forêt dominante
- \( 40 < I_a \): Forêt exclusive (5FB141-2)

**FIGURE 20.2b ARIDITY INDEX OF MARTONE (SIC) IN ENGLISH**

\[
A_1 = \frac{R}{T+10}
\]

R = annual rainfall expressed in mm
T = annual mean temperature

According to the formula above, the more arid the area the lower the \( A_1 \). This index determines the distribution of plants (phytogeographic distribution):

- \( A_1 < 10 \): desert
- \( 10 < A_1 < 20 \): steppe
- \( 20 < A_1 < 30 \): grass land
- \( 30 < A_1 < 40 \): mainly forest
- \( 40 < A_1 \): exclusively forest. (5EB141)
TEA insisted this index did not exist in English. (T3:10). TEB pointed out that this index takes the average temperature, while example three below uses the maximum and minimum temperatures. 'forêt' 'dominante' and 'forêt exclusive' were with difficulty translated as 'mainly forest' and 'exclusively forest'. The symbol of the index was also changed, from Ia to Ai.

Example 3, l'indice d'aridité mensuel
The French and its English translation are given in full in figures 20.3ab below.

FIGURE 20.3a MONTHLY ARIDITY INDEX, IN FRENCH

\[ I_{am} = \frac{12 \text{ Pm}}{Tm + 10} \]

Pm = pluviosité du mois considéré exprimé en mm.
Tm = température moyenne mensuelle en degré celsius
Un mois est considéré très sec si \( I_{am} < 10 \)
sec si \( 10 < I_{am} < 20 \)
humide si \( 20 < I_{am} < 30 \)
très humide si \( 30 < I_{am} \)

(5FB142)

FIGURE 20.3b MONTHLY ARIDITY INDEX, IN ENGLISH

\[ A_{im} = \frac{12Rm}{Tm + 10} \]

Rm = rainfall of the month in question expressed in mm.
Tm = monthly mean temperature expressed in °C
If \( A_{im} < 10 \) the month in question is very dry
\( 10 < A_{im} < 20 \) the month in question is dry
\( 20 < A_{im} < 30 \) the month in question is wet
\( 30 < A_{im} \) the month in question is very wet. (5EB141)

This scale was not known in English, and the symbol for the scale was changed, in the translation, from Iam to Aim.
Example 4. Rainfall and temperature quotient of Emberger

The French is quoted in full in figure 20.4 below, with the English as used in the translation added besides the labels of the subdivisions. The English and the French were accompanied by a map of Tunisia with these eight sub-divisions marked. The translation into English used the same formula, substituting 'R' (rainfall) for 'P' (pluviosité). The subdivisions in particular were hard to translate, superior and inferior do not fit in English but no alternative occurred to the teachers. The name of the scale, the eponym Emberger, was used even though it is not known in English, and the index itself was not known even to TEA who had done her degree in botany and geology.

FIGURE 20.4 RAINFALL AND TEMPERATURE QUOTIENT OF EMBERGER
(5FB142-3, 5EB142)

B) Quotient pluviothermique d'Emberger Cette formule est plus élaborée puisqu'elle tient compte, à côté de t et de p, de la variation annuelle de la température.

\[
Q = \frac{1000}{1000} \frac{P}{P} \frac{1000}{P} \frac{2000}{2000} \frac{P}{P} = \frac{1000}{1000} \frac{P}{P} \frac{1000}{P} \frac{2000}{2000} \frac{P}{P} = \frac{t(M-m)}{(M+m)(M-m)} \frac{2}{(M+m)(M-m)} M^2 - m^2
\]

Where:

- \(P\) = pluviosité annuelle exprimée en mm.
- \(t\) = température moyenne annuelle en degré Kelvin.
- \(M\) = moyenne des maxima du mois le plus chaud en degré Kelvin.
- \(m\) = moyenne des minima du mois le plus froid en degré Kelvin.

REMARQUE: 1° Kelvin = 1° Celsius +273. Ce quotient permet de classer les différents types de climats méditerranéens caractérisés par des saisons thermiques nettes et une pluviosité concentrée sur la période plus ou moins froide de l'année. Il permet également de distinguer des étages, des sous-étages et des variantes climatiques. Les étages et sous-étages sont fonctions de Q. Les variantes sont fonctions de m.

1) Les Étages:
- Humide: \(70 < Q\)
- Semi-aride: \(35 < Q < 70\)
- Aride: \(10 < Q < 35\)
- Saharien: \(Q < 10\)

2) Les Sous-Étages
- Perhumide: \(110 < Q < 150\) Superhumid
- Subhumide: \(70 < Q < 110\) Subhumid
- Semi-aride supérieur: \(50 < Q < 70\) Superior Semi-arid
- Semi-aride inférieur: \(35 < Q < 50\) Inferior Semi-arid
- Aride supérieur: \(25 < Q < 35\) Superior arid
- Aride inférieur: \(10 < Q < 25\) Inferior arid
- Saharien supérieur: \(5 < Q < 10\) Superior saharian
- Saharien inférieur: \(Q < 5\) Inferior saharian

(English)
4. DISCUSSION

Indices give several problems for CSL. The examples above are ones which are known in French, but not in English, and even if they are known by experts, they were still not known by the small group of teachers who had to translate them. With reasonable confidence it can be stated that if these teachers did not know the index, then it was not known at school level in England, therefore scientific language is not constant, at least at school level. With several of the indices went the problem of how to translate an eponym that was not known in English, and whether to leave the symbols in the index as the initial letters of French but not English words, or, as happened above, to change them for suitable English symbols. The problem of labelling the subdivisions was particularly difficult. If CSL were valid, then the vocabulary of subdivisions would transfer easily between French and English. In example two, the aridity index of Martone, the French *dominante* and *exclusive* were translated by 'mainly' and 'exclusively', which are passable translations, there being no known standard equivalent in English. Emberger's quotient, example four, gave greater problems, *supérieur* and *inférieur* do not translate well as 'superior' and 'inferior' even though these terms are used in the senses of 'above' and 'below' in anatomy.

5. SUB-CONCLUSIONS

Indices are not necessarily constant, neither in their name, their formula, or in the labels given to the various parts of the index.
SECTION IV NON-VERBALS

CHAPTER 21

EQUATIONS

1. INTRODUCTION

This chapter is a development of Chapter 19 'Symbols'. In the introduction to that chapter it was mentioned that equations in French often use the vector sign, the numerical value symbol and unit vectors where English does not.

The importance of this is hard to appreciate, for they indicate not just a change in the use of symbols, but are the outward expression of a whole different way of approaching the mathematics of physics. In my opinion this is far more difficult to cope with than mere re-arranging of formulae. In particular, someone who has never used unit vectors, cannot easily appreciate the subtleties of the physics that relies upon them.

In addition, 'A' level physics does not formally require that a student knows how to integrate and differentiate (though a grasp of $\Delta x$, $\delta x$ and $d/dt$ for rate of change is expected, AEB 1988 p302). It is inconceivable that anyone doing physics as one of the major subjects in a French or
Tunisian baccalaureate would not know the basics of integration and differentiation. This is clearly a major difference in skill level expected of pupils, and it is reflected in the equations students are expected to use in French physics.

In the cases where a choice of mathematical expressions is possible, CSL would imply that the same choice would be made in different languages, for a particular level of teaching.

The examples given below are not exhaustive, they are taken mainly from those I met in the classroom situation, or those used in the questionnaire.

2. SUB-HYPOTHESES

The symbols used and the formats of the equations are the same in English and French.

3. RESULTS

Example 1, Ohm's Law
The usual English statement of this is \( V = IR \), voltage equals current times resistance. Quid (p199b) gives a similar formula \( V = RI \) but the Tunisian French and English texts use the symbols \( u = Ri \). (4EP140, 4FP181). The symbols are not the same in French and English for this law.

Example 2, Newton's Second Law of motion \(^{(1)}\)
The usual English expression of this law is that force equals mass times acceleration, \( F = ma \). Whelan and Hodgson (1989 p34) also give 'force is proportional to the rate of change of momentum', as in equation one of figure 21.1 below. Equation two below was given in a summary in the French Tunisian book. It means the sum of the external forces equals the rate of change of the quantity of movement of the physical system (vector p, 6FP114), and also equals mass times vector acceleration.

1. Compare Chapter 14 'Eponyms' where the name of this law is discussed, and Chapter 13 for the abbreviation of this law in French: R.F.D.
RESULTS: NON-VERBALS Equations 21.3

FIGURE 21.1 EQUATIONS OF NEWTON'S SECOND LAW

<table>
<thead>
<tr>
<th>(1) English:</th>
<th>$F \alpha \frac{dv}{dt}$</th>
<th>Whelan &amp; Hodgson (1989 p34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2) French:</td>
<td>$\sum_{i=1}^{n} F_{\text{ext}} \rightarrow \frac{dp}{dt} = M_{\gamma}$</td>
<td>(6FP119)</td>
</tr>
</tbody>
</table>

It is probable, because the English version of the equation is simpler than the French version, that those used to the French would be more likely to understand the English than vice versa. The English equation is considering one force, the French equation is considering the sum of the external forces. The equations are comparable, the French equations being more complete.

Example 3, motion equations

The equations for uniformly accelerated linear motion, in English and in French are as in figure 21.2ab below.

FIGURE 21.2A MOTION EQUATIONS IN ENGLISH

| (1) $v = u + at$ | $v = \text{final velocity}$ |
| (2) $s = \frac{u+v}{2} t$ | $u = \text{initial velocity}$ |
| (3) $s = ut + \frac{1}{2} at^2$ | $a = \text{acceleration}$ |
| (4) $v^2 = u^2 + 2as$ | $t = \text{time}$ |

(Whelan & Hodgson 1989 p29)

FIGURE 21.2B MOTION EQUATIONS IN FRENCH

| (5) $v = \gamma t + V_0$ | (1) |
| (6) $x = \frac{1}{2} \gamma t^2 + V_0 t + x_0$ | (3) |
| (7) $v_{A^2} - v_{B^2} = 2\gamma (x_A - x_B)$ | (4) (6FP53) |

$v = \text{final velocity}$

$V_0 = \text{initial velocity}$

$\gamma = \text{acceleration}$

$t = \text{time}$

$x = \text{distance travelled}$

$v_A - v_B = \text{change in velocity between A and B}$

$x_A - x_B = \text{distance between A and B}$
It can be seen that the equations in English look much simpler. Some of the symbols have changed. But these summary equations conceal a much more complicated situation, which is discussed in example four below.

Example 4, unit vectors and motion equations
Unit vectors have been mentioned several times. The real complexities of their use is best illustrated from a worked example question. It is not necessary to understand the mathematics involved to appreciate that this level of complexity is not required for physics 'A' level. The worked example taken from the French text (6FP19) was translated by the teachers at the English school (6EP14) and concerns rectilinear motion. The material comes from the beginning of the sixth year text, which goes on to study velocity vectors and acceleration vectors for both rectilinear and circular motion. As such it is by no means one of the more complicated examples, but is sufficient to illustrate the complexities of the French system.

FIGURE 21.3 EXAMPLE OF A QUESTION INVOLVING UNIT VECTORS

A moving body, in a system \((O, \mathbf{i}, \mathbf{j})\), has a space vector \(\mathbf{OM} = x\mathbf{i} + y\mathbf{j}\); with \(x = 3t\) and \(y = 4t\).

1º) Give the trajectory equation in the system \((O, \mathbf{i}, \mathbf{j})\).
Deduce its nature.

By eliminating \(t\) from the two equations we get: \(y = (4/3)x\).
The trajectory is then a straight line passing through the origin.

The cartesian equation of the trajectory is a relationship between \(x\) and \(y\).
FIGURE 21.3 CONTINUED...

2°) Write the expression of the space vector in the system (0,5) (R a unitary vector held by the trajectory) and give the equations of the motion.

In the system (0,5) the space vector can be written as:

\[ \vec{OM} = \|\vec{OM}\| \cdot \vec{R} \]

\[ \|\vec{OM}\| = \sqrt{x^2 + y^2} \]

\[ = \sqrt{9t^2 + 16t^2} \]

\[ = \sqrt{25t^2} = 5t \]

\[ \|\vec{OM}\| = 5t\vec{R} \]

In the system (0,5) the abscissa of M is then \( z = 5t \). It is the motion equation.

4. DISCUSSION

I have not been able to make a quantitative assessment of how many equations differ, and how many are the same. There is enough evidence given though to question CSL at this point, in that some equations differ between English and French, either in their symbols, or in their format, or in both.

It is quite another issue as to how important these differences are, though I have already given my opinion that the use of vector notation is very significant, in that the whole approach to equations is different.

I suspect the French formulae for motion equations for instance would be understood by English pupils if the symbols were defined. Often, in class, in the textbooks and in science articles, common symbols are not defined every time a formula is used, some prior knowledge is assumed. A strict form of CSL would indicate that the format alone should be sufficient to make a formula recognisable, rather like the rhythm of a song can be enough to make it recognisable, without even the tune being
played. It was in an attempt to put this question of format to the test that I gave the French school pupils the formulae in the English format, without explaining them, to see how well they coped. (cp Chapter 23 'Questionnaire on physics, and graphs').

There are also several ways which could be, or could have been used to study how important these differences are. Firstly the English school Tunisian teachers themselves, when first sent on the year's course in UK could have been studied to see how they coped with the English, which was simpler than the French. Secondly students going from French to English in their studies, maybe physically changing country, or simply using English textbooks and articles in their studies in a French speaking country, could be used to see how significant these differences are, perhaps using methods like those used in the physics questionnaire, and comparing those students with some knowledge of English ways, with those with none whatsoever. There is also the case of the British teachers who had to adapt to the Tunisian way. Unfortunately the British physics teachers TEG and TEH had left by the time I came to ask this question. How to assess the struggles and difficulties of adapting also remains an open question, to see how significant the differences are for people in their studies and work.

5. SUB-CONCLUSIONS

a. There can in some cases be more than one way of expressing a rule mathematically in physics. It is not necessarily true that at the same level in school, the same choice will be made as to which expression to teach, or which one to use most frequently.

b. The symbols used in formulae are not necessarily the same.

c. The format of an equation is not necessarily the same, even given a similar choice of expression. (eg example 3, motion laws). Vector notation, unit vectors and additional symbols add to these differences.
1. INTRODUCTION

There are three pieces of evidence which are not worth a heading all to themselves, and yet deserve a mention. They all concern non-verbal items of science, which could be assumed to be the same in French and English. These are the periodic table, long division and labelling the axes of graphs.

2. SUB-HYPOTHESES

The following will be the same in English and French:

a. The form of the periodic table

b. The forms employed when long division is performed

c. The conventions associated with labelling the axes of graphs and indicating the scale.
3. RESULTS

a. The periodic table [1.]

When the versions that exist of the periodic table are compared, the main point of difference concerns the noble gases. Modern British practice is to label them as Group 0 (zero). (ASE 1983 p21–3). The Tunisian books (eg 5FC140) used Colonne VIIIb (column VIIIb).

This is hardly a very important difference between English and French, especially as both names are known in English. ASE (1983 p21–3) has a discussion of the changing practices of labelling, and the differences between Britain and America. A new system of numbering from 1–18 is also suggested and it is of interest that the French textbook notes the new system, and adds that,

Cette manière de numéroter les groupes est conforme aux recommandations de l'IUPAC. (5FC140)

This way of numbering the groups conforms with the recommendations of IUPAC.

The example then more properly belongs to the heading of language change in English and French and is an example of how change is working the same way in two languages.

b. Long division.

One only has to look in a first year Tunisian mathematics book, (eg p70) to see a worked example of long division and to realise that French and English have two different systems. This fact was not accounted for by Défourneaux (Défourneaux 1980 p34) who gives the French format and English wording for it. Défourneaux is quoted in full in figure 22.1 below to show how different the forms are:

1. It was TFC who first informed me that he suspected that the periodic tables were not the same in English and French. (T237:2). What these differences were though, he was not too sure.
FIGURE 22.1 LONG DIVISION THE FRENCH WAY

- Diviser 236 par 5  
  divide 236 by 5

\[
\begin{array}{c|c}
236 & 5 \\
36 & 47 \\
\hline
1 & \\
\end{array}
\]

|二十 by five, four |  
|-------------------|---|
| put four, carry three |  
| thirty six by five, seven, carry 1 |  
| put seven |  
| remainder one |  

(Defourneaux 1980 p34. The English wording given by Défournex makes more sense if "by" is understood as 'divided by'.)

But giving an English translation of wording used in long division makes little sense as the format of the symbols used is not English. The British way to such a sum would be expressed as in figure 22.2 [2.]

FIGURE 22.2 LONG DIVISION THE ENGLISH WAY

\[
\begin{array}{c|c}
5 & 236 \\
20^* & 36 \\
35^* & 1 \\
\hline
& 47 \text{ r. 1} \quad \text{forty-seven remainder 1 [3.]} \\
\end{array}
\]

| fives into 23 go four, remainder 3 |  
|-----------------------------------|---|
| fives into 36 go seven, remainder 1 |  

(Optionally a short multiplication table may be compiled as follows:

\[
\begin{array}{c|c}
4 & 20^* \quad \text{four times five equals 20} \\
7 & 35^* \quad \text{seven times five equals 35} \\
\end{array}
\]

(* The stars refer to intermediate steps).

2. Here I am following the example given by Défournex. There is of course the other custom of calculating using decimal places rather than remainders. This is not the point at issue here.

3. I have quoted the English system partly for non-British readers of this thesis who will not necessarily be aware of how different the English system is, (at the risk of stating the obvious for British readers) and partly for the sake of full documentation of the differences.
The two ways of writing the non-verbal forms of long division in English and French are evidently very different. Note also the way that the French way requires more mental effort in that intermediate steps (starred in figure 22.2 above) are omitted in French.

c. Labels on the axes of graphs and the indication of scale

The statements of guidance for schools in UK include ASE (1981), ASE (1985) and IOB (1989). The consensus is that at the upper school level:
1) the quantity is to be stated alongside each axis,
2) the units are adjacent to the quantity, and separated from them by the solidus,
3) the divisions of the axis line are to be numbered.

The scale is usually implied by the labelling of the axes.

To take the example of the problem I set the students in the questionnaire in which a velocity against time graph was required. The British convention would be to label the x axis ' \( v/m.s^{-1} \) ' and the y axis ' \( t/s \) '.

The Tunisian custom was to label the axes using brackets round the units, instead of the solidus. This would be understood in Britain but is not the accepted UK convention. (IOB 1989 p5). The French Anabacs also used the brackets round the units convention or used the word 'en' meaning 'in' eg "\( t \) en \( 10^{-3}s \)" (Anabac 1988b p99).

<table>
<thead>
<tr>
<th>Label</th>
<th>Scale</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>English school /88 40 12 22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>French school /104 32 10 20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Label = students labelled their axes the French way, using 'en' or 'in' or brackets ( )
Scale = use of the French scale as below
Both = use of both labelled axes and scale

(Three students at the English school used other variants for scale, "10mm \( \rightarrow \) 3s" or "1cm = 2 second". S2.20, S2.22, S3.21).
Note that in not a single case was the correct English form used at either school. Scale was indicated (if at all) by students in the form as given in figure 22.4, which is taken from the question set to the pupils. Usually the scale would be drawn in the top right hand corner of the graph, the length of each arrowed line being one square (0.5cm or 1cm) of the paper. English translations (eg 4EP109) followed French practice.

**FIGURE 22.4 A FRENCH WAY TO INDICATE SCALE**

This is easily understood, but is not the British way. The practice was also widely used in the Tunisian French textbooks and the French books, and was used in classes (eg T204:25). The position of the scale on the graph does not appear to be constant (Anabac 1988b p98,113). I never saw the old English convention of writing scale using the 'represents' symbol, eg 1 cm = 4s and as this symbol '=' appears not to be standard or known in French, this old English custom is unlikely to exist in French.

4. DISCUSSION

Widdowson, in explaining his ideas that science is a universal language specifically in the area of

... graphs charts, conventionalised diagrams, and so on which take the same form irrespective of the verbal context in which they occur. (1979 p42).

All three instances studied in this chapter are evidence against his assumption. But of the three instances, the one of most significance is probably that of the labelling of graphs. The school standards in English are those of the working scientist, when material is published in journals for instance. They are completely different to the standards used in French at school level.
5. SUB-CONCLUSIONS

a) The format of the periodic table is changing, the current version being the same in English and French apart from minor differences over the number for the noble gases.

b) The ways of writing long division on paper are different in English and French.

c) The ways of labelling axes of graphs are different in English and French especially in the way a solidus is preferred (not brackets) in English to separate the quantity from the unit.
SECTION IV NON-VERBALS
CHAPTER 23
QUESTIONNAIRE ON PHYSICS, AND GRAPHS

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1. INTRODUCTION

As discussed in Chapter 28 'Implications for Linguistics' Widdowson is of the opinion that science textbooks are probably the same in different languages.

I think that it is likely that scientific textbooks written in different languages express essentially the same methodology. (1979 p43)

It was clear to myself and to the teachers at the English school that there were differences: that the methodology in the science textbooks is not necessarily similar between English and French. Many of the differences have already been documented in other parts of this thesis.

Given that some of the ways of doing physics are different, the question is worth asking as to how different: how easily could pupils adapt to different approaches. The challenge was to design ways to assess - not only to describe - the differences.

This chapter reports the results on one way of assessing the differences between English and French for the pupils. Two questions were given, each extremely easy in that they were 'O' level standard or less, and so designed that the pupils were strongly encouraged to try out the English way. The translation in French followed the English way and was an interesting exercise in itself in that French was being moulded to fit the English, whereas the work up till then had studied the English school adapting to French. The English school did the English version and the French school did the French version of the text.

If CSL Is valid then these physics questions should have posed no difficulty to any of the students, and they should have been able to interpret results and manipulate formulae in the English way without any problems.

In practice one would also have expected that, because of the greater exposure of the students at the English school to English influences, the pupils would have done better on these questions than students at the French school. Given the similarities between the two schools, If CSL is valid there should be no difference at this point. If velocity/
time graphs are considered an essential part of a subject in one host culture, as science is supposedly one culture, then they will be an essential part of science in another host culture.

The questionnaire itself is in Appendix 7. In this chapter the format is changed from the usual one. The results take each part of the questionnaire in turn, and put the sub-hypotheses, data and discussion under that part. All the subsequent tables below use the notation in figure 23.1.

**FIGURE 23.1 KEY TO ABBREVIATIONS USED IN THIS CHAPTER**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunisian</td>
<td>Tunisian method</td>
</tr>
<tr>
<td>Mixed</td>
<td>Mixture of methods</td>
</tr>
<tr>
<td>English</td>
<td>English method</td>
</tr>
<tr>
<td>Ø</td>
<td>Empty set, ie no answer</td>
</tr>
<tr>
<td>/xxx</td>
<td>out of so many attempts</td>
</tr>
<tr>
<td>E</td>
<td>English school</td>
</tr>
<tr>
<td>F</td>
<td>French school</td>
</tr>
</tbody>
</table>

2. RESULTS

**Question 1a) 'speed'**

**Sub-hypotheses**

This question tested, in the English version, if the word 'speed' was understood. At the English school this word had been avoided in favour of 'vector velocity'. (See Chapter 9 'Definitions' b. Physics, Example 2). If CSL is valid then this word would give no problems. In the French version, when the French school teachers proof read the questions, their advice was that the wording be left at 'vitesse' and not 'vecteur vitesse'. The format of the question is also a little unusual in French as it is written in the English way. If CSL is valid there would be no difficulty with this question. If CSL is not valid, on a practical level one would expect the English school pupils to do better, due to their prior contact with the English world.
RESULTS: NON-VERBALS Questionnaire: physics graphs 23.4

Data
The data are in figure 23.2 below.

FIGURE 23.2 Q1a) SPEED

<table>
<thead>
<tr>
<th>Answers</th>
<th>Right</th>
<th>Wrong</th>
<th>No answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>English school /88</td>
<td>84</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>% 95</td>
<td>5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>French school /104</td>
<td>83</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>% 79.8</td>
<td>38.5</td>
<td>16.3</td>
<td></td>
</tr>
</tbody>
</table>

Discussion
The English school pupils had no problem with this question, as CSL predicts, The French school pupils had a 16% no attempt rate. The question was a poor test of CSL as it did not differentiate between speed and velocity, therefore the results are inconclusive.
Question 1b) 'draw a v/t graph'

Sub-hypotheses
It can be argued that the pupils have not done velocity/time graphs in Tunisia by the end of the sixth year. [1.] But this does not exclude the material from use in the test. If CSL is valid then the way of covering a topic will be the same. The students have done this topic, to a high level algebraically. If CSL is holding, then students would know how to draw a simple velocity/time graph. Practically, one would expect the English school pupils to cope better than those at the French school because of their greater exposure to British teachers, texts in English, and Tunisian teachers trained in the UK.

Data The data are presented in figure 23.3 below.

Discussion
In both schools, those who tried succeeded in drawing a graph, though drawing it to the accepted British standards for style including labelling of the axes is another question (discussed in Chapter 22 'Miscellaneous'). This then favours CSL except that there was a high number, 21%, of no attempts at the French school, which suggests the extra exposure at the English school to the English ways helped the students there to understand the questions.

1. The sixth year French text mentions acceleration/time, and distance/time, but the topic is not formally studied, nor are pupils expected to use such graphical methods to solve problems.
FIGURE 23.3 Q1b) DRAW A V/T GRAPH

<table>
<thead>
<tr>
<th>Answers</th>
<th>Right</th>
<th>Wrong</th>
<th>No answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>English school</td>
<td>80</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>90.9</td>
<td>9.1</td>
<td>0</td>
</tr>
<tr>
<td>French school</td>
<td>77</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>74.0</td>
<td>4.8</td>
<td>21.2</td>
</tr>
</tbody>
</table>

Question 1c) 'distance travelled, calculated from graph'

Sub-hypotheses
Pupils would, from the graph alone, be able to work out the correct numeric answer, and to calculate from the graph, the distance travelled.

Data The data are presented in figure 23.4 below.
RESULTS: NON-VERBALS Questionnaire: physics graphs 23.7

FIGURE 23.4 Q1c) DISTANCE TRAVELLED: CALCULATED FROM THE GRAPH

<table>
<thead>
<tr>
<th>Answers</th>
<th>Tunisian</th>
<th>Mixed</th>
<th>Tunisian &amp; Mixed</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Wrong</td>
<td>Right &amp; Wrong</td>
<td>Right</td>
</tr>
<tr>
<td>English school</td>
<td>/84</td>
<td>7</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>%</td>
<td>8.3 17.9</td>
<td>4.8 3.6</td>
<td>30 35.7</td>
<td>36.9 17.9</td>
</tr>
<tr>
<td>French school</td>
<td>/104</td>
<td>1</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>%</td>
<td>0.96 13.5</td>
<td>0.0 1.9</td>
<td>17 16.3</td>
<td>23.0 7.7</td>
</tr>
</tbody>
</table>

Answers (%)
Discussion
Few students who attempted this question got it right using only a graphical method as required by the question. The results were worst at the French school. The significant difference again though is that half the French school students did not even attempt an answer, despite it being extremely easy. Comments made later by the pupils suggested that I had put the harder question first. This should have made little difference as both questions were easy compared to what the students were used to. The only feature that could have made them appear to be difficult was the way the questions were worded. They were worded in an 'English way'. The existence of a 'French way' and an 'English way is inconsistent with CSL. These high numbers of no-attempts are therefore evidence against CSL.

Question 1d) 'formulae'.
Sub-hypotheses
1) Pupils would recognise the formulae even though given in a British format, and without specifying the meaning of the symbols.

2) Pupils would correctly manipulate the formulae to a correct answer, without recourse to Tunisian terms and methods.

3) Results between the two schools would be comparable.

Data The data are presented in figures 23.6 and 23.7 below. (Note the numbers are totalled allowing four formulae over the whole question, therefore 348 questions for the English school with 87 pupils and 416 at the French school with 104 pupils).


FIGURE 23.5 FORMULAE IN DETAIL

<table>
<thead>
<tr>
<th>Answers</th>
<th>style:</th>
<th>Tunisian</th>
<th>Mixed</th>
<th>Tunisian/Mixed</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Right</td>
<td>Wrong</td>
<td>Right &amp; Wrong</td>
<td>Right</td>
</tr>
<tr>
<td>English school</td>
<td>/348</td>
<td>37</td>
<td>23</td>
<td>56</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>10.6</td>
<td>6.6</td>
<td>16.1</td>
<td>8.3</td>
</tr>
<tr>
<td>French school</td>
<td>/416</td>
<td>38</td>
<td>19</td>
<td>14</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>9.1</td>
<td>4.6</td>
<td>3.4</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Answers (%)

School: E F E F E F E F E F E F E F E F E F E F
Style: Tunis Right Tunis Wrong Mixed Right Mixed Wrong Tunis/Mixed Right/ Wrong English Right English Wrong No answer
FIGURE 23.6 NUMERICAL ANSWER

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Wrong</th>
<th>No answer</th>
<th>Suspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>English school</td>
<td>15</td>
<td>30</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>17.9</td>
<td>35.7</td>
<td>8.3</td>
<td>41.6</td>
</tr>
<tr>
<td>French school</td>
<td>13</td>
<td>25</td>
<td>53</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>12.5</td>
<td>24.0</td>
<td>51.0</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Discussion

Not all students were able to recognise the formulae to the point of correct use. The English school pupils did best and there were significantly fewer no-attempts though for the formulae, only forty percent could do them the English way.

Although not conclusive, the data does suggest that CSL is not fully applicable.

2. These are the correct answers where they were not derived in full from the graph. At this point correct answer means correct with full reasoning from the graph.
Question 2a) 'area of graph'

Sub-hypotheses
Given that graphs, a non-verbal way of expressing information in science, are supposedly international, and the presumption that science will be taught in similar ways in different countries, then students should be able to interpret a velocity/time graph, and to state that the area underneath such a graph represents the distance travelled. I was told, warned even, by teachers at both schools not to expect pupils to get the correct answer to this question, as it was not taught until the seventh year.

Data The data are presented in figure 23.7 below.

FIGURE 23.7 AREA OF GRAPH

<table>
<thead>
<tr>
<th>School</th>
<th>Right</th>
<th>Wrong</th>
<th>( \phi )</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>87</td>
<td>67</td>
<td>9</td>
</tr>
<tr>
<td>French</td>
<td>104</td>
<td>55</td>
<td>21</td>
</tr>
</tbody>
</table>

Discussion
The evidence is broadly in favour of CSL because students in each school could do the question, except that the English school did better than the French school which would not be predicted by CSL.
Question 2b) 'distance travelled, using graph'

Sub-hypothesis

If teaching techniques are the same, and the content of a subject is the same, then pupils would be able to interpret a velocity/time graph, and be able to calculate using the area of the graph method, the distance travelled (which is represented by the area under the graph).

Data The data are in figure 23.8 below.

FIGURE 23.8 DISTANCE TRAVELLED: USING GRAPH

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Wrong</th>
<th>ρ</th>
</tr>
</thead>
<tbody>
<tr>
<td>English school</td>
<td>/84</td>
<td>54</td>
<td>7</td>
</tr>
<tr>
<td>%</td>
<td>62.1</td>
<td>8.0</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>29.9</td>
</tr>
<tr>
<td>French school</td>
<td>/104</td>
<td>79</td>
<td>10</td>
</tr>
<tr>
<td>%</td>
<td>76</td>
<td>9.6</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14.4</td>
</tr>
</tbody>
</table>

Discussion

The results are broadly in line with the hypothesis, in that most students at both schools could find, using the graph, the distance travelled.
Question 2c) 'formulae': Sub-hypotheses

Pupils would be able to recognise and use the formulae given in the English way, and that both schools would have similar results. (As Q1d above).

FIGURE 23.9 Q2c FORMULAE: RECOGNITION & USE

<table>
<thead>
<tr>
<th>Answers</th>
<th>Tunisian</th>
<th>Mixed</th>
<th>Tunisian/Mixed</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Wrong</td>
<td>Right &amp; Wrong</td>
<td>Right</td>
</tr>
<tr>
<td>School:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>1/174%</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>115</td>
<td>66.1</td>
<td>11</td>
<td>6.3</td>
</tr>
<tr>
<td>French</td>
<td>1/208%</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>131</td>
<td>63.0</td>
<td>25</td>
<td>43.0</td>
</tr>
</tbody>
</table>

| Answers (%) | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 |
|-------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| School:     | E  | F  | E  | F  | E  | F  | E  | F  | E  | F  | E  | F  | E  | F  |
| Style:      | Tunisian Right | Tunisian Wrong | Mixed Right | Mixed Wrong | Tunisian/Mixed Right | Mixed Wrong | English Right | English Wrong | No answer |

Results: Non-verbals Questionnaire: physics graphs 23.13
RESULTS: NON-VERBALS Questionnaire: physics graphs 23.14

Data
In the data of figure 23.8 above the 'use of formulae' and 'getting correct answer' are combined, meaning the scores are out of 174 attempts for the English school and 208 attempts for the French school.

Discussion
For these simple formulae, the evidence is in favour of the sub-hypothesis, in that an equal proportion of pupils at both schools could recognise and use formulae.

Question 2d) 'slope means acceleration'.

Sub-hypothesis Pupils would recognise that the slope represents the acceleration.

Data The data are in figure 23.10 below.

FIGURE 23.10 SLOPE MEANS ACCELERATION

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Wrong</th>
<th>φ</th>
</tr>
</thead>
<tbody>
<tr>
<td>English school</td>
<td>87%</td>
<td>70.1%</td>
<td>16%</td>
</tr>
<tr>
<td>French school</td>
<td>88%</td>
<td>65.4%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Answers

Discussion
The evidence is in favour of the sub-hypothesis, in that pupils at both schools in roughly equal proportion were able to recognise that the slope of the velocity/time graph represents acceleration.
The questions set, and their implications for CSL are summarised in figure 23.11 below.

### FIGURE 23.11 SUMMARY TABLE

<table>
<thead>
<tr>
<th>Question &amp; task</th>
<th>Assessment and Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a) Speed</td>
<td>± Inconclusive</td>
</tr>
<tr>
<td>1b) ability to draw v/t graph</td>
<td>+ most could</td>
</tr>
<tr>
<td></td>
<td>- large numbers no attempt at French school</td>
</tr>
<tr>
<td>1c) by graph find distance travelled</td>
<td>- many failed</td>
</tr>
<tr>
<td></td>
<td>- French school: many no attempts</td>
</tr>
<tr>
<td>1d) formulae:</td>
<td>- many could not, especially at French school</td>
</tr>
<tr>
<td>recognise</td>
<td>- French school: many no attempts</td>
</tr>
<tr>
<td>use</td>
<td>- English school better than French school</td>
</tr>
<tr>
<td>English = French</td>
<td></td>
</tr>
<tr>
<td>2a) identify graph area</td>
<td>+ most could</td>
</tr>
<tr>
<td>English = French</td>
<td>- English better than French</td>
</tr>
<tr>
<td>2b) by graph, distance</td>
<td>+ most could</td>
</tr>
<tr>
<td>2c) formulae</td>
<td>+ most could</td>
</tr>
<tr>
<td>recognise</td>
<td>+ most could</td>
</tr>
<tr>
<td>use</td>
<td>+ true</td>
</tr>
<tr>
<td>English = French</td>
<td></td>
</tr>
<tr>
<td>2d) slope = acceleration</td>
<td>+ most identified this</td>
</tr>
</tbody>
</table>

(+ favours CSL   -against CSL   ± inconclusive)
4. BROADER DISCUSSION AND CONCLUSIONS

The evidence from question two is more in favour of CSL than the evidence from the first question. Simple formulae for instance were recognised and used equally well in both schools in the second question.

The English school almost invariably did better than the French school, both in a higher success rate and in a higher attempt rate. The differences are most marked when question one is compared with question two. The English school pupils did consistently better on the harder, first question. Maybe this was due to the different setting at the English school, for instance the presence of British teachers, or the Tunisian teachers who had been educated partly in England, or the access the pupils had to British textbooks.

Concerning the British textbooks. The English school pupils were asked in the questionnaire if they read physics books in English. The results are in table 23.12 below. This exposure level to English ways cannot have hindered the pupils in their answers to the questions.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequently</td>
<td>12 = 14.3%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>53 = 63.1%</td>
</tr>
<tr>
<td>Rarely</td>
<td>13 = 15.5%</td>
</tr>
<tr>
<td>never</td>
<td>3 = 3.6%</td>
</tr>
</tbody>
</table>

The first question was especially good at revealing the differences between the two schools and the effect exposure to English ways had. This is notable especially from the way many pupils in the French school could not even attempt the question, and were not able to recognise and use formulae written in the English way which existed in their own textbooks.

CSL seems to break down when a situation gets complicated, and the results clearly show that the English way was different: it was difficult for the pupils at the French school. Others may be more impressed by how fast students learnt to cope, so that by the second question students were getting right answers, with fewer 'no-attempts'. But the question of how quickly students can adapt to new ways presupposes that there are two or more ways in existence. It is also another, and a follow-on question from these results.
SECTION IV NON-VERBALS
CHAPTER 24
PHYSICS OPINIONS

1. INTRODUCTION

This is one of the rare sections in the questionnaire (Appendix 7 & 8) when I deliberately sought the opinions of the pupils. If CSL is valid then pupils would not perceive any difference between the physics questions I gave them and their normal questions. It was very hard to formulate questions to get at this difference. Inevitably the style of test question is invoked as much as any different way of doing things. Indeed, style and a different way could be considered to be two facets of the same difference, though for convenience below I have spelt out the facets as two sub-hypotheses.

The question in French was worded more vaguely than the question in English. A pilot of the questionnaire would probably have picked this up, but for reasons already explained in Chapter 6 'Procedures', this was not possible under the circumstances. As it turned out the vaguer wording yielded more interesting information.

There was scope here for interviews and other techniques to find out what the pupils really thought and experienced. For the purposes of this thesis though such work would not have contributed to the overview of CSL at the verbal and non-verbal level.

Another issue was thrown up by two of the students at the English school. Two of them, 3.19 and 4.4 said that the previous year they had
had a British teacher for physics and he had taught the subject of kinematics using graphs. It is not known at this stage if the classes were re-grouped each year, so it cannot be specified that classes three and four had had direct British input. The teacher concerned had also left the year before I attended physics lessons. (1988). It can be said though that at least one class of students had direct British teaching on this topic. In theory, the pupils at both the English and the French school were following exactly the same curriculum. But the English school was more open than the French school to influences from the English world due to British teachers, British textbooks in English, and Tunisian teachers who had studied in England for a year.

2. SUB-HYPOTHESES

if CSL is valid then
a) There will be no perceived differences between the questions I have put, and questions as normally set in Tunisia
b) The style of test questions will be perceived of as international.

3. RESULTS

(See Appendix 8 for examples of quotations)

French school:
There were forty-seven students (out of 96) who said they preferred the Tunisian way, the way of algebra, mainly because they were more used to it, as opposed to the so called 'English' way, meaning for instance graphs, which twenty said was easier.

Opinion was divided over the clarity of the questions, and whether or not graphs or algebra gives more mistakes. Twenty-seven gave no opinion or an opinion irrelevant to the question.

English school:
A majority of 38 to 27 said that graphs were easier than equations and thirteen were ambivalent, with only ten no answers.
4. DISCUSSION

The French school results, with its better, vaguer worded question, give the clearest indication that students did perceive a difference between the questions and the usual Tunisian example questions, and this difference resided primarily in the use of graphs which they were not used to. Only one student commented on the symbols and said that I should have defined them (French Student 3.12).

In that the English school pupils had had exposure to English ways, through a British teacher, libraries, and Tunisian teachers trained in the UK and the USA, it is not surprising that the pupils were more receptive to graphs while still insisting that while graphs might be easier they were more used to algebra: the Tunisian way.

5. SUB-CONCLUSIONS

a) There was a perceived difference between the style of questions used here and the style the pupils were used to.

b) There was a clear opinion that the graphs are not Tunisian.
SECTION V DISCUSSION

CHAPTER 25

SUMMARY OF THE RESULTS

INTRODUCTION

To get an overview of the results each topic has been graded to show how far scientific language is constant between English and French at school level. It will be seen that only in a very few limited areas is CSL completely valid, and also in only a few areas completely invalid.

What is perhaps surprising from these results is that even taxonomy, which might be thought to be a fixed and well defined subject, is not the same in English and in French in several important details, and the differences are likely to get greater for a time in view of current changes being proposed in the naming structure. In addition there are the different ways of doing the mathematics, for instance in mechanics, and this adds up to a large difference between England and France.

There are a large number of faux amis, and my data is by no means exhaustive. It simply cannot be assumed any more that the technical vocabularies of English and French are so similar that the differences can be ignored. It is also significant that the important non-verbal conventions associated with the correct labelling of graphs are not international. Yet Widdowson thinks that science will be universal particularly at these non verbal levels, and he in fact builds a whole approach to language teaching on this point: as the non-verbals are international, they can serve as an intermediate common language when translating between English and French. (cp Chapter 28 where this is discussed in detail).
**FIGURE 25.1 GRADING SYSTEM FOR THE RESULTS**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>**</td>
<td>Needs further study</td>
</tr>
<tr>
<td>1</td>
<td>CSL is completely valid. A full study has been done and no exceptions have been found.</td>
</tr>
<tr>
<td>2</td>
<td>CSL is generally valid, apart from some exceptions.</td>
</tr>
<tr>
<td>3</td>
<td>Partly valid.</td>
</tr>
<tr>
<td>4</td>
<td>Largely invalid.</td>
</tr>
<tr>
<td>5</td>
<td>Completely invalid, a full study has been done.</td>
</tr>
</tbody>
</table>

**FIGURE 25.2 RESULTS GRADED ACCORDING TO CONSTANCY BETWEEN FRENCH AND ENGLISH**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>COMPLETELY VALID</td>
</tr>
<tr>
<td>- Symbols of the elements</td>
<td></td>
</tr>
<tr>
<td>- Symbols and names of the amino acids used in man</td>
<td></td>
</tr>
<tr>
<td>- SI system of units</td>
<td></td>
</tr>
<tr>
<td>- Symbols in genetics</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>GENERALLY VALID, EXCEPTIONS NOTED</td>
</tr>
<tr>
<td>- Prefixes and suffixes</td>
<td></td>
</tr>
<tr>
<td>- Names of the elements</td>
<td></td>
</tr>
<tr>
<td>- Inorganic chemistry nomenclature</td>
<td></td>
</tr>
<tr>
<td>- Periodic table</td>
<td></td>
</tr>
<tr>
<td>- Ways of writing the charge on ions</td>
<td></td>
</tr>
<tr>
<td>- Symbols in biology</td>
<td></td>
</tr>
<tr>
<td>- Names of vitamins and minerals</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>PARTLY VALID</td>
</tr>
<tr>
<td>- Names of diseases</td>
<td></td>
</tr>
<tr>
<td>- Taxonomy</td>
<td></td>
</tr>
<tr>
<td>- Names in organic chemistry</td>
<td></td>
</tr>
<tr>
<td>- Language of description in chemistry</td>
<td></td>
</tr>
<tr>
<td>- Names of reagents and tests</td>
<td></td>
</tr>
<tr>
<td>- Mathematical equations</td>
<td></td>
</tr>
<tr>
<td>- Indices</td>
<td></td>
</tr>
<tr>
<td>- Ways of writing symbols</td>
<td></td>
</tr>
<tr>
<td>- Dot and cross diagrams in chemistry</td>
<td></td>
</tr>
<tr>
<td>- Symbols in mathematics</td>
<td></td>
</tr>
<tr>
<td>- Names of the sugars, especially the group words</td>
<td></td>
</tr>
<tr>
<td>- Ability to write formulae in organic chemistry</td>
<td></td>
</tr>
<tr>
<td>- The way of solving mechanics problems in physics</td>
<td></td>
</tr>
<tr>
<td>- Abbreviations</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>LARGELY INVALID</td>
</tr>
<tr>
<td>- Faux amis</td>
<td></td>
</tr>
<tr>
<td>- Definitions</td>
<td></td>
</tr>
<tr>
<td>- Eponyms</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>COMPLETELY INVALID</td>
</tr>
<tr>
<td>- Punctuation:</td>
<td></td>
</tr>
<tr>
<td>- Organic chemistry numbers</td>
<td></td>
</tr>
<tr>
<td>- Orthography of numbers</td>
<td></td>
</tr>
<tr>
<td>- State symbols (chemistry)</td>
<td></td>
</tr>
<tr>
<td>- Method of long division</td>
<td></td>
</tr>
<tr>
<td>- Customs: labelling graphs</td>
<td></td>
</tr>
</tbody>
</table>
SECTION V DISCUSSION

CHAPTER 26

VALIDITY AND RELIABILITY OF THE RESULTS

1. INTRODUCTION

LeCompte and Goetz (1982) have an important article on the reliability and validity of ethnographic research. While the thesis is not an ethnograph, the thesis began in a field situation and has used many of the techniques of ethnographers (see Chapter 5 'Foundations of the project' Section 2). The questions and analysis of LeCompte and Goetz therefore form a useful test for the results.

FIGURE 24.1 RELIABILITY AND VALIDITY OF THE RESULTS
(Derived from LeCompte & Goetz 1982 p32)

<table>
<thead>
<tr>
<th>RELIABILITY</th>
<th>VALIDITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>REPLICABILITY</td>
<td>ACCURACY</td>
</tr>
<tr>
<td>EXTERNAL</td>
<td></td>
</tr>
<tr>
<td>Independent researchers discover the same phenomenon or generate the same constructs</td>
<td>Degree of generalisation possible, and how comparable across groups</td>
</tr>
<tr>
<td>INTERNAL</td>
<td></td>
</tr>
<tr>
<td>Degree to which other researchers would match generated constructs with data given.</td>
<td>Extent to which observations are authentic representations of reality.</td>
</tr>
</tbody>
</table>
a. External reliability

External reliability addresses the issue of whether independent researchers would discover the same phenomena or generate the same constructs in the same or similar settings. Internal reliability refers to the degree to which other researchers, given a set of previously generated constructs, would match them with the data in the same way as did the original researcher.

... validity is concerned with the accuracy of scientific findings. ... Internal validity refers to the extent to which scientific observations and measurements are authentic representations of some reality. External validity addresses the degree to which such representations may be compared legitimately across groups. (Le Compte & Goetz 1982 p32).

The external reliability of the hypotheses is high in that my constructs were derived from several sources in the situation. I had to do the work of spelling them out in detail, and to adopt certain techniques such as to state the hypothesis in a testable form. Goetz & LeCompte say that external reliability is enhanced by being explicit about five major problems:

1) Researcher status position. "Research reports must clearly identify the researcher's role and status within the group investigated". (p38). (cp Chapter 5 'Foundations of the project' Section 2.e. 'Understand one's role').

2) Informant choices. "External reliability requires both careful delineation of the types of people who served as informants and the decision process invoked in their choice". (p38). (cp discussion in this chapter under 'Internal validity').

3) Social situations and conditions. "Delineation of the physical, social and interpersonal contexts within which data are gathered enhances the replicability of ethnographic studies". (p39). (cp Chapter 2 'The situation in Tunisia').

4) Analytic constructs and premises. "Replication requires explicit identification of the assumptions and metatheories that underlie choice of terminology and methods of analysis". (p39). Recognised frameworks and classifications have the advantage of helping the research to be understood and making the results more comparable, but they may hinder, in that the categorisation may be made prematurely, and the data may be made to fit the headings thus misrepresenting the data.
5) **Methods of data collection and analysis.** "Ideally ethnographers strive to present their methods so clearly that other researchers can use the original report as an operating manual by which to replicate the study." (p40) (cp Chapters 5 & 6) The authors argue that shorthand designations for methods are inappropriate, since there is no commonly understood set of descriptors for the many methods that can be used in ethnography. They also give an admonition (which by their own admission is elementary to researchers with a strong background in the so called experimental pure sciences) that replicability is impossible without precise identification and thorough description of the methods used to collect and especially analyse data. (p40).

b. **Internal reliability**

This is a key concern for ethnographers and LeCompte and Goetz go into detail on how to enhance the probability that within a single study, several observers would agree on the findings, and how the theory fits with the data.

The internal reliability of this research is high given the very specific nature of the sub-hypotheses, it being clear in most cases what data is applicable to each sub-hypothesis. The work used techniques of ethnographers, but is not an ethnography as such. In particular, the fact that wherever possible information from more than one source has been used, has enhanced the internal reliability.
2. VALIDITY

The validity of the research is a question as to how closely the propositions generated, refined and tested match the reality of a situation in everyday life.

a. External validity

As ethnographers study one situation the question arises as to how easily the findings can be generalised to other situations. [1.] The common way of enhancing external validity is to establish how typical a phenomenon is, ie the extent to which it compares and contrasts with other known phenomena. This means for instance the clear identification, specification and evidence for distinct characteristics of what is being investigated. (p51). Statistical techniques are usually impossible to use as the goal of the research is the explication of meanings or microsocial processes in one situation.

The external validity of this research varies. At the level of documenting the differences between English and French the validity is high, as there is a lot of information at the linguistic, 'here is a clear difference' level. The questionnaire results though, as discussed below, are indicative, not conclusive and cannot be generalised to other situations. Also, the work is only between English and French: no comment can be made about the constancy of scientific language extending to other host languages.

Where it is not possible to use techniques of random sampling and statistical analysis, the characteristics of the group studied must be spelled out clearly. The results can then be compared with others and hence have a wider applicability. This I have done in the introductory chapter on the situation in Tunisia, and in particular the French school served as a control, especially when the questionnaires were used.

1. Compare Chapter 5 'Foundations of the project' Section 2.k. where the principle of comparing with other situations is discussed, in this case with other Arab countries, and the lack of similar comparable work is noted.
The research has implications for linguistic theory, (Chapter 28) and for the teaching of English to science students (Chapter 29), particularly those students who have studied in French. Though the country of field studies was Tunisia not France, French sources have been consulted, so the work can be generalised to the French speaking world. The area where the research is only indicative is where the questionnaires are concerned. The sample of students, though almost the entire available population, was small, and it was not possible to repeat the tests in subsequent years to new groups of sixth year pupils as the research in the schools finished. In some cases the test tool in itself was not sufficiently refined. The questionnaires are indicative in that a French way and English way of doing science were perceived to exist, and some of the differences between English and French are not trivial, in that they gave pupils real problems, especially to actively change a language (eg re-writing a chemical formula in French) as compared to just recognising differences and understanding them when reading them.

b. Internal validity

The 'Internal validity', how closely the theories match the situation, is often a major strength of an ethnographer in that unlike surveys and other quantitative techniques, the ethnographer often lives in a situation over an extended period of time, which gives the opportunity for refinement, and continual re-evaluation of the research. The assumption that there is constancy of scientific language across host languages was initially suggested by the field situation in the earliest interviews of the teachers and the Head of the English school. I was not imposing a theory on the situation, rather I started from the situation and found that the situation was an ideal testing ground for the field assumption. LeCompte & Goetz suggest several techniques for enhancing internal validity, especially in the area of use of informants (p46). [2.] Certainly when I had finally refined my ideas of what I was looking for, some informants became extremely helpful, especially TEK and TEJ. I was able to compare their suggestions with information from other sources.

2. Compare Chapter 5 'Foundations of the project' Section 3b,c,d,e where similar principles are applied.
and in some cases I was able to report back my results to them, either for them to use in class, or for them to check my understanding.

The biggest danger pointed out by LeCompte & Goetz is selectivity of informants. This can be minimised by seeking corroborating evidence.

The internal validity of this research has been enhanced by the way observations in the classroom have been compared with the textbooks, teacher opinions and dictionaries. I also deliberately asked teachers on issues such as vectors, in the form of written summaries and wrote down their reactions and corrections. This is comparable to criteria 'f' (Observation should be validated by comments from people in the field situation) and 'g' (Evidence needs corroboration) of Section 2 of Chapter 5 'Foundations of the project').

Where the work has low validity is on those occasions when I was unable to crosscheck field observations, and when for pressures of time reasons I could not replicate them, or observe all the classes I wished. In comparison I could study all the textbooks and translations without undue pressure of time.

3. CONCLUSIONS

The results presented here have a high reliability and validity, especially in those areas where triangulation and corroboration of results through one method, by other methods, was possible. Topic areas where the work is incomplete have been noted, in each relevant results chapter and in figure 25.2. Also, the results of the questionnaire must be seen, in general, as indicative that the differences cause real difficulties to pupils, rather than conclusive.

Good use has been made of the fact that the field situation provided both the assumption and the circumstances conducive to testing the assumption. The data collected requires anyone assuming constancy of scientific language to be cautious. One cannot start by assuming constancy then making deductions: there is a need for a contrastive approach so that it is known when constancy is a valid assumption.
SECTION V DISCUSSION

CHAPTER 27

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INTRODUCTION

The results have shown that scientific language is not necessarily constant. The question can now be asked as to why it is not constant and conversely, what are the forces operating which favour scientific language being constant across host languages.

2. SOME OF THE FORCES TENDING TO ENCOURAGE CSL

a. Language dominance in history

Historically, claims can be made for various languages being primary in the transmission of science, including Chinese, Greek, Arabic and Latin and in recent times in certain subject areas, German. (Maher 1986b p208).

Since the eighteenth century, scientists have tended to formulate new names by reference to Latin and Greek roots. Many of the prefixes and suffixes used in science to form the complex words are of Latin or Greek origin. Between French and English, there does seem to be a certain amount of unanimity, of mutual use of such words.

In the last few decades, the use of English as a worldwide language, especially as a second language has brought with it the dominance of English in the area of textbooks and papers in science. The spectacular growth of not only English teaching to foreigners, but also English for Special Purposes such as airline pilots and businessmen as well as scientists testifies to these general statements. Where there is a host language of science which dominates, then linguistic standards of science in that dominant language will influence other languages, directly or indirectly.
b. International Commissions

There have been and are various international commissions, which in various areas have sought to standardise nomenclature across several languages. 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 Réglementation en vue de l'Approbation de l'Équipement Électrique (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. [1.] 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 1986*, 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.

c. 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

1. A misleading name, as the term 'British' here means 'applicable in Britain', not that the origin is necessarily from Britain.
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.

d. 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.
e. 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. (S. Watts 1990 p37).

3. POSSIBLE REASONS WHY SCIENTIFIC LANGUAGE IS NOT ALWAYS CONSTANT BETWEEN LANGUAGES

a. 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).
b. 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.

c. 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).

Chapter 17 has shown that there is then more than one system of systematic names in use in organic chemistry. There are also reportedly a wealth of trivial names. 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.

d. 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 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. [2.] 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.

2. This biology text though was long overdue for revision, unlike the more recently produced chemistry text.
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 acetylectoine 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, instead of a consensus of what is thought to be true, expressed in different forms which can change with time. 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. This includes the areas listed in figure 27.1 below.

FIGURE 27.1 AREAS OF LANGUAGE CHANGE

<table>
<thead>
<tr>
<th>Topic</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Definitions of normality and molarity</td>
<td>Ch 9 Section 3c Ex 1</td>
</tr>
<tr>
<td>b) Inorganic names</td>
<td>Ch 17 Section 3b</td>
</tr>
<tr>
<td>c) emergence of 'dichlorine' in English</td>
<td>Ch 17 Section 3b Ex 2</td>
</tr>
<tr>
<td>d) Food tests</td>
<td>Ch 17 Section 3d</td>
</tr>
<tr>
<td>e) Units of pressure</td>
<td>Ch 19 Section 3b Ex 6</td>
</tr>
<tr>
<td>f) Units of standard pressure in chemistry</td>
<td>Ch 19 Section 3c Ex 1</td>
</tr>
<tr>
<td>g) Energy</td>
<td>Taber 1989, Elle 1988</td>
</tr>
<tr>
<td>h) symbols for cell reactions in chemistry</td>
<td>AEB 1985 p24</td>
</tr>
<tr>
<td>i) Nomenclature for osmoregulation: units terms and notation</td>
<td>IOB 1989 p24</td>
</tr>
<tr>
<td>j) Periodic table</td>
<td>Ch 22 Section 3a</td>
</tr>
<tr>
<td>k) Taxonomy</td>
<td>Chapter 16</td>
</tr>
</tbody>
</table>

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).

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).
f. 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.

g. 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. [3.]

h. 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).

j. 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.

3. 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).
k. Differences in curricula: the relative importance of the subjects.

There are 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 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. [4.] 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.

Compared with England's tradition of three subjects such as physics, chemistry and mathematics, studied at 'A' level, [5.] the following statements can be made:

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.

4. 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. For further details in Tunisia see for instance the 1987 examination papers published in Tunisie (1988). For France see for instance ONISEP (1987b).

5. 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.
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 a severe handicap in 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, and the almost total ignoring of statistics, so that for instance even elementary distinctions between mean, median and mode are not taught. Also mathematical skills required to do approximations are not taught whilst in England, estimating an answer before doing a detailed calculation, is an important technique, and the 'A' level physics examinations can include estimation questions. 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.

c) The amount of mathematics used in physics

This can be difficult to estimate. The figures in figure 27.2 below though are indicative. Figure 27.2 gives the marks allocated to mathematics in physics examinations taken in England, Tunisia and France, according to my judgement on inspection of the papers.
The emphasis on mathematics was to the detriment of practical work, and this was picked up by the students in the questionnaire 27/88 (31%) of whom said that in English, practical considerations are more important than in French.

2) Biology is taught at a relatively low level

The fact that biology suffers, is not of great significance, as 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, though a weakness in chemistry would be more serious. In the 'Bac D' of France, biology is given coefficient 4, (which is more comparable to the 'A' level biology than in the 'Bac C') and mathematics and physical science have their coefficients reduced to 4 each to compensate.

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.

6. This is the figure without counting the practical examination, which would tend to reduce the percentage, and accentuate the differences.
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 the supremacy of mathematics downgrades chemistry, which in England is so important.

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

There is also the problem 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.

It is a generally known occurrence 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 broader assumptions of CSL 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.
5. CONCLUSIONS

There are many social forces operating to either promote, or hinder the internationalness of science. When the effects of these social forces are combined with the results of this thesis, the assumption that scientific language is a constant becomes even more questionable, for the assumption cannot take into account these social forces.

Having identified and discussed some of the forces that work towards and against constancy of scientific language in this chapter, the next chapter presents a study of the implications of the results for various theories.
SECTION V DISCUSSION
CHAPTER 28
VARIOUS THEORIES AND CSL

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1. INTRODUCTION

The previous chapters have established where, at pre-university level, the language of science at both verbal and non-verbal levels can be regarded as constant between French and English. This chapter considers how the results bear upon various ideas and theories.

First HG Widdowson's views that in science are found universal modes of communication is examined, elucidated and commented on with the aid of other authors, and compared with my results. His use of the word 'universal' merits a separate section which links 'universal' with 'international'. There follows a section dealing with the views of various practitioners of ESP. Two topics dealt with earlier in Chapter 4, scientific language, and Zylbersztajn's conceptual framework are then re-examined, and the bearing these results have upon the Sapir-Whorf hypothesis, constructivism, Cummin's hypotheses, and reference books are discussed.

2. 'UNIVERSAL' AND 'INTERNATIONAL'

In linguistics the word 'universal' commonly has two senses:

a) A linguistic feature claimed as an obligatory characteristic of all languages;

b) A type of linguistic rule which is essential for the analysis of any language.

Chomsky called the former substantive universals, the latter formal universals. The establishment of linguistic universals is of considerable contemporary interest particularly in relation to the question of how children learn a language. (Bullock & Stallybrass 1977 p654 "universal").

Widdowson though, when he uses 'universal' seems to use it in the common sense of occurring whenever science is studied and practised. According to him not all languages have a scientific language or a scientific culture, but those which do use a universal set of methods, procedures, concepts, non-verbal conventions and semantic structures that are an essential part of science. His concept of 'universal' does not fit either of the two normal linguistic meanings mentioned above. Widdowson's ideas are similar to the case of notation in music in which conventions of musical notation are international. Widdowson does not use the term 'universal' in the sense that Berlin & Kay (1969) do when
they argue that there is a basic set of colour categories common to all cultures. For a further discussions of these points see Appendix 19.

If scientific language were to be a universal mode of communication, then all scientists would use only one set of international terms. Also every host language when needing scientific terms, would only use these international terms, to the total non-existence and non-use of any others. In the example of musical notation it is clear that there are at least two systems of notation that could be considered to be international. Therefore there is no one universal system. Universality implies that the notation system would be uniquely and exclusively international.

For the description 'universal' to apply, two conditions must be met:
a) The scientific language must be fully international between all languages
b) There has to be only one, and exclusively one, international system in use: the existence of two international systems would mean that no single international system was universal.

If it can be shown that a feature of scientific language is not fully and consistently international, or that any international feature is not in unique exclusive use, then that feature is not universal.

It is quite possible for a feature to have a degree of universality, which is expressible as a percentage, one hundred percent being completely universal. As the language used in science is vast, it is possible that some features of scientific language are universal to a greater degree than others. If that particular feature also plays a very important part in a subject discipline, then that discipline will be less enmeshed in the host country or language than other disciplines. For example, if symbols used in mathematics were to be completely and exclusively international, then mathematics would have a universal component, which would be one factor in favour of regarding mathematics as being a strongly universal subject. This illustrates how a feature of scientific language can be related to a discipline, and the universality of a feature can influence the universality of that discipline.
3. SCIENTIFIC LANGUAGE: THE VIEWS OF WIDDOWSON

a. Introduction

The assumption that there is constancy of scientific language has many resemblances to Widdowson’s idea that scientific language is a universal mode of communication (Widdowson 1974a, 1975 & 1979). Several caveats must first though be stated. Widdowson is primarily a linguist, interested in ways of teaching English to students who need English to function in science. This means in practice undergraduate and postgraduate levels. He is however not a scientist, and this unfortunately means that some inaccuracies find their way into the science he discusses. [1.]

Widdowson does not set out in a formal way the theory that scientific language is a universal mode of communication, though he makes several important statements. Therefore his ideas are elaborated here by studying other writers, both those who acknowledge Widdowson and those who do not refer to Widdowson directly.

Swales (1984) writes that Widdowson has been . . . the single most influential voice in the development of English for Science and Technology over the last fifteen years. (p69)

Since Widdowson and his views are so influential, and he holds to the belief that the discourse of science is universal, which has much in common with the assumption tested in this thesis, it is important to explain what Widdowson does and does not assert, and to point out in what respects this thesis has been an experimental test of Widdowson’s ideas.

1. For instance, in a table (1979 p29) comparing the symbols of atoms and molecules, he classifies the following as 'molecules': Cl₂, H₂O₂, S₈, Fe, Pb, and Cu₂. The molecules H, Fe, and Pb, do not exist! Also by definition a single symbol such as 'H' cannot be used to signify a molecule! The error is unfortunate, and in no way detracts from the point he is making, which is that English teaching to science students should make use of examples from science.
b. Widdowson's arguments

Widdowson's arguments can be summarized as three propositions:

1) Scientific language is not a register within a language but a cross-language mode of communication that is universal.

2) The concepts and procedures of science are independent of any host culture.

3) Translation of material concerning science should be easier between host languages than simplification and popularisation science within any single language.

Each of these propositions is discussed below.

1) Scientific language is not a register within a language but a cross-language mode of communication

Here the concern is with Widdowson's argument that the discourse of science is not so much a 'register' or a 'style' in any one language, but is something much more, something that stays constant no matter what the host language happens to be.

What I want to suggest is that specialist use of language such as we find in scientific papers, technical reports, textbooks of different technologies, and so forth, are not to be associated with formally different varieties in a particular language but with certain universal modes of communication which cut across the individual languages. (1979 p23)

... the way English is used in science and in other specialist subjects of higher education may be more satisfactorily described not as formally defined varieties of English, but as realizations of universal sets of concepts and methods or procedures which define disciplines or areas of inquiry independently of any particular language. (1979 p24).

Therefore English used in science is seen as a mode of communicating which is neutral with respect to different languages. (1979 p42).

Widdowson sees English used in science as having (not merely being comparable to the linguistic idea of) 'surface' and 'deep' expressions. The deep structure he thinks of as the concepts and methods of science. (1979 p110). He says that the learning of science must involve acquiring knowledge of:
... certain universal concepts and methods. The concepts constitute the grammatical deep structure and the methods the rhetorical deep structure of scientific discourse... Thus, if any language is to serve the needs of scientific discourse, it must have the means of expressing such deep structure concepts as, for example, the relationship between solids, liquids, and gases or between acids, bases, and salts which are instances of the universal semantic structure of science.

The pragmatics of rhetorical deep structure would be represented by sets of conditions defining such communicative acts as classification, description, explanation, and so on which constitute the basic methods of scientific investigation and exposition. (1979 p.110 italics added).

So Widdowson views science as comprising universal concepts and methods. In addition, when such deep structure concepts and methods are expressed, then the same semantic configurations are maintained.

Earlier in the same book he writes,

I think that this communicative deep structure frequently emerges on the surface as mathematical expressions, formulae, graphs, charts, conventionalised diagrams, and so on which take the same form irrespective of the differences of the verbal context in which they occur. (p.42).

The universal concepts and methods are thought to be revealed through various non-verbal forms, which in turn are regarded as invariable in form.

Robinson (1980) understands Widdowson as equating non-verbals and verbals with the surface structure, and as asserting that non-verbals are universal.

The surface realization of scientific discourse in any language eg English, will be a combination of verbal forms - unique to the language - and non-verbal devices, such as formulae and graphs, etc which are universal or 'neutral' with respect to different languages'. (1980 p 24).

The question of what is meant by 'depth' is not dealt with by Robinson though Widdowson uses it to argue that non-verbal material can be a useful intermediate step between languages which facilitates translation, since the non-verbals are the same in both languages.
It is clear from Sinclair (1972 p8) that modern textbooks of grammar can have different 'depths'. The non-verbals can be regarded either as the surface expression of the concepts of science, or as a deeper expression of verbal statements. Similarly in science a non-verbal, such as the symbol 'Na' of the element sodium, can also function as a verbal (sodium) in a sentence which uses the symbol 'Na' as a shorthand for the word 'sodium'. Either way, Widdowson regards non-verbals as universal. The example Widdowson gives is from chemical discourse.

Since these (devices such as symbols, equations, diagrams, and models of chemical compounds) are drawn from a universally accepted set of conventions for representing specific concepts and procedures in chemistry they can be said to constitute part of the deep structure of chemical discourse. (1979 p24).

Widdowson sees the non-verbals in particular as being a type of interlanguage, which he reasons is universal because they are drawn from a "universally accepted set of conventions" (1979 p24). Such non-verbal conventions make the understanding of scientific language when embedded in a foreign host language much easier. Widdowson schematises this as in figure 28.1 below.

**FIGURE 28.1 WIDDOWSON’S THREE WAY TRANSLATION**

A non-verbal device

L1 use

B

English use (L2)

C

(Widdowson 1975 p7, "(L2)" added for clarity).

Translation between L1 and L2, where symbols are involved, uses translation between A-B, and A-C. From previous studies of science in L1, the A-B translation will be known to a student. As non-verbal devices are said to be universal, where they are present they will be readily understood in L2.
To summarise,

Scientific exposition is structured according to certain patterns of rhetorical organization which, with some tolerance for individual stylistic variation, impose a conformity on members of the scientific community no matter what language they happen to use. ... scientific instruction is a means of secondary socialization whereby this conformity is transmitted. ... this conformity is reflected in the universal conventions associated with non-verbal modes of communicating. (1979 p61 italics added).

Science itself then has a universal semantic structure, universal concepts and methods, and universal conventions for non-verbals, the latter, non-verbals, functioning as an inter-language which if learnt in one host language will transfer readily into another host language.

2) The concepts and procedures of science are independent of the host culture

Scientists are presumed to have a common culture which is expressed in their textual material. This means for instance that the way of presenting an argument will be international, and that textbooks will be similar, irrespective of the host, or 'carrier' language (to borrow an idea from the world of radio waves) or as the French say, langage véhicule.

I think that it is likely that scientific textbooks written in different languages express essentially the same methodology. (1979 p43).

I assume that the concepts and procedures of scientific inquiry constitute a secondary cultural system which is independent of primary cultural systems associated with different societies ... the discourse conventions which are used to communicate this common culture are independent of the particular linguistic means which are used to realize them. (1979 p51).

Widdowson gives as examples of where he thinks the scientists culture is independent of the host language, the formulation of hypotheses, and the expression of relations of cause and effect, in the various 'texts' of scientists.

So I would wish to say that scientific discourse is a universal mode of communicating, or universal rhetoric, which is realized by the science text in different languages by the process of textualisation. (1979 p51).
Further, he sees this universality of scientific discourse as an important feature of science itself, or, to be more precise, as the feature which makes a particular text 'scientific'. Science itself, to be science, must be independent of language and culture, and so too must the linguistic expression of this science.

... scientific discourse represents a way of conceptualising reality and a way of communication which must, if it is to remain scientific, be independent of different languages and different cultures. (1979 p110).

In a similar way Dhaif (1985) regards the discourse of science as a universal mode of communication, and sees the implication as being that ESP is more strongly linked to the disciplines of science than to the individual learner and his culture and language.

... since science is a universal area of enquiry with identifiable communicative acts which are neutral to any specific language – and I am here referring to Professor Widdowson's model – it is assumed that it is possible to produce teaching materials which will be suitable to any EST group of learners irrespective of their learning contexts and/or cultural backgrounds. Thus the springboard of such materials is the discipline and its communicative acts rather than the learner and what he brings with him to the learning situation. (1985 p224). [2.]

3) Translation is easy in science

Translation should, according to Widdowson and his theory, be easier in the domain of science, between host languages, than the process of simplifying and popularising science within a given language.

Scientific discourse expressed through one language, for example, is likely to be closer semantically and pragmatically to scientific discourse expressed in another than to other areas of discourse expressed in the same language. ... as far as scientific material is concerned ... translation for peers is easier than simplification for a popular readership.(1979 p109).

2. Compare Chapter 29 Section 2 'ESP and constructivism' where this view that science (not the children) should be the starting point in teaching is briefly discussed in the light of work done on childrens' conceptions in science.
To put this in terms of Zylbersztajn's model (cp Chapter 4), the linguistic distance between the 'science of the scientist' in one language and the counterpart in another will be less than that between 'science of the scientist' and 'science of the student' within a single language.

Note, this is not exactly the same point as the one that Savory (1953) makes. Savory says that science is perfectly translatable while Widdowson is here making a point about linguistic distance and asserting that translation from scientist to scientist should be easier than translation (or adaption) from scientist to non-scientist. Savory (1953) clearly regards textual material in science as easy to translate. This is in part due to the use of words originating from Latin or Greek, which gives the words used in science a constancy of meaning. Savory goes on to make the extreme statement that,

Scientific prose has in fact a valuable and not uninteresting characteristic – almost alone among all the different categories of prose it can be translated into languages other than the language in which it was first written, not merely satisfactorily but perfectly. (1953 p113).

c. Critique of Widdowson

There are few direct critiques of the theory that scientific language is a universal mode of communication. Widdowson's views on translation will not be dealt with as I am not concerned here to assess if translation between host languages is easier than simplifying science within a language. My critique follows below (and in Chapter 29 Section 2a, for the implications for teaching).

1) Robinson (1980)

Robinson (1980) in her admirable survey of ESP, when she comes to Widdowson criticises him in areas other than that of the universality of the discourse of science, even though she mentions it as one of Widdowson's assumptions.
2) **Coffey (1984)**

Coffey (1984) comments that Widdowson makes two assertions.

a) Underlying science in any language is a universality in the
cognitive processes of science and technology.

b) ESP students will be familiar with these universals from
their previous studies of science in their own language.

If these two assertions are valid, then as Coffey says, ESP
consists largely of teaching methods of transferring this
knowledge between languages.

The first statement he regards as "not proven", and the second
one as often incorrect in practice. (p6).

3) **Bryan Wilson (1981)**

Bryan Wilson (1981) in an important review article argues that
science is not necessarily cut off from the culture of students,
as various attempts (which he cites) to export curricula seem to
have assumed.

A few writers, such as Morehouse (1967) and Ziman (1969) have
expressed optimism that science education is sufficiently
culture-free to be able to adapt relatively easily to new
cultural contexts. The weight of evidence, however, points the
other way. The dissatisfaction with imported or adapted
science courses which has been a feature of the educational
scene in many of the developing countries in the 1970's has
usually been directed at the syllabus, the textbook or the
examinations. It is likely, however, that its roots lie deeper,
in the alma, teaching methodologies and learning styles implicit
in the imported curricula. There is a growing awareness that,
for science education to be effective, it must take much more
explicit account of the cultural context of the society which
provides the setting, and whose needs it exists to serve. (p29)

Wilson recognises that sciences are culture bound to a certain
extent, particularly in view of the great scope for variety of the
sciences syllabuses compared to the uniformity of the mathematics
syllabuses.

Simple critical path analysis and basic arithmetical competency
alike are as relevant to planning an annual cycle on a farm
as they are to working on a production line or in mass
catering. The remarkable uniformity of mathematics syllabuses
across countries in vastly different economic and
technological circumstances is less surprising than the
Wilson then, while regarding sciences as relatively culture bound, still sees mathematics as culture free. This assumption was tested in particular in Chapter 11 'Linkwords'.

4) Swales (1984b)
Swales (1984b p69-72) has a lot to say in his introduction to Allen & Widdowson's seminal paper, "Teaching the communicative use of English" (1974) reprinted in a book of important papers of ESP which Swales (1984a) edited. First Swales puts Widdowson in context, as an applied linguist involved in the training of teachers of English as a Foreign language. (EFL). He then explains the classic distinctions between 'use' versus 'usage', and 'text' versus 'discourse'.

In linguistics, 'usage' basically means text analysis, and 'use' basically means an act of communication. Scientific English described as 'text' means to Widdowson that it is a "variety of English defined in terms of Its formal properties" (Swales 1984b p70) ie in terms of lexis and grammar. Widdowson rejects the idea that scientific English is 'text' and prefers to describe it as 'discourse' ie "a way of using English to realize universal notions associated with scientific enquiry". (1984b p70). In other words 'text' refers to analysing prose in terms of lexis and grammar, while 'discourse' refers to the particular communicative purpose.

The importance of these distinctions to Widdowson is that students of English should not just learn for instance the grammar of the passive, ('usage' or 'text') but make sure they know how to utilise the passive in meaningful communication ('use' or 'discourse'), combining knowledge of a foreign language with prior knowledge of subject matter from science.

Swales dislikes the classic distinction between 'use' and 'usage' because it is too simplistic, and in his view the two often go together. Swales also dislikes the way Widdowson failed to show any interest in the variety of discourse between different science disciplines and focused on discourse in general.
Swales says that Widdowson takes the assumption that there are universal modes of communication in the discourse of science, and by adding to it the fact that in ESP teaching at university the students already know some science in their first language [3.], Widdowson is able to draw the following conclusion:

... (the) EST teacher's task is to provide an alternative and English way of communicating the knowledge of science they already have. (Swales 1984b p70).

In his commentary Swales argues there is an inherent contradiction in Widdowson's arguments. If scientific language is a universal mode of communication, then 'use' is not important, for that will be similar across languages. The problem will be the particular realization of the universal mode of communication in another host language ('usage').

If science and engineering students and researchers are acquainted with the universal rhetorical organization of the text-types in their discipline they are faced with a simple problem of usage i.e. they are faced with a problem of linguistic translation. Such non-native speakers of English do not apparently need to be taught how scientific textbooks, papers, or lectures are constructed in English; all they need to be taught is the English language (the correct use of English tenses etc) that will transform their first-language script into a foreign language. (Swales 1984b p71).

This means that given similar approaches and content, only the linguistic form of the host language changes, therefore students need to learn these forms ('usage').

Widdowson argues that the best teaching approach is to make the English lesson as similar as possible to a science lesson, and to build on the educational knowledge and experience of the students. Swales argues that this line of argument contradicts Widdowson's own assertions that there is universal rhetoric in science. If such universal rhetoric exists, then the problem is the correct form to use in the host language. Therefore the science lesson model is irrelevant, since a science lesson model would reinforce the already known universal rhetoric.

Swales questions that science lessons are the same in English and French. If they are, the science lesson taken as a model for ESP is not needed, and if not, then paradoxically again, a science lesson might be a good teaching model to utilise.

The irony is (as Swales points out) that if Widdowson is wrong about universal rhetoric, then the stress he puts on good communication of scientific material in English becomes even more important, for the new rhetoric will need to be taught, as well as the verbal realisations of that rhetoric.

On the other hand, we have to abandon Widdowson's hope of using a methodology based on the teaching of science in the first language because it is now recognised as a local phenomenon. (Swales 1984b p72).

d. Discussion of Widdowson in the light of the results

It is clear that Widdowson regards the concepts and methods of science, the discourse of science, and the non-verbals used, as all being in some way 'universal' (as explained earlier in Section 2). His views on words are less clear, and these are discussed below. It is very interesting then that the clearest results of this thesis, in which scientific language has been shown to be fully constant or not constant at all between French and English, come from the non-verbals. It was for the non-verbals that Widdowson seemed the most confident, even postulating that non-verbals were a kind of inter-language. While some non-verbals could not be classified in such a clear cut way, none of the types of words could be classified as completely constant, or not at all constant between languages. This thesis has therefore been a good initial test of Widdowson's ideas that non-verbals are a kind of universal interlanguage.

On the other hand it is not clear what Widdowson's views are concerning words. Following the reasoning of Widdowson, if words could in some way also be regarded as universal, then the semantic space would be similar. Each language would divide up the semantic space in the same way: collocations and connotations of equivalent words would be kept constant, though the actual term used may have a different form. This overlaps with the views of some ESP
practitioners, considered in Section 4 below. This thesis provides some answers to the question as to how 'universal' scientific words are. Take for instance Chapter 14 'Eponyms'. In Widdowson terms, the existence of two terms with different form is irrelevant, provided that the semantic fields and the connotations are maintained. But with eponyms, though the semantic fields often stay the same, the connotations change when either different eponyms are used in French and English, or one language uses an eponym and the other language does not. Newton's second law of motion, which is called in French *la relation fondamentale de la dynamique* is a classic example where the law in English has the connotation of 'secondary' and in French bears the connotation of 'primary'.

If the concepts and methods are similar, expressing the same semantic space, then presumably definitions will be similar in French and English. Several clear examples have been found where this is not the case. A force is defined differently in French and English, and a 'line' has a different semantic field to its French equivalent 'ligne' which is rooted in fundamentally different ways of viewing reality so expressed (Chapter 9). 'Negative' has a different semantic field and collocations in English and French (Chapter 10). Faux amis are in themselves not evidence against Widdowson's views as the actual form the words take is irrelevant provided the semantic fields are maintained, with one to one correspondence. It is significant therefore that almost all the faux amis studied in Chapter 8 show a lack of one to one correspondence, and examples have been documented where a single word in one language needed two words in another eg lens = *lentille + cristallin* and *respiration* = breathing + respiration. The assumption that there is a "universal semantic structure" (Widdowson 1979 p110 cited page 6 in full above) can no longer be held uncritically.

Neither can it be assumed that non-verbals are necessarily an 'interlanguage'. Some evidently could be (at least between French and English), and in such a case will be comprehensible across languages as Widdowson argues. But others are not constant across languages therefore cannot function as an interlanguage as Widdowson hopes. The argument also fails to distinguish between
recognition and correct use: students were able to recognise chemical formulae in another language, but when asked (at the English school) to re-write formulae they were used to in the foreign (in this case French) way, pupils found significant difficulties. (See Chapter 18 'Chemistry questionnaire').

Widdowson's views overlap with those of some practitioners of ESP, and their views on the constancy of scientific language will now be considered in the light of the evidence presented in the results.

4. SCIENTIFIC LANGUAGE: THE VIEWS OF ESP PRACTITIONERS

a. Introduction

Widdowson is a linguist. There are other authors who are involved in the teaching of ESP who have expressed views on the subject. The views of these ESP practitioners overlap with those of Widdowson, but are not identical.

b. Various viewpoints

1) Richards (1976)

Richards (1976) says about scientific English,

... it uses the stock of international scientific terminology based on Greek and Latin roots, the terms of particular branches of science, and other coinings; it assumes familiarity with the symbols and visual conventions of mathematics. (page x)

The terminology and the symbols of science are presumed to be largely international and exclusively so. Richards does not mention explicitly the possibility that there could be more than one international system in existence and use by scientists, therefore he fails to make explicit this condition of exclusivity, but is is fair to assume he includes this as he refers to a single scientific language.
2) Strevens (1973, 1977)
Strevens (1973) gives some of the features of technical, technological and scientific English and gives some hints for teaching in these areas. In his appendixes classes of linkwords are listed, and some of the prefixes, suffixes and root words of Greek and Latin origin used in science with examples and approximate meanings. Elsewhere (1977) he outlines his views on the internationality of language in science as follows,

What is the nature of scientific discourse? The answer to this question is complex, but one essential component of the answer is that science is international in a peculiar linguistic way. Not only are the numerals of mathematics, the written names of chemical elements, the symbols of logic, and a few other sets of operators, largely inter-comprehensible by scientists everywhere irrespective of the language used by the individual scientist, but in addition there is a stock of Latin and Greek roots and affixes which combine to form a large number of words whose meaning is 'science specific', as it were, rather than language-specific. . . . A central core of this vocabulary makes up a normal part of the training of all scientists. (1977 p153).

Strevens views scientific discourse as international in areas such as symbols and words. But to say that he is not aware of differences would be to misinterpret him. In the same paragraph cited earlier, Strevens argues that teachers of English to scientists should be aware both of the central areas of agreement, and that they must,

. . . know and be able to teach the particularities of how this core is verbalised in the language being learned, and especially how it is spoken. To take a trivial example, he needs to know that the translation equivalent of English 3.5 ('three point five') is 3,5 ('three comma five' in French, German and several other languages). (1977 p153. cp also Austin & Howson 1979).

Strevens then views Science as international in the area of symbols, and in certain verbal areas such as words of Greek or Latin origin. In common with Richards (1976) above he too fails to add in the concept of international being exclusively so, though from the context this is arguably what he meant.
3) Ewer (1971)

JR Ewer (1971) identifies the "items essential to basic scientific English" (p67) which were not dealt with adequately in the English courses then used in Chile, and goes on to talk about types of exercises the teacher could use to fill these gaps. He paid particular attention to "the all important structural and modifying words and phrases". (p68) Also, other exercises were developed, which he saw as mainly of local interest and origin, dealing with areas such,

- false cognates [ie faux amis]
- shades of colours
- oral forms of numbers,
- letters of the alphabet,
- symbols. (p68)

As someone involved in course development, Ewer was interested not just in the differences as such, but in the significance of those differences. This significance he defines as,

... to discriminate carefully between 'acceptable' mistakes, ie those that do not interfere materially with communication between scientist and scientist and those that do: it is the latter that require additional exercises. (1971 p68).

Ewer is helpful in spelling out some of the areas in which scientific language is evidently not constant. In particular he recognises that what in this thesis are called 'linkwords' are important, also that faux amis can give problems.

c. Discussion

Like Widdowson, non-verbal forms are generally though of as international, with a few exceptions. The comments made above on Widdowson are therefore equally applicable here. But in addition the actual words used, the scientific language is seen as international in particular "scientific terminology" (Richards 1976 page x) the written names of chemical elements and the affixes (Strevens 1977 p153).

As has been shown in Chapter 17 'Chemical terminology', a third of the names of the chemical elements have different names in English and French, with seven of them having completely different names.
The results of Chapter 12 'Prefixes and suffixes' show that affixes are not always international, and that even when the forms correspond the usage in combination with other word stems is not necessarily constant between French and English.

The results have shown that at neither the level of words nor the level of symbols and other non-verbals can it be assumed that there is constancy of scientific language: some scientific language is international but not all of it.

5. SCIENTIFIC LANGUAGE AND NON-SCIENTIFIC LANGUAGE

If the language in science is so non-international, the question is asked, what makes linguists think language used in science is so special? What distinguishes scientific language from the use of language in any other domain? The question has already been asked and partly answered in Chapter 4 'scientific language'. The results have shown that there are many differences in vocabulary between English and French. It would be a momentous and probably pointless task to find out if the differences were greater or lesser for scientific topics compared with non-science subjects. But the assumption that science is somehow immune from the vagaries of language is plainly no longer tenable.

Science then could be like any other subject, it is not necessarily special despite the supposed internationalness of science, and various forces working towards making scientific language international. Science needs precision, and there are pressures at work to support clear communication across language barriers. But precision is also needed in other domains.

The language of science includes mixed words. It is possible that the older the word, and the more a word has a common usage, the greater the probability the usage will be different between languages. This possibility ought to be testable, but the problem would first be, to be sure that in a small topic area, one had identified all the possible scientific words, and all of them were tested between languages, and all
the suspect words could be analysed for their semantic fields, [4.] and their age specified. Having done this for one topic area, small enough and delimited well enough to ensure with reasonable confidence that the word list was comprehensive, the results would only apply to that one small topic, and could not be generalised upwards to scientific language as a whole. This exercise might be most useful for narrowly circumscribed areas such as the language of pilots, especially in the clear identification of differences, but is hard to envisage for the whole of science. This is despite the clear need for more of the differences to be identified and elucidated in view of the proposed free movement of students in the European Community.

A good example of older words being a problem is the way that the detailed names of sugars are much more international than the group words (see Chapter 17 'Chemical terminology'). It is possible that the group words come from the general language and the specific words, invented in more recent times, are more international because of their modernity.

Therefore it is possible that CSL has a greater applicability when the newer, 'science only' words are in use.

But, the situation is not so simple. Cases in point do not prove a general rule, only illustrate a possibility. The idea that newer words are international sounds attractive as a theory, and undoubtedly is a force operating in certain circumstances, but its generalisation rests questionable.

6. ZYLBERSZTAJN RE-VISITED

Figure 4.3 presented Zylbersztajn's framework as applied to science in two languages if scientific language is constant. The results are strictly applicable to the parts of Zylbersztajn's framework called 'Science of the Curriculum' and 'Science of the teacher'. Figure 28.2

4. For the clear identification and study of semantic fields in definitions across languages Werner has developed a system called MTQ, which is explained in Werner & Schoepfle (1987), the theoretical basis being given in detail in Werner & Topper (1976).
shows these parts, adapted in the light of the results. I have deleted the 'science of the scientist' because the results were not in this area.

FIGURE 28.2 SCIENCE IN TWO LANGUAGES ACCORDING TO THE RESULTS & CSL

Effectively then, just as for the science of the student, there is some scientific language that is constant, there is also scientific language that is not constant between French and English for the science of the teacher and the science of the curriculum.
7. THE SAPIR-WHORF HYPOTHESIS

This hypothesis has two forms, the weak form and the strong form. The weak form is that our conceptual categorisation of the world is partly determined by the structure of our native language. The strong form, linguistic determinism, is that our conceptualisation is largely or wholly determined by our native language.

The strong form has been rejected by most linguists, as is stated by Hill (1988) in a review of the evidence.

No strong form of linguistic determinism is supported either in the writings of Sapir or Whorf...or in the available data. (p15).

But the question as to how much content is influenced by language, is worth commenting on in the light of CSL. In terms of CSL, the question is asked as to how much language is the neutral conveyor of content. If scientific language were to be completely constant, then this would imply that the nature of science determines both the conceptual categorisation of the world and the language of science. Therefore the reverse of Sapir-Whorf would be tenable. Instead of language determining thought, thought would determine language.

To some extent thought in science has determined language. For instance, matter being viewed as made up of elements and the assigning of a unique international symbol to represent each element, or the setting up of a single international system of units and quantities.

In other areas language has influenced thought, for instance some definitions (eg of a force, or a line), the differing connotations of eponyms, and the differing ways of doing long division in which a different written style is linked with different patterns of thought to achieve the same goal.

The lack of constancy in scientific language shows that there is some interaction occurring between language and thought such that language can itself be said to be influencing thought. Science is not supra-cultural: it is inside cultures and inside host languages. Scientific language is affected by the host culture and host language.
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Widdowson has said that scientific language is a "mode of communicating which is neutral with respect to different languages" (1979 p42) i.e. thought influences language, which is the opposite idea to the Sapir-Whorf hypothesis. In a similar vein he refers to the "universal semantic structure of science" (1979 p110).

If these Widdowson's viewpoints are valid, then they are contrary to the Sapir-Whorf hypothesis. This thesis has shown that there are not necessarily universal semantic structures in science in that the host language can have an influence over thought in science. Even the "non-verbal devices" (1975 p7) which supposedly function as an 'interlanguage' are not necessarily constant therefore cannot be assumed to function in this way. It cannot be asserted that the independence of scientific discourse from host languages is what makes it scientific (1979 p110). To the extent that constancy is not maintained, the weak form of the Sapir-Whorf hypothesis is supported. Likewise, where there is constancy (e.g. of the symbols of elements) the weak form of the Sapir-Whorf hypothesis is not supported.

It is obvious from the results that the form students are taught science in affects their whole approach to a subject. For instance, Tunisian students were taught science using a lot of mathematics and this influenced the way they learned a subject, and how they regarded it. [5.]

The situation has some interesting parallels with a question that comes up in the area of the philosophy of science as to the relationship between observation and theory. Does one make observations and seek a theory to fit them, or does one have a theory in mind and look for evidence? Hodson (1986c) argues that "In practice some view of the world (some theoretical perspective) precedes observation" (p21). In a similar way host language precedes scientific language, which, (like observations) in turn often modify the host language (or theory). "All concepts are anchored to some theory" (p23) in the same way that scientific language is anchored to a host language. "Particular concepts will even undergo a marked change of meaning when transferred from one

5. This agrees with the viewpoints of Berry (1985 p19) and Austin & Howson (1979 p168).
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different theories and CSL. As far as language is concerned there is for instance a marked change of meaning when the definition of a force was changed from French to English.

Hodson (1986c) argues that observation and theory are integrated together, and what makes science objective is this close integration. It is the consensus within the scientific community about which theoretical interpretations are accepted that gives observations in science their objectivity (p24-5).

It could be said that some scientific language is cross cultural because the consensus in the scientific community of different countries about the form, meaning and use of this language makes the language constant and supra-cultural.

In another article Hodson a five point summary. I have quoted him below in the left column and paraphrased him in terms of the Sapir-Whorf hypothesis in figure 28.3 below.

**FIGURE 28.3 OBSERVATION AND THEORY, COMPARED WITH SCIENTIFIC LANGUAGE AND HOST LANGUAGE**

<table>
<thead>
<tr>
<th>Observation and theory (Hodson 1986b p385)</th>
<th>Scientific and host language (Paraphrased, IL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Recognition that observation in science is unreliable and theory dependent.</td>
<td>Scientific language is not necessarily constant and is dependent on host language.</td>
</tr>
<tr>
<td>2. Realization that techniques of scientific observation have to be learned.</td>
<td>Scientific language has to be learnt.</td>
</tr>
<tr>
<td>3. Acceptance of children's existing conceptual frameworks as the starting-point for science education.</td>
<td>Acceptance of children's existing host language as the starting point for teaching the language of science.</td>
</tr>
<tr>
<td>4. Reconsideration of the desirability of the discovery approach in the light of the dynamic relationship between observation and theory.</td>
<td>Reconsideration of the leaving of students to learn scientific vocabulary for themselves in the light of the dynamic relationship between scientific language and host language.</td>
</tr>
<tr>
<td>5. Rejection of the objective and value-free image of science traditionally projected by the curriculum.</td>
<td>Rejection of the constancy of scientific language traditionally assumed.</td>
</tr>
</tbody>
</table>
As can be seen above, there are therefore some interesting parallels between Hodson’s view of the relationship between observation and theory, and that between scientific language and host language. The comparisons cannot be pushed too far. It is difficult to see what is the equivalent for instance of rejecting an observation or theory. But in both areas the relationships are dynamic and integrated.

8. CUMMINS’ INTERDEPENDENCE HYPOTHESIS

Cummins, working in the bilingual situation of Canada, has propounded several hypotheses concerning learning through a second language and how the languages inter-relate. His three main hypotheses are:

a. The 'developmental interdependency' hypothesis, which proposes that the development of competence in a second language (L2) is partially a function of the type of competence already developed in L1 at the time when intensive exposure to L2 begins.

b. The 'threshold' hypothesis, which suggests that there is a minimum level of competence a bi-lingual child must attain to overcome the disadvantages of working in two languages and to begin to benefit. (Cummins 1979 p222).

c. The 'interdependence' hypothesis, which suggests that, ...
   cognitive academic knowledge is held in common storage and underlies the ability to understand or express it in either language given adequate levels of linguistic proficiency in both languages. (Cummins & Swain 1986 p39)

It is this latter, 'Interdependence' hypothesis that is relevant to this research. Given that thought does not take place in words (despite the commonly held opinion that it does), then thought can use any language for expression, and any language is in principle able to express thought, though in some areas the terms may need developing. (Strevens 1976 p58). The key 'given' in this hypothesis, is the given of adequate linguistic proficiency in both languages.

What then is adequate linguistic proficiency for someone communicating scientific ideas? If scientific language were to be constant then the knowledge in one language would transfer easily to another, and 'adequate' would refer to general linguistic proficiency with no special attention being paid to science.
Communication across language barriers in science does indeed require a basic general proficiency. But this thesis has shown that this is not enough. Adequate linguistic proficiency must include a grasp of the different ways a concept, an idea, an approach is expressed in the two languages, in short, not just the differences at the level of words and symbols, but also the general culture. The scientific culture in schools is not the same in England and in Tunisia in many important respects.

This thesis underlines the unfashionable, but important task of doing contrastive work in language teaching. Cummins' interdependence hypothesis, that skills and knowledge in one language are transferable to another is only valid if his concept of 'adequacy' includes that fact that the language forms can vary, (both for symbols and words) and even the content itself can change (eg force having 'sens' and 'direction' in French).

9. REFERENCE BOOKS AND TRANSLATORS

The failure of CSL is at its most dangerous when someone is not aware of a difference and assumes constancy between languages. Without the knowledge of differences, there can be no accommodation for them. This awareness needs to be knowledge in depth as the questionnaire showed, when some students who were aware of differences overestimated their ability to handle them. Even an area such as the prefixes and suffixes is not a safe area for when there are similarities of form, it does not always follow that their meaning will be the same in each language.

One big problem in this area was the inadequacy of the dictionaries. One dictionary in particular I must single out as inadequate, the Harrap's Science Dictionary (1985). It is an important one in the Tunisian context, in that it was the only bi-lingual science dictionary on sale in Tunisia during the time this research took place. The basic problem is that differences between the languages are not explained: giving synonyms for translation is not enough. The English distinction for instance between speed and velocity is not present, and the key English noun, 'control' is not even listed, 'témoine' being translated as 'standard'. At least the Harrap's 'New Shorter' French and English Dictionary (1978)
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gives for the English 'control' the French 'témoi\'n'. Other examples could be multiplied (see results chapters).

bi-lingual dictionaries are weak in giving both meanings and available equivalents. the lack of good reference material is in my opinion a serious deficiency that linguists trained in science ought to meet.

10. CONCLUSIONS

It has not been possible in the scope of one thesis to test all the aspects of the constancy of scientific language. Instead, I have concentrated on the verbal and non-verbal levels of communication. It has been shown that constancy is often only partial: there are a few very restricted linguistic features where constancy can be assumed and there are other areas where there is a total lack of constancy.

Two viewpoints have been explained in this chapter, that of Widdowson, and that of some practitioners of ESP. The latter ESP viewpoint is similar to the situation in Tunisia as explained in Chapter 2. They are all summarised in figure 28.4 below.

Before any attempt to teach English to French speaking students of science can be made, differences between 'science through English', and 'science through French' must first be documented. Only then can it be known what prior knowledge of science and its conventions can be safely assumed to be constant, and left without any formal teaching.

Documentation of differences must also precede an evaluation of their significance. Ewer (1971) quoted in figure 28.1 lists some features of scientific English and points out that given the differences and the difficulties they cause for students,

the important thing here is to determine clearly which of the difficulties that students appear to encounter are significant. (1971 p68)

This raises the question as to what is a significant difference. Ewer sees a significant difference as one giving significant difficulties to the students. This helpfully stresses the student's opinion about the differences (in contrast to the teacher dealing thoroughly with the
points he himself may have had difficulty with, or conversely, points he has a special facility in teaching), but begs the question as to what is a significant difficulty. Ewer describes a significant difficulty as that which gives rise to 'unacceptable' mistakes ie that interfere materially with communication between scientist and scientist.

**FIGURE 28.4 COMPARISON BETWEEN WIDDOWSON AND ESP PRACTITIONERS**

<table>
<thead>
<tr>
<th>Widdowson</th>
<th>ESP practitioners</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Non-verbals constant</td>
<td>2. Non-verbals constant</td>
</tr>
<tr>
<td>3a. If scientific words constant:</td>
<td>3a. Scientific words constant:</td>
</tr>
<tr>
<td></td>
<td>-1:1 correspondence</td>
</tr>
<tr>
<td></td>
<td>-same semantic space</td>
</tr>
<tr>
<td></td>
<td>-form is irrelevant</td>
</tr>
<tr>
<td></td>
<td>-similar connotations</td>
</tr>
<tr>
<td></td>
<td>-similar collocations</td>
</tr>
<tr>
<td></td>
<td>-a word can be mixed in one language and science specific in another and vice versa provided there is correspondence when the word has a scientific meaning</td>
</tr>
<tr>
<td></td>
<td>-existence of a choice of words, either scientific or mixed is irrelevant provided there is 1:1 correspondence for the scientific words that are compared</td>
</tr>
<tr>
<td>3b. Faux amis only acceptable as valid evidence against if the semantic fields differ</td>
<td>3b. Mere existence of faux amis is valid evidence against</td>
</tr>
<tr>
<td>5. Rhetoric and discourse constant</td>
<td>5. Rhetoric and discourse constant</td>
</tr>
</tbody>
</table>
In this thesis a provisional attempt was made to assess the significance of some of the differences. In particular some of the faux amis were tested in sentence completion exercises (cp Chapter 8 'Faux amis' Section C 'Faux amis questionnaire'). In addition students were asked how confusing they found some of the differences and these opinions were contrasted with their actual ability to cope with the differences. Students were found to be over-optimistic. Some of the examples given also have had a greater significance than a mere difference, because they exemplify larger trends and differences of approach to a subject.

It is in schools that the foundations of mathematics and sciences are laid. Whatever the future specialism of a student is, it is here that the core of knowledge and skill is established, and the core, however deficient it is in certain areas, will be in the common possession of all science students at University who turn to learning English. This is particularly true given the narrow range of options possible in the baccalaureate in the French system.

The question if this core differs when languages are changed, has been substantially answered, and the areas identified where a teacher or student in an ESP situation can assume constancy of scientific language, and where he cannot, between English and French at pre-university level.
SECTION V DISCUSSION

CHAPTER 29
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   b. ESP teachers need to be fully aware of the differences.........3
   c. Differences need full comprehensible documentation..........3
   d. Ways of transferring between languages need teaching........4
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      2) Explanation of language change..........................5
      3) Old units and symbols.....................................5
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      6) Special attention is needed for linkwords......................6
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5. DISCUSSION: A POSSIBLE ESP APPROACH..................................9
1. INTRODUCTION

This chapter considers what bearing the results have upon the subject of English for Special Purposes, particularly English to students of science. Section 3 considers the implications for constructivism, an area which has a lot to contribute to ESP. The fourth section considers ESP teachers and their training, and how the implications could be worked out in practice, given that most English teachers have very little background in science. The final part, Section 5 reconsiders possible ESP approaches.

1. GENERAL IMPLICATIONS OF THE RESULTS FOR ESP

a. There Is a need for ESP

If scientific language is constant then there should be no need for special teaching of the language of science to scientists. Yet there is such a felt need, and a whole industry exists to meet that need. The results have shown that the language of science while being constant in some respects, is not fully constant, therefore the felt need to have English courses specially designed for those studying sciences or other special subjects is supported by the evidence of this thesis.

Widdowson's views have already been discussed in the previous chapter. Widdowson, while stressing constancy, particularly in the discourse and the non-verbs of scientific language, at the same time has stressed the need for the science lesson to be taken as a model teaching approach for ESP. Swales' critique of Widdowson has already been examined.

The results of this thesis support neither Swales nor Widdowson. Insofar as scientific language is constant, there is no need to teach it afresh in a second language. Insofar as the knowledge of science is divided up semantically in a constant way then there is no need to re-teach a science subject in another language. But where there are clear differences, of non-verbs, of verbals, and in the whole approach to a subject, then the science lesson could well be a good teaching model in ESP: to the extent that there are
differences, then the scientific language and even the science itself will need to be re-learnt in English. The "English way of communicating the knowledge of science" (Swales 1984b p70 cp Chapter 28 Section 2c4) is not merely the "English language (the correct use of tenses etc) that will transform their first language script into a foreign language" (Swales 1984b p71 explanations in brackets added) but the actual forms and content of science itself.

b. ESP teachers need to be fully aware of differences
It may be stating the obvious, but in order to best help their students to cope with the differences, their teachers need to know about them.

c. These differences need full comprehensible documentation
Most teachers of ESP are not from a science background. Therefore there is a need for the differences to be documented, and explained in such a way that a teacher who is a non-scientist can understand them well enough to communicate the essentials of the differences to the students.

ESP is often, though not always, taught to students studying many different scientific disciplines. But all of them will have had a similar background at baccalaureate level, and that is a small enough area of common ground for a teacher to become acquainted with. Also, (as documented in this thesis) many of the fundamental differences exist at school level, and school level is not too difficult an area to work in. There is no reason, in principle, why good documentation cannot be produced that can be understood by Arts trained ESP teachers at least for pre-university level science.
d. Ways of transferring between languages need teaching

It is not valid to assume that scientific language is necessarily constant between languages. There are hundreds of differences between school science in English and in French, without accounting for the differences imposed on the science by the host language. This thesis is written having studied only words and symbols. If even at this level there are many differences, their number can only increase as sentence structure and style for instance are considered. These differences are numerous enough and significant enough to imply that they need explaining, suggesting the need for a contrastive approach in ESP teaching.

I am fully aware that this assertion flies in the face of much accepted language teaching philosophy. For reviews see for instance Klein (1986) and Ellis (1985). The philosophy is that language must be taught in and through that language without translation, and without reference to other languages. This is not just due to practical necessity, (because the teacher has a mixed group of students whose first languages vary), but also because of the idea that students must learn to think in a new language. From a common base a new language must be built up to encompass the world in a new way, without the restrictions of the semantic fields of one language being imposed on the other by the learner.

The traditional British approach to language teaching has always included the contrastive approach. (See for instance Astington (1980), Batchelor & Offord (1982)). ESP teaching in another country (as opposed to a mixed group in England, potentially from many different countries) can take into account the language background of students, which will be coherent enough for contrastive work to have its place. I submit that students going from one language to another when there are so many differences great and small, need the differences to be highlighted and explained to them. The teaching method of staying only in the taught language needs supplementing by explaining contrasts and paying special attention to:

1) Semantic fields

Raude (1985 p79, 182) in an article in *Science et Vie* (the monthly French equivalent of New Scientist) remarks that the French have
less a sense of semantic fields than the British do [1.] and that many of the differences between English and French can be put down to the different semantic fields that similar words might have in English and French. Therefore he concludes that more teaching and explaining of such fields needs to take place. In his view the 'direct' method of language teaching, without reference to other languages, gives problems at the intermediate stage when there is a tendency to impose the fields of one's first language on the fields of the second language. Explanation would help a student to know when to be careful, and in knowing what the differences are, how to be correct.

2) Explanation of language change
Some of the problems of transferring between English and French are simply due to the evolution of the two languages. A good ESP teacher needs knowledge of the recent history of these changes, as well as the present position in various fields, and not only be able to teach the major differences, but also be able to make available authoritative sources of guidance for students and other teachers. In the third world context libraries are often painfully inadequate. The ESP teacher, with all his links back into England for instance, with access to people, libraries and reviews, can begin to obtain and make available such information.

3) Old units and symbols
There are a certain number of units and symbols which continue in use in both French and English, which students may not be familiar with. Some are easily explained such as the Angstrom (See Chapter 19 'Symbols'). Other units such as units of pressure are not so easy. At the very least students need informing of such old units they might encounter and conversion factors from old to new units made available.

1. Though Raude (1985) makes many valid points in the article and explores some of the differences between English and French in science, he oversimplifies when he puts the British sense of semantic fields down to the existence and use of 'Roget's Thesaurus'!
4) The customs of science
The prime examples of this are the styles of labelling for graphs and tables. These are clearly very different in English and French. Should any students in ESP be at the level of writing for the journals, then obviously the detailed style sheets will need to be obtained, but so basic are the labelling differences that these could well be taught early on.

Another example would be the different ways of writing formulae, not only their recognition but their correct and fluent use. In the physics questionnaire not all students at the French school were able to correctly recognise formulae and use them in the English way despite the fact that they had used similar French formulae in class only a few weeks before.

5) Insist on high standards when using units and quantities, but train students to cope with low standards
I could not find a national policy for the use of units and quantities in France or Tunisia. Teachers in the English and French schools resorted to reading examination papers, textbooks, and curricula for their standards.

There is a tradition in England that insists on accuracy in this area from the early years of learning science. Students of science in English may need bringing up to English standards, while training them to be tolerant of authors, in French for instance, who are not so careful.

6) Special attention is needed for linkwords
This thesis has reinforced the importance of link-words in a language, and these need teaching both for their general use, and for their special use in science.

7) Special attention is needed for faux amis
Far from thinking that vocabulary need not be taught in English because scientific vocabulary is international, special attention needs to be given to the many faux amis. Faux amis are at their most difficult when they are not known about.
8) Special attention is needed for mixed (sub-technical) words

Mixed words, ie those which have two meanings, a common meaning and a restricted scientific meaning, give problems for monolingual pupils (cp Chapter 4 'Scientific language Section 4). The problem is exacerbated when two languages are involved because they are not necessarily going to have similar distinctions in any given word.

e. Gaps in knowledge and skills need remedial teaching

Given that in English there are different levels of assumed knowledge and skills, if students in French are to be brought up to comparable standards, then they will need extra coaching. Whether the ESP teacher does this, or arranges for it to be done, or provides material to the students for individual learning, will depend on the skills of the ESP teacher and the work context, but the gaps need filling. These gaps include:

1) Techniques of estimation
2) General chemistry
3) More familiarity with practical work
4) Basic statistical ideas and techniques.

For a discussion of these points see Chapter 27 Section 3k. 'Differences in curricula'.

f. Alternative methods of working need teaching

In cases where students are taught only one set method of solving a particular problem for instance in mathematics, then alternative ways, where they are more common in English, need teaching. A good example of this is graphical techniques which were not really known by students in the sixth year of physics, though their mathematical ability in algebra was superior to that required of students in physics 'A' level in England. It is apparently not that common in the French system to teach more than one way of solving a problem, whereas in England for instance, it is usual for both graphical and algebraic methods to be taught, where appropriate. In an examination the choice of method may be left to the student. In the French system there would be no choice, and algebra preferred to graphical methods.
2. ESP AND CONSTRUCTIVISM

CSL ignores the research from the constructivist school of psychology into the preconceptions and ideas pupils bring with them into a science lesson. Dhaif for instance says that,

it is assumed that it is possible to produce teaching materials which will be suitable to any ESP group of learners irrespective of their learning contexts and/or cultural backgrounds (1985 p224).

This view is no longer tenable in the light of constructivism. For example, Driver and Bell (1986), in explaining the main points of constructivism write,

Learning outcomes depend not only on the learning environment but on what the learner already knows: Students' conceptions, purposes and motivations influence the way they interact with learning materials in various ways. (p444 cp Driver Guesne & Tiberghien (1985) and Gilbert & Watts (1983)).

ESP materials need to take account of the language and culture differences, as both these results and constructivism would suggest. Given that French culture has influenced other countries, and Tunisia was a French protectorate 1883-1956 (Quid 1985 p934) and still has extensive cultural ties with France, the material presented here has the potential for being applicable to France and other Francophone countries. ESP material for the Franco-phone world needs to account for, and work within, the differences that exist between English and French.

3. ESP TEACHERS AND THEIR TRAINING

Most teachers of English to scientists are from an Arts background. While they know, or learn to teach English structures and forms well, they are ill at ease teaching English that involves science. A medical student here in Tunisia complained to me for instance that their teachers of English wanted to use easy texts, chosen by the teacher, and would not help them with texts they chose themselves that they were having difficulty with.
The implications of this thesis seem to increase the demands upon them to have a knowledge of science. The differences documented in this thesis at school level ought not to be beyond the intelligence or diligence of an Arts graduate to master, so this should be more feasible than might perhaps otherwise be thought.

Conversely, there is a need for science graduates like myself to learn to teach English. I have few fears that a medical student can give me a text I could not cope with given a little homework on my part. But science graduates are getting fewer, and the demand for them getting greater. It is unrealistic to expect that many science graduates will get involved in English teaching, though the few that do should find an important place in helping the other ESP teachers to cope with science.

This puts the pressure then back on publications. In principle it should be possible to produce teachers aids that help teachers to come to grips with the real language aspirations and problems of their students, and which while concentrating on the English do not ignore the actual content.

4. A POSSIBLE ESP APPROACH

Widdowson, as has been mentioned earlier (Section 2a.) saw the ideal ESP lesson as being as close as possible to a science lesson.

Scientific language is not always the same in French and English, therefore the model of the science lesson is potentially very useful.

To avoid the boredom of mere repetition of existing knowledge in another language, a possible approach is the one adopted by Tunisia in the English school. This was to teach science through English, with examinations in English, and having general English lessons as well alongside the science. At the English school the teachers of English were innovative, open to ideas, and worked with the science teachers.
Would it not be possible to choose, for instance for medical students, a subject like psychology which is an important but subsidiary subject, and to teach it at a slower pace, but in English and to take time to teach both the psychology and the English? This should be possible at least for advanced level English. Psychology is one of those subjects that Arts graduates should be able to understand, and to teach a new subject through a foreign language is to make the language meaningful to the students.

Another approach would be to simply highlight and teach the differences between science in English and science in another language in the course of normal teaching of English language.

Where mathematics is concerned, any ESP teacher weak in mathematics is going to find it extremely difficult to cope with a completely different approach, as is found in the French education system.

But a great deal of mathematics is realised through the verbal realisation system and cannot be dismissed by the language teacher as the responsibility of the specialist department. (Roe 1977 p30).

These verbal forms and the fundamental differences identified in this thesis, would not be too difficult to teach, thus giving students a good foundation upon which they can learn the English required in their speciality.

The demands on an ESP teacher are high. The ESP teacher will need to teach the English of science just as intensively and just as actively as the teacher of general English teaches the understanding, speaking and writing of non-science topics.
SECTION V DISCUSSION

CHAPTER 30

CONCLUSIONS

In the English school in Tunisia it was assumed that because scientific language was constant it would be possible to teach sciences according to French based curricula and textbooks with little difficulty; only the host language would change.

The results have shown that such an assumption is overstated. At school level the assumption is only tenable for linguistic features such as the symbols of the elements, the symbols and names of amino acids in man, and the SI system of units. Symbols and other non-verbal devices are not necessarily international; scientific vocabulary is sometimes similar but not always.

There is a desire in the scientific community for common standards, and a single international way of communication. The pressures within the European Community are towards increasing the areas where scientific language is constant and international. The pressures come not only from a desire to standardise for the sake of manufacturing, but also as a result of the pressures to make the education systems more alike and compatible. It is quite possible that in years to come scientific language will become more international.

To the teacher, the more interesting question is to what extent the assumption of CSL is valid. It is this breakdown into topics that is potentially more useful to a teacher than an overall statement: to know where the assumption is tenable and where it is not. The results as summarised in figure 25.2 are a good guide. For instance the parts 1 'completely valid' and 2 'generally valid' mean that a teacher has no need to teach these areas, as it can be assumed such features will transfer between languages, leaving just a few exceptions from section 2 to be noted. Part 5, 'completely invalid' can in contrast be taught in a formal way. It is the parts 3 'partly valid' and 4 'largely invalid' that are the hardest, and need the most care over an extended period of
time. In parts 3 and 4 of figure 25.2 each difference needs to be considered separately, generalisations are not possible, and the forms and semantic fields in a new language need to be incorporated into the teaching programme.

The results gathered here would have been of immense interest to the teachers in the English school if they had been available to them at the time. Ironically, it was the English school situation itself that made possible the gathering of much of the information presented in the results. Knowing what some of the differences are, where science is international and where it is not, and to what extent, would have saved the teachers a lot of work. For instance, knowing why a difference exists in the definitions of a straight line would have enabled more informed decisions about what vocabulary to use, how to stay close to French in English, and when it would have been preferable to teach both languages, rather than adapt the English.

Much of English teaching to science students (ESP) is at university level. Therefore it could be argued that these results are not much use to ESP. This objection ignores the fact that school science is foundational for much university science. When teaching a group of university students from several disciplines, it is the school science that will be the common ground between them. If differences can be shown to exist in scientific language in English and French at school level, then these differences will undergird any other differences found within a given science discipline.

No doubt other differences exist at the levels of symbols and words. A sufficient number have been gathered in this thesis to show where CSL is tenable and where it is not. Some areas, particularly the collocations, could benefit from considerable more work. It is a matter of regret that the names of enzymes has not been covered as there were few mentioned in the Tunisian books and syllabi. Much of the study of words has concentrated on those with differing semantic fields: it would be profitable to find words with the same semantic fields and connotations, yet with a different form. Students could then simply learn the new form and be confident that they could use such words in the other language as they do in their first language.
Though the research has concentrated on words and symbols, frequently such a narrow focus has brought great depth of field as details serve to encapsulate major differences which go beyond a consideration of just words and symbols. Further work needs to be done to assess other communication levels, such as rhetoric, style, grammar, and 'broader concerns' such as examinations, aims, contents and approaches of the curricula.

Similar work to this thesis could with profit be done between other language pairs, particularly within the languages of the European community and in view of pressures within it to make educational qualifications and skills transferable. The Arab world could benefit from the comparisons between Arabic and French, and Arabic and English.

There are two fundamental areas which need further work. A researcher with a mathematics background needs to identify and assess the differences between English and French. This thesis has touched on some of the differences, but my knowledge of mathematics is insufficient to do this task.

Secondly, given that differences do exist, more work needs doing to assess their significance. And this begs the question of significant for whom. For instance it would be interesting, in order to analyse the practical significance of the differences, to follow a cohort of pupils from the English school, and see how easily they adapt to university studies in French. It should also be possible to find French students coming to England and coping with science in English. For comparison with Arabic the situation of the Tunisian curriculum being taught in Arabic in the écoles normales needs exploiting.

The results are significant in that a widely held assumption when stated uncritically has been shown to be untenable. But to an ESP teacher, the question, as Ewer (1971) understood it still remains: In what way are differences significant for a student, and why? A teacher should assess his students' needs which have to do with their science in English. If only recognition and understanding is sought, then for instance there will be no need to teach how to write formulae in organic
chemistry the English way, since the different styles of formulae appear to be readily understood. But the other differences affecting comprehension, particularly the faux amis will need pointing out. A way to do this would be to give sentences as used in the questionnaire, or to get students to write sentences showing the correct English usage of the faux ami in question. [1.]

But before an assessment of significance can be made, the differences must first be documented. So this thesis has provided teachers and course writers with some of the important differences in scientific language between English and French which have been documented and explained. This thesis provides some more of the hard experimental data upon which decisions as to what should go into lesson materials can be based.

The results show that any school embarking on a curriculum in another language needs to know about the differences between the languages, as it is not valid to argue that science or scientific language is the same, that only the host language changes. The alternatives to teaching both languages are to adapt one language to follow the other, to decide to follow the English completely, or to teach both languages. The choice of action depends on other than linguistic reasons, though the linguistic factors need to be known. There is also a need in such circumstances for native speaker teacher-translators. Translators themselves are not necessarily going to know science, so a better solution is probably a team approach, of science teacher and translator.

It is also not possible to argue that mathematics, being based on symbols, is the one subject that is the most independent of the host language, therefore it can be the first subject to be taught in a foreign language. In Chapter 11 'Linkwords' I have argued that mathematics makes high linguistic demands upon pupils. It may well be that subjects relying less on linkwords and specialist vocabulary would be easier to teach in a foreign language. But this ignores the political

1. Van Roey (1988) is a source for such sentences, even though there is limited science content. Robert (1984) gives many phrases as examples of use, and these can with profit be translated into English, as was done when preparing the questionnaire.
and historical reasons why sciences are taught in a foreign language. Traditionally in North Africa, French has been the language of modernity, of opening into the western world. Arabic has been the language of history and culture. Therefore for reasons derived from the larger context it is probably not possible to consider taking the alternative route of teaching humanities rather than sciences through a second language.

With relation to Cummins' work on language transfer, the results indicate that skills in one language will only transfer to another language if the forms in the second language and the second language culture are fully known. This includes knowing exactly where the science is the same and where it is not.

The research has shown the need for a contrastive approach in teaching English to science students, because only by comparing and contrasting will differences be adequately mastered, and there are a large enough number of differences in the domain of science to warrant specific attention.

Finally, the list of linguistic features considered gives a framework for any future analysis in other disciplines. In the field of medicine for instance, some work has already been done, but teaching English to medical students would benefit from the broader considerations discussed in this thesis, so that the analysis can go beyond merely listing scientific words with their equivalents in another language.
APPENDIX 1: LETTERS

LETTER 1, REQUEST FOR PERMISSION TO DO RESEARCH IN THE TWO SCHOOLS.

(This was submitted with a letter from Dr Clark, head of the British Council in Tunis, stating that I was a research student at the University of Surrey in Britain, and that I was researching into Education in Tunisia "dans le cadre de la Coopération Technique". The letter commended my request in letter 1).

Ivan Lowe
Tunis, Tel: 1e 22 octobre 1987
A Monsieur le Secrétaire d'État auprès du Ministre d'État de l'Education, de l'Enseignement et de la Recherche Scientifique.

Monsieur,

Je vous serais reconnaissant de me permettre, ainsi que vous l'avez fait l'an passé, d'assister aux cours de Sciences et de Mathématiques dans les deux lycées pilotes de l'Aréana et Bourguiba.

Je vous rappelle que je fais un travail de recherche, en vue d'obtenir un Ph.D à l'Université de Surrey, sur l'usage de langues secondes dans l'enseignement des Sciences dans ces lycées. Ma patronne à Tunis est Madame Souad E. Zaiane Jamoussi à la Faculty de Lettres et Sciences Humaines.

Pour cela je souhaiterai avoir la permission d'assister régulièrement pendant l'année scolaire aux cours donnés en premières et cinquièmes années de ces lycées.

Dans l'espérance d'une réponse favorable je vous prie de croire en mes sentiments respectueux.

Ivan Lowe

SUMMARY OF THE REPLY
Letter received from Leila Bellalouna, on behalf of the Ministre de l'Education Nationale on 18 December 1987, addressed to Dr Clark of the British Council authorising attendance at science and mathematics lessons in the two schools and advising that I should contact the respective directrices direct.

LETTER 2, THANKYOU LETTER TO THE ENGLISH SCHOOL.

Tunis 20 June 1989
Dear Madame Soua,

I would like to express to you a huge "thankyou" at the end of my practical work for a Ph.D. These last two years have been extremely interesting and profitable, your staff have always been very kind and helpful and in a way of a small return, I have done my best to assist them whenever I could.

As far as I now know, there is nothing that remains to be done except to write up the results as a thesis, which I expect to take at least a year. When I have finished, and hopefully passed the examination, I will of course write to you and inform you of the result.

Once again, thankyou for all your kindness and help, and I wish you, your staff and your students, every success in the future.

LETTER 3, THANKYOU LETTER TO THE FRENCH SCHOOL.

Tunis le 20 juin 1989
Madame la Directrice,

Je voudrais vous remercier pour l'accueil que vous m'avez accordé pendant les deux dernières années. Pendant ce temps mes recherches ont bien avancé et je suis très reconnaissant pour toute l'aide que j'ai reçu de la part de professeurs de votre lycée.

J'espère après avoir écrit la thèse, d'obtenir un doctorat, (Ph.D) et vous serez informée.

Une fois de plus je vous remercie et je vous prier d'agréer, Madame la Directrice, l'expression de mes sentiments les plus respectueux.
Appendix 2: Informants

(TE = English speaking informant, TF = French speaking informant)

**English school**

TEA British biology teacher. At least ten years experience. Degree in Botany. Worked in Tunis 1986-88

TEB Tunisian biology teacher

TEC Tunisian biology teacher

TEF British mathematics and computers teacher 1986-89

TEG British physics teacher 1986-7

TEH British physics teacher 1986-88

TEI British physics and computers teacher 1988-90

TEJ British biology teacher 1988-90

TEK Tunisian physics teacher

TEL Tunisian physics teacher

TEH Tunisian physics teacher

TEI Tunisian physics teacher

TEP Dr Graham Stott. British lecturer in Tunis until 1986

TEQ Dr Clark. Head of British Council Tunis until 1988

TER American linguistics researcher, Tunis, until 1986

TES British parent, whose children were in the French mission schools in Tunisia, both of whom did the Bac-C.

TEU Tunisian teacher of English at the English school

TEV British mathematics teacher until 1988

**French school and others**

TFA French biology and computers teacher

TFB Tunisian biology teacher

TFC Tunisian physics teacher

TFD Tunisian physics teacher

TFE French biology teacher

TFF Tunisian physics teacher

TFG Madame Jamoussi, Lecturer, University of Tunis, sponsor for authorisation to do research. Honorary supervisor in Tunisia 1987-89

TFH Mahdi Abdeljaouad. Head of mathematics, then head of the Institut Supérieur de l'Education et de la formation continue. Honorary supervisor in Tunisia 1987-89

TFI Ex deputy head at the English school, early source of ideas.

TFJ Mathematics lecturer at the Institut Supérieur de l'Education et de la formation continue.

TFK Bannour H. Lecturer in English, Sousse. Thesis on Tunisian Education.

TFL Deputy head, French school.
## APPENDIX 3: LESSONS OBSERVED

### LESSONS OBSERVED. TERMS 2 & 3 1987 BIOLOGY

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<th>TFB</th>
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<th>TFA</th>
<th>TEA</th>
<th>TEB</th>
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<td>T15</td>
<td>T14</td>
<td>T16</td>
<td>T17</td>
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<td>T19</td>
<td>T21</td>
<td>T20</td>
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<tr>
<td>25-29 Jan</td>
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<td>T22</td>
<td>T25</td>
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<td>T26</td>
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<tr>
<td>1-5 Feb</td>
<td>T29</td>
<td>T27</td>
<td>TEST</td>
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<td>T28*</td>
<td>T32</td>
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<td>10</td>
<td>16</td>
<td>10</td>
<td>12</td>
<td>32 = 101</td>
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### Notes

* Indicates two hours of practical. Each lesson was an hour and each meeting two hours.

1. Few lessons were observed near end of term and beginning of term, as explained in Chapter 6 'Procedures' section 2.
2. Term officially ended in mid June for the pupils.
3. T103 included a long interview with the inspector for biology. T105 was a follow on, and the inspector took a prominent part in T82.
### Appendix 3 Lessons observed -2-

**LESSONS OBSERVED TERMS 4-6 1987-88**

(P or Phy = physics, C or Chem = chemistry)

<table>
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<th>Teacher</th>
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<th>TEM</th>
<th>TEN</th>
<th>TEK</th>
<th>TEL</th>
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#### Notes

1. The French school for TFF Physics was not in phase with the English school, as the English had done dynamics in the first term. In all other cases the lessons were roughly in phase.

2. In addition I saw one lesson of sixth year optics, (T235, on the 20 Jan 1989 TEL) and two lessons of fifth year pressure (T234, 240 on the 28 & 27 Jan 1989 TET).

3. The time in meetings is a minimum, I attended other times and found nothing interesting so have not reported them here.

4. The times do not account for all the work of administering the questionnaires.

---

$ Meeting at the French school, not the English school as for all the other meetings.
 PERSONAL INTERVIEWS

These references exclude notes made after meetings with various ministry officials in obtaining authorization, the phone calls and other short discussions. (REF = reference)

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APPENDIX 4: CONCEPT MAP

Presented below is a concept map of the English school in the setting of education in Tunisia with special reference to definitions. The double and single lines have no meaning, they are used solely for purposes of clarity. (See Chapter 6 'Procedures' Section 7 'Concept map'.)

Ultimately responsible for:

- **THE MINISTER OF EDUCATION**
  - Appoints team

Appoints:

- **Directorate of Curricula and in-service training (ministry department)**

Equipment:

- **Personnel hire & fire**

Members of:

- **National Commissions - Programme -**
  - Check contents of Examinations setting of

Given to:

- **Inspectors**
  - Some involved in

Tasks:

- **Outside courses**
  - Responsible for the implementation

- **Assist and assess student teachers**
  - Supervise marking of examinations and finalise results

- **Supervise marking of examinations and finalise results**
  - Assist and assess student teachers
  - Supervise marking of examinations and finalise results

- **Inspectors**
  - Responsible for the implementation

- **Members of National Commissions - Programme -**
  - Check contents of Examinations setting of

- **University professors**

Sets:

- **Programme content and philosophy**
  - Determines
  - Influences

- **French textbook**
  - Influences

- **Adaptation English school**
  - Influences

- **Science lesson**
  - Influences

- **Definitions**
  - Feeds into

- **Uses**
  - Creates need for

- **Create expectations**
  - Pupils
  - Sixième examination
  - Primary school: parents & other influences

- **Teachers**
  - Assist & assess

- **Assist and assess student teachers**
  - Supervise marking of examinations and finalise results

- **Diverse backgrounds**
  - Influence

- **English/French teaching**
  - Influences

Influences:

- **Science lesson**
  - Influences

- **French textbook**
  - Influences

- **Adaptation English school**
  - Influences

- **Programme content and philosophy**
  - Determines
  - Influences

- **Definitions**
  - Feeds into

- **Create expectations**
  - Pupils
  - Sixième examination
  - Primary school: parents & other influences

- **Teach English/French lessons**
  - Diverse backgrounds
  - Influence
APPENDIX 5: HOURS OF STUDY

Hours of study per subject, comparing the English school E, the French school F, and a normal Lycée N. ('Year 1:1' refers to year one term one, 'year 1:2' year 1 term 2, and 'year 1:3' year 1 term 3).

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APPENDIX 6: CHEMISTRY QUESTIONNAIRES

EXPLANATION

(See also Chapter 18 'Chemistry questionnaire'.)

Reproduced below, in a compressed format, are the organic chemistry parts of the questionnaires given to both the English and the French schools. The originals had sufficient spacing for the answers of the pupils. The first two questions concerning the E and Z forms of but-2-ene were withdrawn from use after initial results had shown that students were only confused between E and Z, and therefore the formulae were not helpful in testing the theory. In the mark scheme, each compound was assigned a list of features which had to be present for a correct answer to be scored. This mark scheme is noted below in script and is recorded after the first set of questions only. At least one class in each of the four sets was remarked at a later date to check the accuracy of the marking. Then each pupil, for each compound, was scored for English version right, English version wrong, French version right, French version wrong, no answer. The results where Language 3 (L3) was wrong, and Language 2 (L2) was right were isolated and compared with L3 right, L2 wrong. The questions were answered under examination conditions.

THE QUESTIONNAIRE

Organic Chemistry, Lycée Ariana. (English school, French version)

I would be grateful for your help in my research. You can help me by answering the questions below. Please note my research has nothing to do with your tests, exams and devoirs. I can assure you that I will NOT give your papers to the teachers and you will not get any marks for these questions.

Please write all the answers in the spaces provided.

YOUR NAME: CLASS NUMBER:

1. IMPORTANT: Do you own any French sixth year Chemistry textbook? (ie from France or from Tunisia). YES/NO.....

2. Do you ever read and use a French sixth year Chemistry textbook. YES/NO.....

Written below are the names for some chemicals, written in the French style. Try and draw the structures for these compounds.

3. Z butène-2 (C=C in right place, four carbon atoms, one CH₃ on each of the two carbon atoms with a double bond and on the same side, top or bottom)

4. E butène-2 (As above but CH₃ groups arranged diagonally)

5. butadiène-1,3 (C=C’s in right place, four carbon atoms)

6. dibromo-1,2 méthyle-3 butane (four carbon atoms, Br Br CH₃ in right order. If students mixed up Br or Cl in this or other questions, this was ignored)

7. dichloro-1,1 méthyl-4 pentyne-2 (five carbon chain, with C=C in right place, Cl Cl on end carbon and CH₃ on fourth carbon)

8. méthyl-2 butanol-2 (four carbon chain, OH and CH₃ on second carbon)

9. diméthyl-3,6 octyne-4 (triple bond between fifth and fourth carbons, CH₃ on third and sixth carbon. Not concerned about numbers of hydrogen.

10. trichloro-4,5,5 pentadiène-1,3 (double bonds in right place, Cl on fourth carbon, Cl Cl on fifth carbon)
I would be grateful for your help in my research. You can help me by answering the questions below. Please note my research has nothing to do with your tests, exams and devoirs. I can assure you that I will NOT give your papers to the teachers and you will not get any marks for these questions.

Please write all the answers in the spaces provided.

YOUR NAME: CLASS NUMBER:

1. How often do you read French Chemistry, Physics or Biology textbooks? FREQUENTLY /SOMETIMES /RARELY /NEVER

2. For each statement below state whether it is TRUE or FALSE for you personally.
   a) I find it easier to read French than English TRUE/FALSE
   b) I would like to read French books but cannot afford to buy them. TRUE/FALSE
   c) I need to read French books because TRUE/FALSE
   d) I do NOT need to read French books as I get all the information I need from the English books and the lessons TRUE/FALSE
   e) I do not have time to read other books TRUE/FALSE

Written below are the names for some chemicals written in the English style. Try and draw the structures for these compounds.

3. Z but-2-ene
4. E but-2-ene
5. 2methylbutan-2-ol
6. 1,1-dichloro-4-methylpenta-2-yn e
7. 4,5,5-trichloropenta-1,3-diene
8. 1,2-dibromo-3-methylbutane
9. buta-1,3-diene
10. 3,6-dimethylocta-4-yn e.

Chimie Organique, Lycée Bourguiba (French school, English version)

Je vous demande de m'aider avec mes recherches, en répondant à quelques questions. Il n'y aura pas de notes, puisque ces questions n'ont rien à faire avec vos examens et vos devoirs. Elles vont être utilisées pour mes recherches seulement, et ne seront pas données à vos professeurs.

VOTRE NOM: VOTRE NUMERO DE CLASSE

1. Est-ce que vous avez jamais lu quelquechose en anglais concernant la chimie organique? OUI/NON.....

2. Si vous avez répondu <<OUI>>, qu'est-ce que vous avez lu?

Vous trouverez écrit ci-dessous quelques noms chimiques, écrits à la manière anglaise. Ecrire les formules semi-développées ou développées.

(Eight questions were then given, the same order as for the English school French version, but written in English. For the French version similar instructions were given, with the French version formulae given in the same order as the second test at the English school)
APPENDIX 7: PHYSICS QUESTIONNAIRES

(See also Chapter 23 'Questionnaire on physics, and graphs' and Chapter 24 'Student opinions on graphs questions'.)

Lycée Ariana, (English school, Physics)
I would be grateful once again for your help in my research. You can help me by answering the questions below. I would like to remind you that the research has nothing to do with your tests, exams and "devoirs" and your teachers will NOT be given your answers.

CLASS NUMBER:..............

Question one.

A car starts from rest and is accelerated uniformly at the rate of 2ms\(^{-2}\) for 6 s. The car then maintains a constant speed for half a minute. The breaks are then applied and the car uniformly retarded to rest in 5 s.

a) What is the maximum speed reached? (2 \times 6 = 12ms\(^{-1}\))

b) Draw a graph of what is happening. Put time on the x-axis and velocity on the y-axis. Use the graph paper attached

c) FROM THE GRAPH find the TOTAL distance travelled. Do your calculations on the graph paper.
(I expected a diagonal line going from the origin up to (6,12), a horizontal line to (36,12) and a diagonal line to (41,0). )

\[
\begin{array}{c|c|c}
A & B & C \\
36m & 360m & 30m \\
\end{array}
\]

(The area under the graph is the distance travelled. It is calculated most easily by first dividing the area into two triangles and a rectangle as shown above, or, by using the formula for calculating the area of a trapezium.)

d) Using one or more of the formulae below, find the total distance travelled:
\[v = u + at \quad x = ut + \frac{at^2}{2} \quad \frac{v^2 - u^2}{2} = 2ax \quad x = vt\]

Do your calculations here
(Triangle A formula 2 or 3
B formula 4
C formula 1 to derive acceleration, then 2 or 3)
Question 2

This is an example of a velocity-time graph for a body moving with uniform acceleration.

a) What does the area underneath the graph represent? (i.e., what exactly is this area?) (distance travelled)

b) By using the graph ONLY calculate the quantity that the area in question a) represents. Write your calculations beside the graph on the graph paper.

c) Using $a = \frac{v - u}{t}$ and $v^2 - u^2 = 2ax$ calculate the quantity that the area in question a) represents. SHOW ALL YOUR CALCULATIONS.

d) What does the slope of the graph represent? (acceleration)

e) What was different about these questions to the ones you are used to? Which method of doing the calculations was easier for you, the method using the graph or the method using the algebra? Why?
Physique, Lycée Bourguiba (French school, French version of physics questions.)
(Nota that the answer scheme and graph for question 2 are given in the English version above and are not reprinted here).

Je vous demande de m'aider avec mes recherches, en répondant à quelques questions. Il n'y aura pas de notes, puisque ces questions n'ont rien à faire avec vos examens et vos devoirs. Elles vont être utilisées pour mes recherches seulement, et ne seront pas données à vos professeurs.

VOTRE NOM: VOTRE NUMERO DE CLASSE

Sujet 1
Une voiture au repos démarre et accélère uniformément avec une accélération de 2ms$^{-2}$ durant 6 s. Ensuite la voiture continue à une vitesse constante durant 30 s, puis elle décèle uniformément pendant 5 s jusqu'à l'arrêt.

a) Quelle est la vitesse maximale atteinte?

b) Représenter sur le papier millimétré un graphe dans lequel l'abscisse représente le temps et l'ordonnée représente la vitesse (de la voiture).

c) En utilisant votre graph trouver la distance totale parcourue. Écrire sur le papier millimétré.

d) En utilisant une ou plusieurs des formules ci-dessous, calculer la distance totale parcourue:

\[ v = u + at \quad x = ut + \frac{at^2}{2} \quad v^2 - u^2 = 2ax \quad x = vt \]

ECRIRE ICI:
Ce graph est un exemplaire d'un diagramme de vitesse pour le mobile avec acceleration constante

a) L'aire au-dessous de la courbe a une signification. Quelle est cette signification?

b) En utilisant seulement le graph, calculer la grandeur que cette aire en question a) represente. Ecrire a cote du graphe.

c) En utilisant: \( \frac{v - u}{t} \) and \( v^2 - u^2 = 2ax \)

calculer la grandeur que l'aire en question a) represente. MONTREZ TOUS VOS CALCULS

d) Quelle est la signification de la pente de la courbe?

e) Vous voyez ici que les questions sont facile, mes ecrutes d'une autre maniere que d'habitude. J'almerais bien avoir vos idees la dessus. Quelle methode de resolution est plus facile pour vous? Pourquoi?
APPENDIX 8: PHYSICS OPINIONS

Note that more than one opinion was often expressed therefore the numbers are larger than the numbers of pupils.

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<th>French school</th>
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</tr>
<tr>
<td>A2 Easiest is equations</td>
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<td>47</td>
</tr>
<tr>
<td>A3 Both easy, ambivalent</td>
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<td>3</td>
</tr>
<tr>
<td>B1 English clearer, simpler, better explanation</td>
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<td>B1b French is simpler</td>
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<td>B3 Same words, English and French</td>
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<td>C2 Questionnaire methods seen as clearer, no need to learn formulas</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>C3 Liked guided format, clear Q's</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>C4 Liked use of graphs</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>C5 Shouldn't give formulas, too guided</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>C6 Little difference</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>D1 Should have put Q2 first</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>D2a Algebra is more accurate, graphs can make mistakes</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>D2b Algebra is less accurate</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>D3 Symbols new, need defining</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>D4 other</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>⚫ No answer</td>
<td>10</td>
<td>27</td>
</tr>
</tbody>
</table>

Below is a representative sample of the opinions given by the French school pupils to the broad question, as to which method they preferred and why, for the physics questions.

Classification, student, opinion

C3 1.3 Cette méthode est plus facile, parce que les questions sont bien posées et personnellement j'ai compris mieux que d'habitude.

A2 1.7 La méthode d'équations est plus facile que celle du graphisme.

C3 1.8 Je vois que cette méthode est plus facile parce qu'elle est plus guidé et plus pédagogique. L'élève sait d'avance ce qu'il va calculer.

B2 1.14 La méthode que nous avons utilisé en cours ressemble beaucoup à celle-ci malgré la différence qui existe entre eux. Je pense que les deux méthodes sont faciles.

C1 1.16 La manière d'habitude est meilleur parce qu'on comprend mieux et on reste pas à demander que signifie [?] ou autre. Je préfère les exercices où les questions sont en ordre et clairement posées.

B1 1.17 Comme vous dites les questions sont écrites d'une autre manière que d'habitude, mais, au contraire elle ne sont pas facile. Personnellement je n'ai pas su faire les questions parce que je n'ai pas saisie le but de ces questions. Je préfère que les questions soient posées clairement, cäd qu'on comprend facilement ce qu'on nous demande, par exemple: on demande de calculer puis déduire ou conclure.

AG 2.2 Je suis habitué à l'autre manière, donc elle m'est peut-être plus facile. Mais cette manière aussi, genre questionnaire, est intéressante.
Appendix 8 Physics opinions -2-

A6 2.3 On n'est habitué à ce genre de résolution.

A1 2.4 La méthode graphique. En effet en prenant des mesures, l'élève arrive a assimiler son cours beaucoup plus bien. Ceci dit, en manipulant les expériences chaque élève pourrait assimiler tout son cours dans la classe. Alors que la méthode théorique laisse l'élève indifférent ou cours dans la classe.

C1 2.13 L'autre méthode de résolution est plus facile car elle est plus précise et y on utilise des formules et les théorèmes vus au cours.

A2 2.23 Je préfère la méthode théorique c'est à dire la 2ème méthode car on réussit à avoir des résultats plus précis et plus proches de la réalité malgré l'incertitude que porte la physique.

A3 3.15 La première remarque qu'on peut faire ces exercices sont intéressants et nouveaux. C'est la première fois qu'à partir de l'aire on peut arriver à calculer la distance parcourue par un mobile. C'est pourquoi, je pense que les 2 méthodes de résolutions sont bonnes et intéressantes.

C1 3.16 À mon avis je crois qu'il ne faut pas donner les formules de résolutions du problème, d'une part et d'une autre part même si les questions sont faciles je pense qu'elles sont moins compréhensibles par les élèves c'est pourquoi je demande un peu plus de précision.

A2 3.18 Je pense que la 2ème méthode de résolution est plus facile, mais la 1ère me plait plus car on n'a pas de formule à appliquer mais on doit réfléchir pour trouver une méthode de résolution.

A2 3.20 La 2ème méthode bien sûr car tout est clair sur le 2ème ou il nous guide à trouver le résultat alors que pour la 1ère c'est un peu vague.

C2 3.21 Cette méthode est plus facile car on a pas besoin d'apprendre le cours et les formules mais seulement de comprendre les phénomènes physiques.

C5 3.51 Personellement, je pense qu'il n'y a pas une très grande différence entre les deux méthodes si ce n'est une autre manière de notation, (y → a, vo → u).

C6 Néanmoins, je pense que dans cette méthode, il y a une certaine suite logique à suivre dans les questions. Par exemple, pour le sujet 1 à la question d' pour calculer la distance parcourue on a eu besoin de a). Pour nos sujets à nous, parfois on n'est pas guidé et on nous donne pas les formules. Cette méthode de résolution est donc plus facile.

C6 4.3 Je préfère de loin la méthode classique de résolution, en effet les questions sont plus claires et directes, tandis que cette méthode, du tout originale, me montre pas très bien là ou l'on veut arriver; c'est une méthode indirecte et assez compliquée.

A2 4.16 Utiliser les formules pour resoudre une question est plus facile car elle donne des résultats plus (I) et plus exact que celle de la méthode 1).

A2 5.5 La méthode d) de l'exercice 1 et c) de l'exercice 2 sont les plus faciles [IL ie equations]
A3 5.6 Vous voyez bien qu'un changement de la manière de poser les questions crée un certain problème dans la résolution car on est habitué à une seule et unique manière de résolution. La méthode de résolution la plus facile pour moi est la méthode générale, parce qu'elle est applicable dans tous les exercices.

A6 5.2 Je vois bien que les questions sont faciles mais la manière de poser les questions laisse les élèves un peu perplexes devant ce changement de manière. Ce n'est qu'une question d'habitude autrement n'importe quelle méthode de résolution est bonne si l'on parvient à la comprendre parfaitement. Je crois que ce changement est bénéfique puisqu'il permet de tester les connaissances d'une autre manière car ce changement ne doit pas être un obstacle devant l'élève. [1.]

A1 5.13 La méthode graphique est plus facile car on comprend ce qu'on fait, le dessin est un outil qui aide beaucoup à raisonner.

A6 5.15 Ces questions sont bonnes dans le mesure où elles invi­ rent l'élève à réfléchir, à imaginer et à se rapprocher de la pratique (courbes, signification de l'aire du triangle). Je préfère les questions là où il y a peu de calculs mais surtout de l'imagination de de la pratique. La méthode de résolution de la classe est plus facile que votre méthode pourtant elle n'est pas meilleure car nous parlons plus facile tout simplement parce que nous y sommes habitués, alors il vaudrait mieux nous habituer à une autre méthode, la vôtre par exemple.

A2 5.19 Je crois que la résolution avec les formules de cours est plus facile car -on peut faire beaucoup de fautes dans dans les graphiques ce qui donne des calculs inexactes -l'utilisation des formules est plus pratique et plus sûre. Cependant, les graphes résument les résultats et les donnent plus nettement.

The English school

Note how the question was phrased slightly differently (Appendix 7 page 4)

A1 1.1 Using the graph seems to be the better method because it is simpler and doesn't lead us to stupid mistakes such as in calculations when solving mathematically.

A2 1.3 These questions can be answered separately. We are used to doing problems of dynamics. The method using algebra is easier for me. I've never done such calculations using a graph while studying dynamics.

A1 1.4 Using the graph is easier because it avoids complex calculations and theorems.

A2 1.6 Algebra because I'm used to it.

A2 1.7 Using the algebra because this method enables us to feel physics and the experimental physics whereas using the graph we can't have a real idea about the problem.

A2 1.9 Using algebra, because I'm used to it, but I think it's stupid, it is just applying rules while as using the graph is more clever and interesting.

A7 1.19 The method using the graph was easier because you don't have to think much about the calculation, but it is more convincing to use algebra, the ideas are clearer.

A7 1.16 In fact using the graph is easier but with algebra I'm more confident of the result.

A2 1.17 Algebra, calculations are much precise.

A1 1.18 I find the graphical method much easier to use because it is simple, non-misleading and quick.

D2 1.22 Using algebra because the graph may not always be accurate.

A1 2.14 In all the exams I had most questions are based on the techniques you possess of algebra, the use of graphs is rare, if I don't say absent. Well I think that the use of graphs is simpler and it saves time.

A1 2.18 The difference is that the questions we are used to have concerns only the method of calculations. The method which I think is easier for me is the method using the graph because there is no complicated calculations and we could get the results easily with no mistakes and in a short period of time.

1. This pupil is saying that there is a difference between science in English and French, that science is not fully international, since internationalness implies the same methods used, and here the pupil sees a clear difference between the approach in the questionnaire and the approach in the lessons.
A2 2.19 I think they are more or less the same but these ones do escape from the usual boring calculations to ask for new things as to use the graph for finding the answers. This doesn't mean that we've never encountered such exercises but it means we don't do them as frequent as those with calculations. I found the method using algebra easier because I'm used to it.

A2 2.22 These questions are very precise. We are used to general questions in which we say all what we know. Using algebra method is easier because we are used to that (application only). Since we have studied the chapter before know the primitive and before practicing studying graph, but I think studying from graphs is better because it helps you to think and to understand what one is doing and what's the purpose of doing so not just applying some rules we have to remember.

A1 2.17 The questions I used to do are much more difficult. The method of using the graph is better because it makes us use our brains.

A7 3.1 The method using the graph but we are not very used to it that's why the method using algebra seems less difficult to me.

D4 3.3 There is no difference between the questions and the ones I am used to. Using algebra is easier for me.

A1 3.13 These question are very easy according to the questions we used to be given. The way of using the graph in calculations was easier.

A1 3.15 The method of using the graph was easier because I avoid calculation mistakes. D2b

A1 3.19 The methods are simple methods of calculation. The method using graph was the easiest because when I first learnt about kinematics it was with an English teacher so I was attached to that first way.

A1 4.4 I was taught by an English teacher who only uses graph for his calculations but I completely disagree with this method in doing exercises even though it is much more easier than algebra. We have to know that we are in the 20th century where we should do everything as quickly as possible and saving money (not using a graph paper which costs money) and this is found mainly in the algebra way. But we can learn the other way to be used in very complicated motions to do our approximations. [IL 'motion' refers to the cases of motion and their formulae].

A2 4.2 From the graph we calculate all the values, but I think using algebra is better than using a graph, because a graph can mislead the pupil and sometimes graphs are complicated.
Appendix 9 Faux amis questionnaire -1-

APPENDIX 9: FAUX AMIS QUESTIONNAIRE

(See also Chapter 8 'Faux amis' Section C).

This questionnaire was administered at the English school only. Lack of time prevented its use at the French school, even though their English was probably good enough to attempt this section. The A numbers are supplied here, as answer numbers. They were not used in the version the pupils had, but were used later to tabulate the results. Pupils had to write the required words in the sentences in full, a multiple choice type of answer was not asked for.

WORDS IN SCIENCE

I would be grateful once again for your help in my research. You can help me by answering the questions below. Please note that my research has nothing to do with your tests, exams, and "devoirs". I can assure you that you will NOT get any marks for these questions.

Please write all your answers in the space provided.

YOUR NUMBER:

1. Give the English for the following French words:
   a) Ingénieur électrique engineer
   b) La masse spécifique density
   c) Le chronomètre (as used to measure intervals of time) stopwatch
   d) Le cristallin lens
   e) La densité specific density
   f) L'ordre de grandeur order of magnitude

In the following questions there are sentences to fill in with the missing word. For each question use one of the possible words given first. Use the word which is most likely to be correct. Each of the "possible words" may be used once, more than once, or not at all.

2. Possible words: A1 experience A3 experiment
   A2 experienced A4 experimented

Sentences to fill in
   a) The A3 experiment showed that water boils at 100°C.
   b) Science is built on observation and A3 experiment.
   c) He is an A2 experienced doctor.
   d) This is an A3 experiment you must never repeat at home.
   e) The A3 experiment was set up as above.
   f) I had a most unpleasant A1 experience yesterday.
   g) Learning biochemistry can be a difficult A1 experience.
   h) Recently, some people in Tunis A4 experienced a small earthquake.
3. Possible words A1 humid A2 humidity A5 damp A6 dampness A3 moist A4 moisture A7 wet A8 wetness

Sentences to fill in:
a) In the rainy season in Senegal, the A2 humidity can, on some days, reach over 80 percent.
b) When she entered the room, it felt oppressively A1 humid / A5 damp.
c) To wipe the table, use a A5 damp / A7 wet cloth.
d) The delicious cake was very A3 moist, not dry at all!

4. Possible words: A1 breath A4 respiration  
A2 breathing A5 respiring  
A3 respiratory

Sentences to fill in:
Emergency! Your friend has stopped A2 breathing. 
To restore his A2 breathing (A4 respiration) and to save his life, someone needs to use artificial A4 respiration! 
The A3 respiratory system includes the lungs, the trachea and the bronchial tree.

5. Possible words: 
A1 average A4 passmark A7 median  
A2 class average A5 moyenne  
A3 mean A6 mode

Sentences to fill in:
a) In Tunisia, to pass an exam, one has to get at least 10/20. This is called the A4 passmark.  
b) The A3 mean / A1 average of the results of the class is calculated by totalling all the marks obtained, then dividing this total by the number of pupils in the class.  
c) At the end of the year, the best student had the marks 15, 15, 16, 16, 17, 17, so his A3 mean / A1 average / A7 median mark was sixteen.  
d) In England, if an exam is difficult, the A4 passmark is lowered so that less pupils fail.

6. Possible words A1 sensibility A4 sensible  
A2 sensitivity A5 sensibly  
A3 sensitive

Sentences to fill in:
a) To receive radio programmes from England, one needs a very A3 sensitive short-wave radio.  
b) Some people are very A3 sensitive to criticism.  
c) The A2 sensitivity of pH paper is lower than that of a pH meter.  
d) He had very A3 sensitive feet.  
e) A A4 sensible student will study the information carefully before beginning to answer the question paper.  
f) When flowers turn their heads to the light, they are showing A2 sensitivity to this stimulus.  
g) This person is completely reliable and A4 sensible, and perfectly capable of doing the job well.

7. All the questions so far have been asking you about "faux amis" or "faux frères". Can you give any other examples that you may know of, particularly from natural sciences or physics or chemistry?
Appendix 10: Faux amis results

(See also Chapter 8 'Faux amis' Section C. This appendix gives the numerical data of the results to the questionnaire on faux amis, and the results of question 3 in Appendix 11 where pupils were asked to score themselves for how confusing they found five well known differences between English and French.)

The results of the questionnaire in the English school on faux amis

<table>
<thead>
<tr>
<th>Question 1: Various Translations</th>
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<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>RIGHT</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>a 11</td>
</tr>
<tr>
<td>b 18</td>
</tr>
<tr>
<td>c 7</td>
</tr>
<tr>
<td>d -</td>
</tr>
<tr>
<td>e 4</td>
</tr>
<tr>
<td>f -</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 2: Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 A2 A3 A4 φ</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>a 1 0 88* 0 0</td>
</tr>
<tr>
<td>b 30 0 54* 0 5</td>
</tr>
<tr>
<td>c 2 80* 1 5 1</td>
</tr>
<tr>
<td>d 30 0 53* 0 6</td>
</tr>
<tr>
<td>e 2 0 85* 0 2</td>
</tr>
<tr>
<td>f 79* 1 9 0 0</td>
</tr>
<tr>
<td>g 71* 1 11 3 3</td>
</tr>
<tr>
<td>h 3 57* 1 26 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 3: Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 A2 A3 A4 A5 A6 A7 A8 φ</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>a - 72* - 4 1 1 3 4 4 4</td>
</tr>
<tr>
<td>b 43* 2 13 1 14* - 8 - 8</td>
</tr>
<tr>
<td>c 1 - 3 1 40* 2 40* 1 1</td>
</tr>
<tr>
<td>d 8 - 38* - - 15 - 23 5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 4: Breathing</th>
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</thead>
<tbody>
<tr>
<td>A1 A2 A3 A4 A5 φ</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>a - 85* 1 - 3 -</td>
</tr>
<tr>
<td>b 63 5* - 18$ 1 2</td>
</tr>
<tr>
<td>c 3 16 4 53* 12 1</td>
</tr>
<tr>
<td>d - 1 85* 1 2 -</td>
</tr>
</tbody>
</table>
### QUESTION 5: AVERAGE

<table>
<thead>
<tr>
<th></th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
<th>φ</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>16</td>
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<td>-</td>
<td>53</td>
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<td>-</td>
<td>1</td>
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<tr>
<td>b</td>
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<td>-</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>c</td>
<td>65</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
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<td>1</td>
<td>65</td>
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### QUESTION 6: SENSIBLE

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<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>φ</th>
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<tbody>
<tr>
<td>a</td>
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<td>1</td>
<td>77</td>
<td>9</td>
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<td>2</td>
</tr>
<tr>
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<td>-</td>
<td>-</td>
<td>47</td>
<td>42</td>
<td>-</td>
<td>-</td>
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<tr>
<td>c</td>
<td>11</td>
<td>77</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>-</td>
<td>-</td>
<td>63</td>
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<tr>
<td>e</td>
<td>-</td>
<td>-</td>
<td>17</td>
<td>70</td>
<td>2</td>
<td>-</td>
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<tr>
<td>f</td>
<td>23</td>
<td>62</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>g</td>
<td>1</td>
<td>-</td>
<td>10</td>
<td>75</td>
<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>

### THE RESULTS OF QUESTION 3 'CONFUSION RATINGS'

#### CONFUSION RATINGS

Students were asked to rate each word by its level of confusion. 1 = Never, 5 = Always. As few students used scores 2-4, the scores are abridged as below.

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<tr>
<th></th>
<th>1-3 YES</th>
<th>1-3 NO</th>
<th>4-5 YES</th>
<th>4-5 NO</th>
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<td>I</td>
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<td>II</td>
<td>14</td>
<td>17</td>
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<td>III</td>
<td>47</td>
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</tr>
<tr>
<td>V</td>
<td>20</td>
<td>8</td>
<td>8</td>
<td>27</td>
</tr>
</tbody>
</table>
APPENDIX 11: VIEWPOINTS

APPENDIX 11A ENGLISH SCHOOL: TEXTBOOKS, GEOLOGY, SCIENCE, DIFFERENCES BETWEEN ENGLISH AND FRENCH

YOUR VIEWPOINTS

1. There are Biology, Physics, Chemistry, and Maths books, in English, in the library.
a) How frequently do you use them?
   FREQUENTLY/SOMETIMES/RARELY/NEVER
b) What similarities and what differences do you find between books in English and books in French (from Tunisia or France)?
   Similarities
   Differences
c) Which books do you prefer? Why?
d) Is the only important difference, that the 'programmes' are different? YES/NO
e) What differences, and what similarities exist between the subjects of Biology, Physics, Chemistry and Maths taught in English, and these same subjects taught in French?
   Differences
   Similarities

2. In the fourth year, you studied Geology through English or French. In the fifth year you did some Geology in your Geography lessons, taught in Arabic.
a) What were your impressions and feelings about the change of language? (use the back of this sheet if you wish)
b) Which language did you prefer to study Geology in?
   ARABIC/ENGLISH Why?
c) What did you find was helpful about this change of languages?
d) What did you find was unhelpful about this change of languages?

3. The following differences exist between French and English.
   Column a) Did you know about this difference before YES/NO?
   Column b) For each example below give a score of between 1-5 for how confusing you found the difference BEFORE YOU READ THIS. 1 = never confused 5 = always confused.

<table>
<thead>
<tr>
<th>French</th>
<th>English</th>
<th>Column a)</th>
<th>Column b) your score</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 0,5</td>
<td>0.5</td>
<td>YES/NO</td>
<td>I...</td>
</tr>
<tr>
<td>II 73°K</td>
<td>73K. (kelvins)</td>
<td>YES/NO</td>
<td>II...</td>
</tr>
<tr>
<td>III &quot;humidity&quot; damp, moist, humid</td>
<td>YES/NO</td>
<td>III...</td>
<td></td>
</tr>
<tr>
<td>IV La Densité specific gravity</td>
<td>YES/NO</td>
<td>IV...</td>
<td></td>
</tr>
<tr>
<td>V La Masse density spécifique</td>
<td>YES/NO</td>
<td>V...</td>
<td></td>
</tr>
</tbody>
</table>

Can you give any more examples of what has confused you?

4a) What is meant by <<studying something scientifically>>?
b) What is the opposite of <<scientific>>?
APPENDIX 11b FRENCH SCHOOL GEOLOGY & SCIENCE

Questions supplementaires

1. En quatrième année vous avez étudié la géologie en français (dans vos cours de Sciences Naturelles). En cinquième année vous avez étudié la géologie dans vos cours de géographie, mais cette fois en arabe.
   a) Qu'est-ce que vous avez ressenti et pensé à l'égard de ce changement de langue?
   b) Quelle langue vous avez préféré pour l'étude de la géologie? FRANÇAIS / ARABE Pourquoi?
   c) Qu'est-ce qui était utile pour vous, ou inutile, dans ce changement?
      Utile
      Inutile.

2a). Quel sens donnez-vous à <<Étudier quelquechose scientifiquement>>?

   b) Quel est le contraire de <<scientifique>>?
APPENDIX 12: VIEWPOINTS
-SUBJECTS AND TEXTS

1. INTRODUCTION
The pupils at the English school had had contact with the Anglo-Saxon approaches to science, as well as the French/Tunisian approaches. This had come through change of language, translated texts, lessons taught by Tunisian teachers who had spent at least a year, mainly in England, but at least one teacher had been to America. The English department was also, by common consent of the British expatriates, excellent and progressive. There were also British teachers there and the library was relatively well stocked with books in English, and sometimes there were videos available in English.

But the basic textbooks in science were translated and adapted from the Tunisian textbooks and translated texts were the main source of material for the pupils. French texts were readily available, and, as the questionnaire shows, were used to some extent by the pupils.

When they [pupils] do seek extra material in English books [from England or USA] the stuff is different enough to cause confusion. 'I looked it up but it was not the same'. 'The exercises tend not to fit the Tunisian way of doing things.' (T9:27) (A teacher reporting what children said on this question).

This part of the questionnaire illustrates the sort of investigation that could be done to test the levels of CSL other than words or symbols.

2. SUB-HYPOTHESES
If CSL is valid, then when questioned, the pupils will not perceive any differences between a subject, or a textbook in English and in French. Any perceived differences are evidence against CSL.

3. RESULTS
To the question, 'Is the only important difference that the 'programmes' [1.] are different YES/NO ' the replies were: YES:12 NO:67 0:9.

Twenty-seven pupils said that French was more theoretical, and English more practical. (A2)

Six (at least) said that the subjects had the same concepts and examples and information. (A1)

Thirty-nine said that English was clearer, simpler, better explained with only one saying this for French. (B1)

Fourteen commented how the exercises were different, usually simpler, in English though there was some limited comment on the exercises in English being more related to the practical.

4. DISCUSSION
While comments about the English texts being generally simpler, may in part reflect the difficulties a developing country has in getting good clear national texts published, I suspect there is more than that involved. English texts do stress less the mathematics and more the explaining of the phenomena. A significant number, 31% freely pointed out that French was more theoretical, and English more practical. (See Appendix 8 for some quotations).

The question about differences being only due to the syllabuses being different was a leading question, but 76% saw differences that did exist as being not just due to this factor. It is interesting how students latched on to the approaches to the subject, the approaches to the teaching, while maintaining that the actual content was broadly the same.

5. SUB-CONCLUSIONS
There were significant perceived differences between English and French, particularly in the area of French being theoretical and English being practical. This has implications for any student changing between the systems, and needs considering in any ESP situation.

1. This was a French word, used in English in the Tunisian context, instead of 'syllabus'. As it was the word used, I chose to use it and to mark it as an unusual word with the commas.
Appendix 12 Questionnaire: subjects & texts

6. SELECTIONS OF PUPIL COMMENTS

Below is presented a selection of the comments made by the pupils at the English school in response to the question as to what they found different and similar about French and English subjects and textbooks.

<table>
<thead>
<tr>
<th>Classification and results summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 Same concepts, examples &amp; information 6</td>
</tr>
<tr>
<td>A2 French is theoretical, English practical 27</td>
</tr>
<tr>
<td>B1 English clearer, simpler 39</td>
</tr>
<tr>
<td>B2 'exercises' different 14</td>
</tr>
<tr>
<td>B3 Only some words, some details differ 3</td>
</tr>
</tbody>
</table>

Classification, pupil, comment.

A1 1.17 [books] same information. [subject] the basic idea of the lesson is the same.

A2 2.1 [books] English books are simple whereas the French ones are a bit complicated. Quite more details in the French books. I like French books because of their simplicity, and their introducing daily life in the domain of science. [subjects] the programs, the names of subjects eg Newton's las (in English) => la fondamontale de la dynamique (in French). Wider rely on daily life, for English books eg the subject of reproduction. The theory dominates of the practice for French books.

A2 1.17 English lessons require a lot of practical. French lessons are based on theory and they give importance to many details.

A2 2.14 English books tend to be based (apparently) on the practice, there are more practical than theory. However for French books it is just the opposite. [subject] the scientific subjects are taught in different languages however the scientific terms don't change and the formulae and the theorems are just kept the same, so it is just the same if you learn a scientific subject in French or in English. The way of teaching differs. the English way depends on the pupils however the French way is dependant on the teacher.

A2 3.6 English subjects are based on experiments. French subjects are based on theory.

A2 3.15 I prefer French books for maths and physics because they explain things and treat exercises mathematically (logically) not by using common sense (means if something is right why do we proof it). However science books are excellent in English because they are based on experimental facts.

A2 3.18 [subjects] English books rely on experiments however French ones rely on calculations and theories. English teachers give questions rather than problems. English teachers explain using experiments however French teachers use calculations and theories to explain some difficulties.

A2 4.1 English books concentrate mainly on experiments and they don't interest much in algebrae and calculus, whereas French books are always full of complicated exercises which are very far from experimentation. I prefer English books since they don't complicate the ideas and they explain very well, but I'm obliged to deal with French books since our physics syllabus is based mainly on maths and applying theorems (it is exactly like the French syllabus).

A2 4.6 In French formulas are important while in English experiments are important. Some names, especially in maths are different in the two languages.

A2 4.19 French books insist on theoretical parts of lessons. English books insist on practical parts of lessons. Exercises in English books are much more difficult than English ones. Especially French books try to make lessons as simple as possible.

B1 2.24 French books use theories for explanation and also use a lot of algebra. English books explain things using experiments. French exercises use complicated exercises, English ones use simple calculations and experimental exercises. [Subjects] The French way of educating need a lot of memory and calculations are introduced in all chapters in any subject even they are not need. The English way of education is simpler enables you to retain informations and makes you understand which is very important. The French way is tiring and the pupil forgets everything/lessons after a few days. The teacher remains the most important one in the class, all the work is done by him, the pupils have a very small participation in the lesson, class.

B1 3.6 English books explain better, use simple things to explain more difficult ones, they contain more experiments that help understanding. French books contain more good & difficult exercises.

B3 4.5 [subject] They are similar because language has no effect on the scientific message.
### Appendix 13: 'Scientific'

The meaning of 'Scientific' and its opposite, as given by sixth year pupils in both schools (see Chapter 8 Section D)

<table>
<thead>
<tr>
<th>Scientific</th>
<th>English School</th>
<th>French School</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 Rational, no feelings, laws, proof objective, logical, theoretical</td>
<td>13</td>
<td>67</td>
</tr>
<tr>
<td>A2 Theory, reasoning AND practical hypothesis and test</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td>A3 practical only, real life</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>A4 other</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>A5 No legible answer</td>
<td>14</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opposite of scientific</th>
<th>English School</th>
<th>French School</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 None</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>B2 literature, artistic</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>B3 irrational, incoherent, absurd</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>B4 practical (empirique)</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>B5 anti/a/un/non scientific</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>B6 chance</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>B7 Stupid, without thinking</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>B8 illogical, arbitrary</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>B9 Not proved</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>B10 morality</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>B11 philosophy</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>B12 mythical, occulte</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>B13 sentimental</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>B14 not based on experiments</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>B15 intuitive</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>B16 other</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>B17 no legible answer</td>
<td>25</td>
<td>7</td>
</tr>
</tbody>
</table>

**English school (selected comments)**

**Code, Student, comment**

A1 1.3 To study sthg. scientifically = to understand it, to see: "what would happen if...", To think logically of what was happening, and finally to make an experiment if possible.

A1 2.15 we use our brain, our study should be based on reasons causes and effects.

A1 2.18 Studying something scientifically means studying it with a scientific mind, with no feeling but using your reasons and your thinking.

A2 2.1 you observe this thing you reflect or think about it you do some experiments on it then you draw your conclusion.

A2 2.6 studying sthg scientifically means having the explanations of the lessons by the help of scientific theorems. The informations that we get are based on experiments.

A2 2.29 As I see it, this expression means studying something objectively, to think about it, to explain why it has a certain behaviour and not another, to go through the study step by step taking experiments as guides.
Appendix 13 Questionnaire: 'scientific' -2-

A2 2.23 that means studying with the scientific way by following certain steps which are: -the doubt -the question -the theory with its reasons -the experiment -the result (real result)

A2 4.6 It means studying it an experimental basis in order to find a solid explanation of a phenomena of interest between different parts of it, for example a formula or a logic hypothesis or a coherent theorem.

A5 1.19 To study something scientifically means to study it experimentally.

A5 1.23 studying subjects that can be applied to our real life.

B14 2.6 [opposite] sthg not based on experiments

French school

A1 1.11 c'est l'étudier logiquement et raisonnablement

A1 1.18 Raisonnement logique

A1 1.43 C'est l'étudier avec un sens scientifique. L'étudier d'une manière raisonnable, logique, "exacte", sans laisser le point de vue personnel de les sentiments intervenir.

A1 4.4 Etudier quelque chose scientifiquement c'est l'étudier logiquement, car la science c'est l'art de raisonner et d'expliquer les choses qu'on voit.

A2 1.8 Etudier quelque chose scientifiquement c'est se baser sur des hypothèses concrètes et essayer de les approuver ou de les approuver.

A2 1.17 Etudier quelque chose scientifiquement c'est d'abord (faire une étude théorique) puis essayer (faire une étude expérimentale) enfin conclure (sous forme d'hypothèse).

A2 2.18 Pour moi cela signifie l'étudier rigoureusement, et en se basant sur des expériences ou sur des résultats précédemment prouvés.

A2 4.19 Etudier quelque chose scientifiquement, c'est aborder le sujet avec une série d'expériences pratiques, utiliser des formules mathématiques et essayer d'être très précis.

A2 4.11 Etudier quelque chose scientifiquement, c'est une étude qui est hors des limites d'une langue ou d'un pays, c'est universel. Une étude scientifique doit être rigoureuse et basée sur des expériences précises.

B1 2.11 Je pense que tout raisonnement se fait scientifiquement d'où le contraire de scientifique n'existe pas, puisque même en littérature on rédige après avoir analysé le sujet.

B4 3.5 [contraire] empirique, travailler en tâtonnant, travailler sans utiliser la faculté intellectuelle tel que l'a dit IBN KHALDOUN: [1.] relier la conséquence à la cause.

B4 3.1 Le contraire de scientifique est pour moi tout ce qui est empirique, c'est à dire qu'on compte parfois sur l'intuition en posant par ex: des hypothèses qui n'ont pas bien pour être posées et on essaye ensuite de les démontrer ou les vérifier.

B4 5.15 empirique, illogique

B4 5.13 empirique.

B9 2.13 tout ce qui n'est pas justifié par des méthodes logiques.

1. Famous muslim philosopher of history.
APPENDIX 14: GEOLOGY QUESTION

1. INTRODUCTION

In the curriculum at the French and English schools, there was one small area which was taught in the European language and in Arabic. In the fourth year geology was taught in the European language, and in the fifth year similar material was taught in Arabic in the geography lessons.

This then was one small area where a comparison with Arabic could be made. I was interested to collect the opinions of the pupils on this change.

Though the material is not of direct interest to the thesis, it is included here for the sake of completeness.

Unfortunately in the actual wording of the questions, an error occurred, which most pupils spotted and corrected, namely, in the English school, the comparison in question 2b) was given as between Arabic and French instead of Arabic and English. From the responses I can see that the error has not significantly affected the results in that most students corrected the error, or the replies were to the correction. In classes 2 and 4 the correction was made orally to the classes. Note that as more than one reason can be given in questions a) c) and d) the totals do not necessarily add up to the number of pupils answering the questions.

To facilitate comparison, before the results are given the texts in full of the syllabi are presented.

2. GEOLOGY SYLLABUS IN FOURTH YEAR NATURAL SCIENCE (TUNISIE 1982-9)

(T.P. = Travaux Pratique (practical work), two hours alternate weeks, taught in half-groups. Cours = lesson (theory) one hour per week taught to the whole group. Total 39 hours)

I - LES ROCHES SEDIMENTAIRES ET LES PHENOMENES DE LA REGION OU DE LA TUNISIE.

T.P.1: Sortie. A partir de l'observation 'un paysage, dégager le lien entre l'aspect de ce paysage (relatif, végétation...) et la nature des roches qui le constituent.

Distinction entre le sol et le sous-sol.


Cours 1: Eaux sauvages, oueds. Localisation de l'oued choisi sur la carte. Son origine, son profil, son régime. Morphologie des éléments paléogéographiques rencontrés dans son lit (galets, sables...) Erosion, transport et sédimentation.


Cours 1: Luttte contre l'érosion. Le reboisement, les barrages.

Cours 2: Les eaux souterraines. Puits et sources. A partir de données locales, dégager la notion de nappe aquifère.


Cours 2: Définition des principaux types de roches sédimentaires en rapport avec leur origine (organique, chimique et détritique) et leur répartition sur la carte géologique de la Tunisie. Notion de sédimentation.

II - ROCHES ET PHENOMENES GEOLOGIQUES D'ORIGINE INTERNE

T.P.6: Etude comparée de deux roches d'origine interne (granite, Basalte etc...).

Les roches métamorphiques: schiste argileux, marnes...

Cours 1: Volcanisation et séisme en Afrique du Nord et dans le monde: Localisation - Histoire d'un volcan ou d'un séisme.

Cours 2: Cycle des roches - Structure de l'écorce terrestre.

III - INITIATION A LA LECTURE DES CARTES

T.P.7: Analyse d'une carte topographique régionale et de la carte géologique correspondante. Légende de la carte géologique, acquisition du vocabulaire du géologue.

Cours 1-2: Comparaison de la carte géologique et de la carte de géographie physique de la Tunisie. Dégager de cette comparaison les définitions des formations de différents âges, de différentes natures, de différentes structures, horizontales ou plissées. Tunisie.
IV - DES COUCHES DE TERRAINS (Notions de stratigraphie)

T.P.8: Etablissement à partir d'une carte au 1/50,000 d'un profil topographique dans une zone non plissée. Établissement de la coupe géologique correspondante. Leur interprétation en s'aidant éventuellement de photographies aériennes.

Cours 1-2: A partir de la carte géologique de la Tunisie au 1/500,000 montrer l'importance de la stratigraphie pour l'établissement d'une chronologie relative, pour certaines reconstitutions paléogéographiques, pour l'établissement de grandes coupures dans l'histoire de la terre.

V - DES MOUVEMENTS DE L'ÉCORCE TERRESTRE (Notions de tectonique)

T.P.9: Etablissement d'un profil topographique à partir d'une carte au 1/50,000 d'une zone plissée. Établissement (sic) de la coupe géologique correspondante (on choisira un pli simple). Comparaison du profil topographique, de la coupe géologique, et éventuellement de photographies aériennes correspondantes.

Cours 1-2: A partir de cartes géologiques et de documents photographiques établir les définitions des principales formes tectoniques: failles, plis, éventuellement charriages. Quelques aspects de la genèse des reliefs. Cycles orogéniques.

VI - DES PAYSAGES (Notion de morphologie)

T.P.10: Étude de quelques paysages. A partir de cartes topographiques, des cartes géologiques correspondantes et éventuellement des photographies aériennes, définir un paysage lithologique, un paysage (desertique) et un paysage structural.

Cours 1: Situation de la région dans l'ensemble géologique de la Tunisie.

Cours 2: Importance pratique de la géologie dans la région: exploitations (pétrole, carrières, matériaux de construction - eaux thermales et minérales etc... alimentation en eau des villes-barrages etc...).

VII - ESSAI D'UNE SYNTHESE REGIONALE

T.P.11: Excursion géologique

Cours 1: Bilan de la sortie; les différents types de roches rencontrées.

Cours 2: Les fossiles et leur signification.


Cours 1: Situation de la région dans l'ensemble géologique de la Tunisie.

Cours 2: Importance pratique de la géologie dans la région: exploitations (pétrole, carrières, matériaux de construction - eaux thermales et minérales etc... alimentation en eau des villes-barrages etc...).

VIII - ORIGINE ET EVOLUTION DE L'HOMME

T.P.13: Analyse de documents paléontologiques et de documents d'archéologie permettant de dégager les principaux aspects de la vie des hommes préhistoriques en Afrique et particulièrement au Maghreb.

Cours 1: Étude de l'histoire de l'homme et de son origine.

Cours 2: Évolution des industries et des arts préhistoriques.

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3. GEOLOGY SYLLABUS IN FIFTH YEAR GEOGRAPHY (TUNISIE 1982b P30-31)

(Original in Arabic, English translation by Ivan Lowe)

GEOGRAPHY: GENERAL NATURAL & HUMAN (total 15 hours)

Beginning of the earth.

Introduction to morphology. The earth's crust: rocks and movement. Erosion, and the process of erosion. (With enlargement of the study of erosion for the semi-desert belt.

Elements of types of topography - principles - old agglomerations - sedimentary basins - Lithuanian chains.

Marine and coastal topography.
4. QUESTIONNAIRE RESULTS

<table>
<thead>
<tr>
<th>Question 2a) What were your impressions and feelings about the change in the language?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
</tr>
<tr>
<td>A1 No impressions, no great differences except perhaps at the beginning</td>
</tr>
<tr>
<td>A2 A large difference in the meaning of the scientific words</td>
</tr>
<tr>
<td>A3 L2 is easier/better</td>
</tr>
<tr>
<td>A4 Arabic is easier/better</td>
</tr>
<tr>
<td>A5 It was boring</td>
</tr>
<tr>
<td>A6 With Arabic one can watch and understand TV programmes in Arabic about geology</td>
</tr>
<tr>
<td>A7 Helpful to be able to do science in more than one language, to read books in both, language is a means to an end, is but a tool, repetition helped</td>
</tr>
<tr>
<td>A8 Confusing</td>
</tr>
<tr>
<td>A9 other</td>
</tr>
</tbody>
</table>

Examples

A1 1.16 there is no a great change because unfortunately it's almost the same words but "arabified".

A1 2.33 Le langage de la pensé est universelement le même. La langue ne joue que le rôle de l'expression de la pensé.

A3 1.7 The geological terms used were very complicated in arabic because these terms are originally taken from the Latin language and I think that may be I found them complicated because I first studied geology in english.

A4 4.14 I felt that the ideas of the lessons are coming directly into my mind without being hardly analysed and besides I felt that my language is a victim of those who pretend that we can never express a scientific idea in Arabic but we can prove the opposite actually and historically.

A4 4.17 well, indeed it's a very good question: when I was taught geology in arabic I understood my lessons much better and the scientific jargons seemed much more easier. I think this is because when taught in english I understand the process (any one) and I learn it's name and all the scientific complicated words too without knowing the origin of this word, but in arabic it's totally different learning all these scientific words seems easier, because I fully understand the word and can understand each word said in class. (any way I think it's a problem of language which is not important).

A7 1.17 Interesting to know words in arabic and their synonyms in english, the words in arabic were taken from the Latin origin as well as those in English. So it was an opportunity to retain them.

A4 5.20 Il y en a des choses que n'avais pas compris en 4ème année et que j'ai compris en 5ème année. J'ai vraiment vu que les choses sont simple en arabe et ce n'est exactement le contraire en français.

A3 1.6 en cinquième année quand on a fait la géologie en Arabe j'ai trouvé ça anormal car je me suis habitué à le faire en français alors j'ai toujours essayé de réduire tous les problèmes de geologie en cinquième année en français pour que je puisse utiliser ce que j'avais étudié en 4ème année.
Appendix 14 Questionnaire: Geology -4-

<table>
<thead>
<tr>
<th>Question 2b) Which language did you prefer to study geology in? ARABIC/FRENCH....why?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabic</td>
</tr>
<tr>
<td>French</td>
</tr>
<tr>
<td>English</td>
</tr>
<tr>
<td>no answer</td>
</tr>
<tr>
<td>neither</td>
</tr>
</tbody>
</table>

B1-3 apply to Arabic
B5 is neither
B6-10 apply to L2

B1 "My language is easier" | 35 | 18 |

B2 like to know some science in Arabic | 2 | 0 |

B3 other | 1 | 0 |

B5 neither, science can be learned in any language, it is the same only the terms change | 9 | 12 |

B6 liked the programme | 1 | 3 |

B7 Vocabulary is more logical, easier to understand, existing technical words are English/French and are transliterated into Arabic, the resources, and books are better in English/French, question of habit, started in L2 | 15 | 63 |

B8 L2 is pupil's best or easier or preferred language | 4 | 6 |

B9 French is better, is precisely written and easier (English school students only) | 2 | not applicable |

Examples

B1 2.6 Because while studying in Arabic I haven't to make an effort for understanding the language, but I have only to concentrate on the meaning of what I study.

B2 2.13 I want to prove that Arabic is not only literature but is also a scientific language.

B5 4.4 It is not a matter of a language, because science can be learned in any language and since I'm Arabic pupil I should know the names in Arabic before any other language.

B5 4.6 I can't make a choice because it's not the language which is important in itself but Geology. However, words of Latin origin would have a greater probability to be understood than Arabic words (!!!)

B7 4.7 I prefer to study geology in English because it is the best language that I use.

B7 4.10 Because the existing technical words that are now available are English, the good books are English, the Arabic ones are just translations of them, and since I know English I prefer to read rather the good books so that I can get better informations.

B7 1.19 Geological words in Arabic are not in Arabic, they are scientific words so it's better to learn them in English.

B7 1.20 I prefer to study in English because some of the vocabulary is taken as it is from English when we're taught geology in Arabic.

B1 5.20 parce l'arabe est notre langue on peut la parler bien et au point de vue de rédaction (exprimer des choses sur des sujets différents) notre langue est la suelle pour nous.

B1 1.6 car c'est notre langue et puisque elle est très riche en vocabulaire scientifique, au contraire à ce que pensait les européens, on a pas besoin d'utiliser une langue importé de l'occident. [Note lack of consensus with remark above A3 1.6]
Appendix 14 Questionnaire: Geology -5-

B5 3.52 cela m'est égal parce que, pour moi, l'essentiel est de comprendre que ce soit en français ou en arabe.

B7 4.11 J'ai préféré le français dans l'étude de la géologie parce qu'il y avait des mots techniques qui définissaient chaque phénomène alors qu'en arabe il y avait un essai d'arabisation de ces mots techniques dont l'origine est française ou anglaise.

B7 1.17 Parce que le vocabulaire utilisé est courant dans notre vie courante.

B8 1.8 Parce que le Français est une langue plus pratique et plus scientifique que l'Arabe.

---

Question 2c) "What did you find was helpful about this change of languages?"

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 know in both languages</td>
<td>33</td>
<td>57</td>
</tr>
<tr>
<td>C2 understood the subject more</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>C3 it was better in Arabic, more familiar with Arabic</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>C4 liked the repetition</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>C5 nothing</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>C6 to see that science is universal</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>C7 other</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>C8 no answer</td>
<td>22</td>
<td>12</td>
</tr>
</tbody>
</table>

Examples

C1 4.11 to enlarge my knowledge in terminology and to be omnipresent in each language I know.

C2 4.21 knowing more about the subject (geology).

C2 4.19 things that were not clear in my mind became clearer.

C2 4.14 we can understand the ideas more quickly and they stick in our minds when we studied them in Arabic.

C6 1.15 To conclude that Science is Universal no matter what language it's taught with.

C1 3.52 la connaissance des termes scientifiques en plusieurs langues.

C2 1.15 Bien comprendre des termes que je n'ai pas assimilé en 4ème année.

---

Question 2d) "What did you find was unhappy about this change of languages?"

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 Texts a problem in Arabic</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>D2 names a problem, more terms to learn, more vocabulary</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>D3 nothing</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>D4 confusion</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>D5 not used to studying science in Arabic</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>D6 learnt nothing new, waste of time</td>
<td>5</td>
<td>52</td>
</tr>
<tr>
<td>D7 other</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>D8 no answer</td>
<td>27</td>
<td>26</td>
</tr>
</tbody>
</table>
Examples

D1 2.21 Differences in explanation. (English books give more detailed explanations—French books give complicated information based on complicated vocabulary—Arabic bases explanation on the logic of the geological processes without insisting on the details and vocabulary.

D2 4.19 Filling our heads with stores of vocabulary that we should learn in English and Arabic.

D2 2.18 the change of scientific words; they are sometimes non translated but written as they are pronounced which is really amazing.

D2 4.11 Seulement les mots techniques, que nous avions pris tant de peine à apprendre, se sont avérés inutile dans cette nouvelle étude de la géologie puisque nous avons en affaire à un autre vocabulaire très différent du premier.

D6 2.30 Il ne sert à rien pour nos études au futur. L’arabe n’est pas utilisé dans les facultés par exemple.

D7 1.24 La géologie était plus détaillé en 5ième année.

D6 3.52 le fait de refaire la même chose deux fois.
APPENDIX 15: PUPIL BACKGROUNDS

1. INTRODUCTION
As a matter of interest, I wished to find out where the pupils came from who attended the English school. Ideally similar information should have been gathered at the French school but because of time pressures this was dropped in favour of the geology question.

To classify the origins I used the Tunisian provinces system, as in Thourson-Jones (1986). With hindsight the question set was a little ambiguous, it could have referred to where the parents live now, where the pupil was born, or where the roots of the pupil were. This third choice was meant, but in three instances where a pupil gave two answers, I chose the origin, not where the pupil's parents currently live.

2. THE QUESTIONNAIRE
YOUR BACKGROUND
1. MALE/FEMALE
2. Which region of Tunisia do you come from?
3. What is the profession of your father?
4. What is the profession of your mother?
5. In your home do you speak
   a) French : ALL THE TIME/OFTEN/SOMETIMES/RARELY/NEVER
   b) English : ALL THE TIME/OFTEN/SOMETIMES/RARELY/NEVER
6. Does anyone in your wider family have a "scientific" job? YES/No. If so, what does he or she do?

3. RESULTS

<table>
<thead>
<tr>
<th>MALE: 50</th>
<th>FEMALE: 36</th>
<th>NO ANSWER: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUNIS 14</td>
<td>ZAGHOULAN 1</td>
<td>BIZERT 8</td>
</tr>
<tr>
<td>BEJA 1</td>
<td>JENDOUBA 1</td>
<td>EL KEF 4</td>
</tr>
<tr>
<td>SILIANA 1</td>
<td>KASSERINE 0</td>
<td>SIDI BOZID 2</td>
</tr>
<tr>
<td>GAFSA 3</td>
<td>MEDENINE 2</td>
<td>GABES 1</td>
</tr>
<tr>
<td>NABEUL 8</td>
<td>SFAX 12</td>
<td>MAHDIA 3</td>
</tr>
<tr>
<td>MONASTIR</td>
<td>OTHER 5</td>
<td></td>
</tr>
<tr>
<td>SOUSSE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes
1. Sousse and Monastir are both in the "Sahel", and since some pupils used this word in their replies, the two provinces are here grouped together.
2. "Other, means: North 2
   East coast 1
   NW 1
   Center 1
3. In the interview accorded to me by the Head of the English school, Madame Soua, on 26 May 1987, I had been told that over eighty percent of the pupils were boarders, ie came from outside Tunisia, and were not able or did not choose to live with relatives in Tunisia. (T9:7) Also, 75-78% had scholarships, indicating poor origin. (T9:20). This scholarships point I did not think it wise to ask the pupils directly about, but fits with the information about where the students came from, and the professions of the parents. The three main cities in Tunisia are Tunis the capital, followed by the rich southern industrial city Sfax, and the touristy city in the coastal center, Sousse.

The information present is consistent with the the official picture of pupils being selected from all over the country, and with many of them having poor origins.

Results: question 5. language in the home

<table>
<thead>
<tr>
<th>Language</th>
<th>Allways</th>
<th>Often</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Never</th>
<th>@</th>
</tr>
</thead>
<tbody>
<tr>
<td>French</td>
<td>1</td>
<td>3</td>
<td>20</td>
<td>33</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>English</td>
<td>0</td>
<td>1</td>
<td>10</td>
<td>26</td>
<td>48</td>
<td>1</td>
</tr>
</tbody>
</table>
### Results: question 3. profession of father

<table>
<thead>
<tr>
<th>Profession</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deed</td>
<td>2</td>
</tr>
<tr>
<td>Civil servant /clerk</td>
<td>8</td>
</tr>
<tr>
<td>Retired</td>
<td>5</td>
</tr>
<tr>
<td>Farmer</td>
<td>10</td>
</tr>
<tr>
<td>Labourer</td>
<td>2</td>
</tr>
<tr>
<td>Engineer</td>
<td>10</td>
</tr>
<tr>
<td>Teacher/in Education</td>
<td>22</td>
</tr>
<tr>
<td>Shopkeeper, businessman</td>
<td>5</td>
</tr>
<tr>
<td>Nurse</td>
<td>3</td>
</tr>
<tr>
<td>Management</td>
<td>3</td>
</tr>
<tr>
<td>One each of: policeman, technician, doctor, politician, judge, accountant, lorrydriver railway-worker</td>
<td>8</td>
</tr>
<tr>
<td>no answer</td>
<td>8</td>
</tr>
</tbody>
</table>

### Results question 6. 'scientific' job

<table>
<thead>
<tr>
<th>Profession</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer</td>
<td>28</td>
</tr>
<tr>
<td>Science teacher</td>
<td>10</td>
</tr>
<tr>
<td>Doctor</td>
<td>24</td>
</tr>
<tr>
<td>Architect</td>
<td>2</td>
</tr>
<tr>
<td>Pharmacist</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory assistant</td>
<td>1</td>
</tr>
<tr>
<td>Biologist</td>
<td>2</td>
</tr>
<tr>
<td>Scientific research</td>
<td>4</td>
</tr>
<tr>
<td>Computing</td>
<td>3</td>
</tr>
<tr>
<td>Food inspector</td>
<td>1</td>
</tr>
<tr>
<td>Technician (cars)</td>
<td>1</td>
</tr>
<tr>
<td>University lecturer</td>
<td>1</td>
</tr>
<tr>
<td>&quot;Petrol&quot; ie oil industry</td>
<td>1</td>
</tr>
<tr>
<td>electrical mechanics</td>
<td>1</td>
</tr>
<tr>
<td>accountant</td>
<td>1</td>
</tr>
<tr>
<td>mathematician</td>
<td>1</td>
</tr>
</tbody>
</table>

### Results question 4. profession of mother

<table>
<thead>
<tr>
<th>Profession</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housewife/no job</td>
<td>48</td>
</tr>
<tr>
<td>Nurse</td>
<td>3</td>
</tr>
<tr>
<td>Teacher, in Education</td>
<td>14</td>
</tr>
<tr>
<td>Manager</td>
<td>1</td>
</tr>
<tr>
<td>Secretary</td>
<td>1</td>
</tr>
<tr>
<td>Civil servant</td>
<td>1</td>
</tr>
<tr>
<td>No answer</td>
<td>18</td>
</tr>
</tbody>
</table>

5. The questions about the profession of the father and mother were set to cross check the origins of the pupils, and broadly confirms the low numbers of parents in high status jobs such as medicine. Along with Salem (1984 p2 ff) I hesitate to impose a British view of "class" on an Arab society and have not therefore classified the professions according to the usual official British distinction into five levels.

Question five, a relative with a scientific job, was put in to facilitate comparison with the work of Swift (1986) Swift asked pupils to list jobs under the headings of very 'scientific', very 'non-scientific' or definitely 'both scientific and non-scientific' and went on to ask them why.

Of interest here is the high number of examples of engineer who were quoted by the pupils as a relative with a scientific job. Also that an accountant and an architect were mentioned. In Swift's results, teachers, doctors, engineers and dentists were classified in the 'both' category. Other comparisons are difficult due to the small samples and differing methodologies.

In view of the fact that the English school was from the outset seen as a school leading to the Baccalaureate in Maths-Science, it would have been interesting to ask this question in a normal Lycée and see if there was a noted trend for the pupils in the lycées pilots to have a relative involved in science.

It would have been interesting to take Swift's results on what professions are viewed as 'scientific' or not, and compare them with the views of the pupils in Tunis.

Due to lack of time, and the concentration of this thesis on words and symbols, this question was not fully investigated.
APPENDIX 16: FAUX AMIS FROM THE LITERATURE.

1. MAILLOT (1981)

The following is a brief summary of les faux amis de l'anglais as found in Maillot (1981). For a discussion of them the reader is referred to the work using the page references supplied. While some of these words might not be used at secondary school level they are more evidence that faux amis do exist in scientific vocabulary, and this is one strand of evidence against the assumption that scientific language is constant.

In fact, Maillot recognises the importance of faux amis when he says:

Les exemples qui vont suivre ne prétendent nullement à remédier à des faiblesses qui se comptent par centaines (un volume n'y suffirait pas) mais ont pour seul objet de montrer que les faux amis jouent aussi un rôle capital dans la traduction scientifique et technique. (p31)

The following examples do not at all claim to remedy the weaknesses [in the literature on faux amis which neglects words from science] which are counted in hundreds, but are given solely with the aim of showing that faux amis have a leading place in the translation of scientific and technical texts.

Note the verb prétendre used in the above quotation is itself a faux ami, and here means "to claim". The English "pretend" is translated by faire semblé à. The word capital is also a faux ami meaning "important, vital". (Van Roey 1988 p642, 106).

<table>
<thead>
<tr>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Conductor</td>
<td>1. lame (conductrice)</td>
</tr>
<tr>
<td>2. insulation</td>
<td>2. isolement isolation</td>
</tr>
<tr>
<td>3a) switch (and compounds of)</td>
<td>3a) commutator</td>
</tr>
<tr>
<td>b) commutator (of a motor)</td>
<td>b) collecteur</td>
</tr>
<tr>
<td>4a) field magnet</td>
<td>4a) inducteur (f), bobine de</td>
</tr>
<tr>
<td>b) inductor</td>
<td></td>
</tr>
<tr>
<td>(but no clash for inductance)</td>
<td></td>
</tr>
<tr>
<td>5. resistance (size)</td>
<td>5. résistance</td>
</tr>
<tr>
<td>resistor (object)</td>
<td></td>
</tr>
<tr>
<td>6. generator</td>
<td>6. génératrice (for DC)</td>
</tr>
<tr>
<td></td>
<td>alternateur (for AC)</td>
</tr>
<tr>
<td></td>
<td>générateur de ..signaux etc</td>
</tr>
<tr>
<td></td>
<td>(for expressions)</td>
</tr>
<tr>
<td>7. alternator</td>
<td>7. alternateur synchrone</td>
</tr>
<tr>
<td>8. conductivity</td>
<td>8. conductibilité (property of)</td>
</tr>
<tr>
<td></td>
<td>opposite of resistivité</td>
</tr>
<tr>
<td>9. fluorine (halogen)</td>
<td>9. le fluor</td>
</tr>
<tr>
<td>fluor [spar] (mineral)</td>
<td>le fluorure [de calcium</td>
</tr>
<tr>
<td></td>
<td>naturel alias spath fluor]</td>
</tr>
</tbody>
</table>

Note, Maillot says such a confusion is destined to disappear as mineralogists in both languages are agreed to use the term "fluorite".

(Examples 1-7 above from page 32, with extra for example 2 from page 15. Example 8 p14, example 9 p37-8)
## Appendix 16 Faux amis from the literature –2–

2. **Défournéaux (1983)**

Note Défournéaux is working from French to English, and therefore sometimes seems to assume a good knowledge of French. Other reference sources have been consulted to make explicit the gaps he leaves in the French.

<table>
<thead>
<tr>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. p32 to annulate, to zero</td>
<td>1. anneler, annuler</td>
</tr>
<tr>
<td>2. p108 to terminate, termination</td>
<td>2. mettre fin à arrêt</td>
</tr>
<tr>
<td>3. to complete, completion</td>
<td>3. mener à son terme d’achevement</td>
</tr>
<tr>
<td>4. to end; end-point completeness</td>
<td>4. se terminer fin plénitude</td>
</tr>
<tr>
<td>5. to ultimately/eventually attain/end-point</td>
<td>5. finir par atteindre la fin plénitude</td>
</tr>
</tbody>
</table>

[Note, the index listed 'eventually' as the problem. This has the translation 'perhaps' while *éventuel* means 'possible'. (Thody & Evans 1985 p69, Harrap’s 1978, and Van Roey 1988 p277).]

6. competing reactions, NOT concurrent reactions (p110)

7. to parallel p111

8. ignition combustion (state of) (p124)

9. preservative condon (p131)

10 Phenol = versatile reagent inconstant (p111)

11 alternative

alternating (p111Robert 1984)

12 product

Has a narrower sense than the French and means in the context of chemistry, the end substance(s) of a chemical reaction. *produit* can mean simply "substance". p106.

13 inorganic chemistry mineral (eg acids, rocks)

14 chloration (-C1) chlorination (-C103)

Défournéaux points out the problem is the contraction in English of *-ation to ation*, and gives ambiguity in English thus:

15 to nitrate; nitration

[1.]

16 strength eg bond strength p8

17 alternative, alternating p9,111 optionnel, alternatif

18 magnetic, magnet p37 magnetique, aimant

19 solution (liquid) (of a problem)

(in)soluble problem p61

20 inconstant (p111) versatile
Appendix 16 Faux amis from the literature -3-

3. DEFOURNEAUX (1980)

<table>
<thead>
<tr>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. single (unit)</td>
<td>simple</td>
</tr>
<tr>
<td>simple p19</td>
<td>simplicité</td>
</tr>
<tr>
<td>to cancel a fraction</td>
<td>simplifier un fraction</td>
</tr>
<tr>
<td>cancellation p44. [2.]</td>
<td>simplification</td>
</tr>
<tr>
<td>22. datum p1. data p29.</td>
<td>donnée(s) (not 'dates' which</td>
</tr>
<tr>
<td></td>
<td>Défournéaux says is a common</td>
</tr>
<tr>
<td></td>
<td>anglophone error).</td>
</tr>
<tr>
<td>23. approximate/approached</td>
<td>approché</td>
</tr>
<tr>
<td>to approach</td>
<td>tendre vers</td>
</tr>
<tr>
<td>24. solid p55, 126</td>
<td>solide, résistant</td>
</tr>
<tr>
<td>25. to summarise</td>
<td>résumer</td>
</tr>
<tr>
<td>to resume (p100)</td>
<td>recommencer, reprendre</td>
</tr>
<tr>
<td>26. to carry out an experiment</td>
<td>réaliser une expérience p117</td>
</tr>
<tr>
<td>27. to insulate p131, to isolate</td>
<td>isoler</td>
</tr>
</tbody>
</table>

4. VAN ROEY (1988)

While working on this thesis Van Roey's (1988) book of faux amis was produced, with a unique style. The faux amis are presented in parallel sentences, of English and French. First sentences where the word is similar are given, then sentences where the English differs, finally sentences where the French differs. Footnotes make finer points clear. Of the hundreds of faux amis noted, the following relate to science, in addition to the instances, where Van Roey's work bears upon material presented in the results. Once again the paucity of basic scientific words in such a dictionary is to be regretted, especially when the words noted in the results are basic ones, no higher than baccalaureate level. The words presented in the results being only baccalaureate level must be considered as basic and within the comprehension of educated people, whether specifically knowledgeable in the sciences or not.

<table>
<thead>
<tr>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. tonsillitis</td>
<td>angine (f)</td>
</tr>
<tr>
<td>angina (pectoris) (p34)</td>
<td>angine de poitrine</td>
</tr>
<tr>
<td>2. Aerial (p38)</td>
<td>antenne</td>
</tr>
<tr>
<td>3. Bachelor of Arts</td>
<td>licencié es lettres</td>
</tr>
<tr>
<td>Person with 'A' levels (p72)</td>
<td>bachelier</td>
</tr>
<tr>
<td>4. A pair of scales, &quot;The tightrope walker lost his</td>
<td>balance</td>
</tr>
<tr>
<td>balance&quot; (p73)</td>
<td>&quot;Le funambule perdit l'équilibre&quot;</td>
</tr>
<tr>
<td>5. Diamond (shape of) (p220)</td>
<td>losange (form de)</td>
</tr>
<tr>
<td>6. even (level, steady) (p252)</td>
<td>égal</td>
</tr>
<tr>
<td>7. &quot;Some drugs tend to accumulate in the body (plus</td>
<td>&quot;Certains médicaments tendent à</td>
</tr>
<tr>
<td>rarement: organism&quot;). &quot;Ces régimes amaigrissants</td>
<td>s'accumuler dans l'organisme&quot;</td>
</tr>
<tr>
<td>mal équilibrés sont néfastes pour l'organisme&quot;. (p489)</td>
<td>&quot;Unbalanced slimming diets like</td>
</tr>
<tr>
<td></td>
<td>these are bad for the system&quot;</td>
</tr>
<tr>
<td>8. &quot;Pourrais-tu orienter l'antenne?&quot;</td>
<td>&quot;Could you adjust the aerial?&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;(p490)</td>
</tr>
<tr>
<td>9. limited knowledge</td>
<td>connaissances primaires</td>
</tr>
<tr>
<td>primary concern</td>
<td>but principal</td>
</tr>
<tr>
<td>&quot;Research is a matter of primary importance to us&quot;.</td>
<td>&quot;Nous attachons une importance</td>
</tr>
<tr>
<td></td>
<td>princesielle à la recherche&quot;</td>
</tr>
<tr>
<td>10. process of digestion</td>
<td>le processus de la digestion</td>
</tr>
<tr>
<td>trial/lawsuit (p548)</td>
<td>procès</td>
</tr>
<tr>
<td>11. wild (p533)</td>
<td>sauvage</td>
</tr>
<tr>
<td>12. strong (p669)</td>
<td>solide</td>
</tr>
</tbody>
</table>

1. cp T249, teacher TEL in a sixth year chemistry class asked me if chloration and bromation existed in English. The same teacher, T269 later asked me if English made the distinction between bromination and bromation. This is a good example of how such material is confusing, and clarification is needed at school level.
2. Note that in English one can also simplify a fraction, or reduce a fraction. These possibilities are not noted by Défournéaux.
APPENDIX 17: REFERENCES TO THE FIELD SITUATION.

1. INTRODUCTION
In pursuance of the aim of a thesis in enabling another researcher to repeat and extend the work done, and because the field situation in Tunisia is little known in Britain, this appendix, as a guide to some of the main references, is included. The material was important in the initial stages of the research, gives some more of the context, and indicates what is available in Tunisia for a researcher.

2. REFERENCES TO TUNISIA IN GENERAL
For a good bibliography on Tunisia in English, with reference to English sources mainly see Findlay (1982) in the World Bibliographical series. There are sections on Language, and Education.

The Annuaire de l'Afrique du Nord (1962- annual) is a vast bibliographical source with summaries of the changes in Education year by year, and articles whose overall theme varies with the yearbook.

Until it ceased publication in 1987 due to lack of sponsorship, the most useful source of information, which was always only a few months behind events was the magazine Grand Maghreb of the Centre d'information sur le Grand Maghreb [1.] Riguet (1984) also has an extensive bibliography and a good summary of the linguistic situation in Tunisia in the last hundred or so years. His work is based upon and extends the work of Demeerseman (1967) which includes chapters on education in the family.

As someone who has had to live in Tunisia, the field work alone being spread over three years, the best practical guidebook is Morris (1985). Perkins (1986) gives more analysis, and is excellent both in the history of Tunisia and on the modern day situation. Entelis (1986) covers the same ground for neighbouring Algeria. Salem (1984) is more concerned with the ex-President Bourguiba himself and his impact on the country.

3. REFERENCES TO EDUCATION IN TUNISIA
A key overview article is found in the magazine Maghreb Machrek by Zoughlami & Skik (1977). Sraib (1974) is also important and detailed. For material specifically devoted to Education in Tunisia the articles in IBLA, the Revue de l'Institut des Belles Lettres Arabes are important. These include Jornier (1949) Demeerseman (1949, 1950a, 1950b), Lelong (1958, 1961, 1971), Baldacchino (1977), and Mizouri (1988).

There are two journals in Tunisia specifically devoted to education. These are Revue Tunisienne des Sciences de l'Education (RTSS) [2.] and the Bulletin Pédagogique de l'Enseignement Secondaire, (BPES) [3.] Both include articles in French and Arabic. BPES regularly publishes a special edition of the previous year's baccalaureate examination papers. Textbooks, all official, can be obtained in many bookshops, or from the Centre National Pédagogique [3.] which also sells some of the official syllabi. The Ministry of Education itself publishes from time to time various reports, especially summaries of the education system for the biennial Conférence Internationale de l'Education. (Tunisie 1977, 1986a) These reports include material submitted for the five year plans (eg Tunisie 1987a). In the national press, the dailies La Presse, Le Temps and the weeklies Réalités, Maghreb, often have announcements and articles on education, the dailies being a semi-official means of communication in Tunisia.


The question of the language policy in Tunisia, otherwise known as 'arabisation' has a large literature. Riguet (1984), Fitosuri (1983) and Fontain & Brechoux (1975) are good starting points. Romdhane's theses (1984, 1987) are studies of the psychology of pupils at the French and English schools.

There are several important libraries, apart from the National Library in the medina. The British Council library [4.] has a small but reasonable linguistics section. There is an English language teaching library at Bourguiba School [5.] . The French have a research library [6.] as do the White Fathers [7.] and the Americans [8.], the latter possess copies of almost all recent theses written by Americans on North Africa.

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1. Institut d'études politiques de Grenoble II, B.P. 45 38402 St Martin-d'Hères Cedex France.
2. Published at irregular intervals by the Institut National des Sciences de l'Education in Avenue Ali Trad, Mont Fleuri, Tunis.
3. Published at regular intervals with occasional special issues by the Ministère de l'Education Nationale and obtainable from the Centre National Pédagogique, the education publisher for the ministry in Tunisia, whose main point of sale is in place de la France. Tunis.
4. Place de la France. Tunis.
5. Institut de Langues Vivantes, Avenue de la Liberté, 1002 Tunis.
8. CEMAT. Impasse Nanubrea, Rue d'Angleterre, Tunis.
Appendix 17 Situation references -2-

4. REFERENCES TO FRENCH EDUCATION
A good comprehensive summary of all aspects of France and French life, including education can be found in Ardagh (1987).

For material in English on French Education there is Barnard (1922 reprinted 1970), and Anderson (1975) who deals with the history. For the more modern day situation see Halls (1965, 1972, 1976) HD Lewis (1985) Elvin (1961) and Gaziel (1989).

The most accessible magazine on French Education is Le Monde Education which as the advantage of being monthly, and has a section in which the latest publications, official and semi-official, are noted.

ONISEP [9.1 produce annual guides to the French system for the French people. Of relevance to this thesis are ONISEP (1987a) describing the system as a whole and ONISEP (1987b) describing the last four years leading to the various kinds of baccalaureate.

Official syllabi and ministerial directives can be obtained from le Centre National de Documentation Pédagogique.[10.]

The Institut National de Recherche Pédagogique (INRP) publishes four journals, and other interesting material for the researcher with detailed brochures being sent on request.[11.]

Examinations are set nationally for the baccalaureate, but with regional papers. These are usually published after the exams have been used, by commercial publishers such as Hatier. The Anabac series publishes simply the questions, by theme, but with tables indicating which questions belonged to the same examination. The Corriges series includes model answers, which are not the official ones and are not to be confused with full examiners mark schemes, but being from such a well known publisher, are presumably very close to the expected answers.

There are numerous books and articles about French Education published in French. Particularly accessible is the fourth 'hors-série' of Science & Vie (1988).

5. ENGLISH EDUCATION
In the last few years, the Education system of England and Wales has undergone considerable change. For instance a national curriculum for the examinations which most pupils take at the age of sixteen. Also examinations known as the GCSE, 'General Certificate of Secondary Education' have been set up, each subject being examined and graded separately. The GCSE attempts to cover in one examination the range of the old 'O' level (Ordinary level set for the higher ability range) and the GCE (General Certificate of Education, set for the middle ability range Attainment targets and tests have also been set for pupils at the age of 7, 11, 14 and 16. Schools are to have much more control over how they spend money allocated to them, and the powers of the school governors have been increased.

So far, the 'A' level has been untouched, giving a welcome stability for comparison purposes in this thesis.

For 'A' level in England Wales and Northern Ireland (Scotland has its own system) there are several examination boards. In addition, in the sciences, there are courses called 'Nuffield', eg 'Nuffield biology' which has examinations set by one of the boards on behalf of the others so, it is in effect a national examination. Nuffield courses were set up to stress principles and experimentation to a greater degree than the more traditional courses. As such it is further away from the French baccalaureate than the so called more traditional courses and examinations, though in recent years the traditional courses have adopted much of the best of the new ideas in the Nuffield courses, so the gap between Nuffield and traditional courses is not now that great.

Also, in 1983 the boards published agreed common cores, as a way of standardising the courses and making sure that each subject, taken with whatever board, had a certain minimum content to a certain level or higher. (Cores, 1983). The cores included a statement of what mathematical knowledge and skill is to be expected of students doing the physics, chemistry and biology 'A' levels.

It is this core material, in conjunction with the syllabi of one of the boards, the Associated Examining Board, that I have chosen to use in this thesis as my standard for comparison purposes.


10. Paris address: 13 rue du Four, 75270 Paris Cedex 06. This agency also has outlets in most towns and cities of France.

11. 29, rue d'Ulm, 75230 Paris Cedex 05. The Journals are Revue Française de Pédagogie, Perspectives Documentaires, Recherche et Formation, Histoire de l'Education, Repères and Aster, the latter being a new journal for the teaching of experimental sciences.
APPENDIX 18: GRAMMAR

1. INTRODUCTION

This chapter deals with several topics which are on the border line between the section on verbals and the wider context of discourse, and being on the border they are excluded from the body of the thesis.

2. SUB-HYPOTHESIS

The differing grammatical forms of French and English will not affect the sense in scientific language when this term is extended to cover phrases and sentences.

3. RESULTS

a. The passive

1) Introduction

The use of the passive is often seen as a characteristic of scientific writing (Strevens 1977 p154, Ever 1971 p67, Widdowson 1974a p289). The opinion that this is a characteristic seems to be widely held among non-scientists. With this view goes the opinion that science is objective and impersonal, therefore as the person is irrelevant, the passive, in eliminating the subject, is actually the most appropriate 'voice' [1.3 to use.

Yet French does not use the passive as frequently as English. But for CSL to be valid, whenever a passive would be used in English, it would be used in French.

2) Form

There are at least twenty active tenses in English (if one includes the infinitives, conditionals and participles, and excludes the imperative). Of these twenty, thirteen have an associated passive. With French it is difficult to make such a clear statement, because French, unlike English, has tenses that are written only, and some of the written tenses are dropping out of use: three of the four subjunctive tenses (imparfait, passé and plus-que parfait) which each have a passive are almost never used. With this restriction and also excluding the imperative there are fifteen tenses in French each having a passive. (Byrne & Churchill 1956 p97-8).

There is no equivalent in French to the English passive with a direct object. For instance, in English alone it is possible to say "I was given a book by my father" (Byrne & Churchill 1956 p97). Anyone wanting to use this construction in French must choose another way, such as to use the 'on' form, or a reflexive verb, or some other way as explained below.

3) Usage

a) In French 'on' is used much more frequently than the English 'one'. The form in French on + verbe actif is used for when a verb is transitive in English but the equivalent in French is intransitive. eg 'On a répondu à la question' for the English 'the question was answered. (Ollivier 1979 p322). As Astington (1980) prefers to put it:

The use of 'on' with the active form of the verb is obligatory with indirectly transitive verbs (i.e. verbs taking prepositions 'à', 'de'), obligatory with a verb followed by an infinitive, and common with transitive verbs. (p54 brackets: Astington).

b) French can use a reflexive verb with a passive meaning. Astington (1980 p54-5) gives twenty-one examples of which I have chosen one, as in figure A18.1. This is considered in more detail in part b. below.

c) Other equivalents of the passive are also possible. These are given by Astington (1980 p56-66). In figure A18.1 below these are listed with one example for each equivalent, selected from the many given by Astington.

1. Tenses are traditionally classified by moods: either indicative or subjunctive, with for each mood two voices: active or passive.
## FIGURE A18.1 FRENCH EQUIVALENTS FOR THE PASSIVE IN ENGLISH
(From Astington 1980 p54-60)

<table>
<thead>
<tr>
<th>Equivalent</th>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 'On' + active</td>
<td>Nous n’avons plus besoin qu’on nous apprenne l’importance de la progression scientifique</td>
<td>We no longer need to be informed of the importance of scientific progress</td>
</tr>
<tr>
<td>2. The reflexive</td>
<td>Un nouveau champ scientifique se développe actuellement</td>
<td>A new scientific field is at present being developed</td>
</tr>
<tr>
<td>3. 'Se voir' + past participle of verbs taking a direct object</td>
<td>Depuis deux ou trois saisons, cette population se voyait submergée par le ras de marée des foules vacancières</td>
<td>For two or three seasons, this population has been submerged by the tidal wave of holiday crowds</td>
</tr>
<tr>
<td>4. 'Se voir' + infinitive of certain verbs taking an indirect object</td>
<td>Les électriciens se voient garantir de 2,5% à 3% de progression du pouvoir d’achat</td>
<td>The electricians are guaranteed an increase from 2.5% to 3% in their purchasing power</td>
</tr>
<tr>
<td>5. Verbs taking an indirect object used impersonally</td>
<td>A ces questions il ne sera pas répondu tout de suite</td>
<td>These questions will not be answered immediately</td>
</tr>
<tr>
<td>6. Verbs used pronominally and impersonally</td>
<td>Actuellement il se crée au centre de la France une sorte d’unité économique</td>
<td>At the present time a sort of economic unit is being created in the centre of France</td>
</tr>
<tr>
<td>7. 'Passer pour' = 'to be thought to be' &amp; equivalents in meaning</td>
<td>La science mathématique passe, à juste titre, pour difficile</td>
<td>Mathematical science is rightly thought to be difficult</td>
</tr>
<tr>
<td>8. Active infinitive, preceded by 'a' with passive meaning</td>
<td>L’histoire de la libération de Paris reste à établir et à écrire</td>
<td>The history of the liberation of Paris remains to be verified and to be written</td>
</tr>
<tr>
<td>9. 'Entendre' + active infinitive with passive meaning</td>
<td>Il avait entendu dire que...</td>
<td>He had heard it said that...</td>
</tr>
<tr>
<td>10. 'Faire' + active infinitive with passive meaning</td>
<td>Elle avait fait réviser la voiture quelques jours auparavant</td>
<td>She had had the car overhauled a few days previously</td>
</tr>
<tr>
<td>11. 'Se faire' + active infinitive with passive meaning</td>
<td>La Marine dr fait connaître par ces prestations</td>
<td>The Navy makes itself known by these displays</td>
</tr>
<tr>
<td>12. 'Se laisser' + active infinitive with passive meaning</td>
<td>L’article 177 prévoit prison et amendes pour les fonctionnaires qui se seraient laissé corrompre</td>
<td>Article 177 makes civil servants who have allowed themselves to be bribed liable to prison and fines</td>
</tr>
</tbody>
</table>
4) Use
According to Widdowson, the passive is used frequently in science because
the message is thus 'detached', 'objective', its truth being independent of who
is addressing whom. (1974a p288).
And this depersonalising is
As much an essential part of science as is the 'subject matter' of pressure, mass . . . and so on. (p289).

Though "The passive is much more widely used in French than has been generally
realised" (Astington 1980 p52) it is clear from figure A18.1 that the structure of
the passive cannot be used in French as often as it is in English. French though
does have other ways of expressing the sense of the passive. Therefore if the
passive does characterise the discourse of science, then it is not the passive
voice that is important, but any grammatical structure having the sense of the
passive voice.
It is in fact a debatable point that scientific discourse is characterised by the
use of the passive voice, or 'structures expressing the passive sense'. The
active voice can be used in scientific discourse, because who did an action can be
important and may need specifying. For the sake of clarity and readability alone
some writers of scientific discourse choose to use the active voice.
The passive though does not serve only to stress objectivity. There are other
reasons for choosing to use the passive. In English, whatever comes first in a
sentence is regarded as more important. The passive can be used to give
prominence to what happened rather than who took part in the event.

Further research needed to find out how much passive sense used in English itself,
and to compare with French.

b. Pronominal verbs
Pronominal verbs exist in French but not in English. These are the verbs with the
reflexive pronoun 'se'. Some pronominals exist only as pronominals eg 'se faire'
(Olliver 1979 p18). Others can also have a pronominal non reflexive form ('les
verbes pronominaux non réfléchis' Olliver 1979 pl17), in which case there is often a
nuance of meaning between the two forms that can be difficult to convey in English.

Défournéaux (1980 p79) lists eleven examples of such verbs. These are listed in
figure A18.2 below.

**FIGURE A18.2 DéFOURNÉAUX'S LIST OF PRONOMINAL VERBS**
(As all can exist with or without the 'se' this is not included below
though it is in Défournéaux's presentation).

<table>
<thead>
<tr>
<th>French</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>appliquer à</td>
<td>to apply to</td>
</tr>
<tr>
<td>référer à</td>
<td>to refer to</td>
</tr>
<tr>
<td>rapporter à</td>
<td>to relate to</td>
</tr>
<tr>
<td>établir à</td>
<td>to settle down at</td>
</tr>
<tr>
<td>changer en</td>
<td>to change to</td>
</tr>
<tr>
<td>accroître de</td>
<td>to increase by</td>
</tr>
<tr>
<td>accumuler</td>
<td>to accumulate</td>
</tr>
<tr>
<td>combiner</td>
<td>to combine</td>
</tr>
<tr>
<td>mélanger</td>
<td>to mix</td>
</tr>
<tr>
<td>séparer</td>
<td>to separate</td>
</tr>
<tr>
<td>rejoindre</td>
<td>to join</td>
</tr>
</tbody>
</table>

Défournéaux discusses three examples of pronominal verbs in detail.

1) *L'équation se résout en . . .*
In English it is not the equation that resolves itself, but the equation is solved
ie the passive is used.

2) *Les droites se coupent en . . .*
In English two lines are not considered to cut themselves ('se coupent') but that
each line cuts the other.

3) *La formule s'applique à . . .*
In English the verb 'to apply' translates both nuances of the French 'appliquer'
(to put into practice, to use) and 's'appliquer' (to be applicable to, to work
with zeal).

It is sometimes difficult therefore in English to translate the nuances conveyed by
the existence in French of pronominal verbs, especially where a non-reflexive form
also exists.
c. English use of the present participle

French does not have the present participle, which is frequently used in English. In particular, French words ending in '-age' and '-ion' are frequently translated in English by the present participle. e.g:

Le partage du volume donne  
Sharing the volume yields

La résolution de l'équation donne  
Solving the equation yields

(Defourneaux 1980 p146, Défournneaux's translation. Note his use of 'yield': 'results in' or even 'gives' would be better translations.)

This time there is a nuance in English which the French does not have. 'The solution to the equation gives' is not exactly the same as saying 'solving the equation gives'. If anything, the former, (closer to the French) is more impersonal, but, as Défournneaux himself says:

Ces expressions sont très courantes et allègent beaucoup les textes anglais.  
These expressions are very common and make English texts much less heavy (to read)

(Defournneaux 1980 p146, translation IL.)

The present participle in English can therefore give a nuance that is difficult to convey in French.

4. DISCUSSION

The passive is not necessarily a characterising feature of scientific discourse. There is a need at times in scientific discourse to state the person doing the action. It is also debatable that science is objective, therefore the use of the passive reflects this. The passive can be used to give the object prominence. In this area of the use of the passive are several assertions which rest open to test.

Similarly, several differences in grammar between English and French have been mentioned, which has implications not only for style, but also a nuance in one language may be difficult to convey in another. How significant these differences are is another matter.

5. SUB-CONCLUSIONS

It is an open question how much grammar affects meaning, and whether French and English are capable of conveying similar semantic meaning through different forms.

If the passive does characterise scientific discourse, then in view of the different ways of expressing the passive in French, this characteristic must be viewed as one of sense not form: a passive construction in English may have a non-passive form which still bears a passive sense in French.
APPENDIX 19: 'BASIC COLOR TERMS'

1. INTRODUCTION

Reference has been made to a topic widely known where it has been proposed that the basic terminology for colour is 'universal' in the linguistic sense of an "obligatory characteristic of all languages" (Bullock & Stallybrass 1977 p654 "Universal"). This appendix presents a brief summary, and contrasts their work with the case of notation of music. Widdowson views the scientific conventions, the discourse patterns, and the non-verbal conventions as 'universal' which is closer to the example of Basic Color Terms.

2. BERLIN & KAY'S (1969) 'BASIC COLOR TERMS'

Berlin and Kay studied the terminology for colour in twenty languages. They argued that:

...although different languages encode in their vocabularies different numbers of basic color categories, a total universal inventory of exactly eleven basic color categories exists, from which the eleven or fewer basic color terms of any given language are always drawn. (p2)

They also proposed rules for when a language uses less than these eleven basic categories.

By implication these colour categories are universal, and interlanguage variability is no greater than the variations for colour perception of individuals in a given language. (p10). Crawford (1983) argues that the criteria used for defining a Basic Color Term were contradictory and ambiguous. For instance, Berlin & Kay (1969 p7) instructed their informants "to indicate for each basic color term, all those chips (coloured objects) which he would under any conditions call x." The problem is that the range of meaning of a term can vary according to the context, and especially the possible collocations. 'White coffee' may refer to a deep shade of brown. Therefore the instructions to informants should have been formulated "in such a way that specific collocations are excluded". (Crawford 1983 p339). Berlin & Kay also fail to take into account that some languages, "employ different terms depending upon whether the object referred to is animate or inanimate". (Crawford 1983 p339).

Therefore Crawford 1983) proposes a new definition taking account of these and other criticisms and says,

It would be interesting to see if experiments based on this (new) definition gave results similar to those originally reported by Berlin and Kay. (p342).

According to Crawford the case for colour categories being universal is not convincingly established.

On the other hand Hill (1988), in a review essay states that "relatively few exceptions... have been identified" (p27) While she notes three well documented exceptions, her review does not account for Crawford's arguments. Three well documented exceptions would also be good evidence that Basic Color Terms are not universal given Popper's principle of falsifiability, (discussed further in Chapter 5 'Foundations of the project' Section 2j).

3. NOTATION IN MUSIC

For many years I was taught that Italian was the international language of music, and I assumed that the way of naming the keys was international. In fact while the instructions given at the head of the music for pace and rhythm may well be traditionally written in Italian, the way of naming the keys is certainly not international. For example the French use the Tonic sol-fa system as key names rather than the key names A to G. Thus the key of 'C' is the key of 'do' and the key of 'E' is the key of 'mi'. This also is applied to the names of guitar chords, meaning that two 'international' naming systems are in operation as such a system is also used by the Swiss, the Germans and the Italians.

The problem is not just a change of nomenclature. The 'tonic sol-fa' system is known in English, but is not used for the naming of individual keys. Instead the first note of any key can be labelled 'do', the second 're', the third 'fa' and so on. To aid the learning of new songs music written for voices can have the notes labelled in the tonic sol-fa system, and singers use the names to help them pitch the sequence of notes.

There are other differences, for instance, even the names of the note-lengths are not the same, with the confusing fact that a crochet is une noire while a quaver is une croche.

Music cannot therefore be assumed to have one complete 'universal' language of notation since at least two systems exist for the naming of keys. The notation of music is neither uniquely international nor 'universal' in the Widdowson sense.
REFERENCES (Tunisian Textbooks are listed at the end).


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Peterson ADC. (1988) *Schools across frontiers.* Open Court, Illinois USA.


**TEXTBOOKS IN FRENCH USED IN THE ENGLISH AND FRENCH SCHOOLS**

The official Tunisian textbooks in French have been referred to in the thesis by a coding and are listed here with their authors:

{year number} {language} {subject} {section, if any} {page number}.


