Science as a Universal Language

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This article is adapted from chapter 28 of my unpublished Ph.D thesis, Lowe I 1992 Scientific language at pre-university level between French and English. University of Surrey, UK. Though the references are old, I see no sign that ESP has fully grappled with this question of the universality of science. In particular, useful textbooks and dictionaries comparing major languages are still scarce.

1. '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.

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.

2. 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.

For instance, in a table (1979 p29) comparing the symbols of atoms and molecules, he classifies the following as 'molecules': CL_2, H, O_2, S_8, Fe, Pb, and Cu_2. 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.

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, it is important to explain what Widdowson does and does not assert

b. Widdowson's arguments

Widdowson's arguments can be summarised 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 p110 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. (p42).

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 1 below.

Figure 1 Widdowson's three way translation

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          A
    non-verbal device
      /       \
     /         \
    /           \
 L1 use        English use (L2)
   B            C
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(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 véhiculaire*.

> 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).

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).

To put this in terms of Zylbersztajn's model the linguistic distance between the 'science of the scientist' in one language and the counterpart in another will be less than that between the 'science of the scientist' and the '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 the 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 aims, 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 similarity of science syllabuses. (B. Wilson 1981 p32).

Wilson then, while regarding sciences as relatively culture bound, still sees mathematics as culture free.

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. Robinson (1980 p25) questions this assumption.

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'. 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 '*droite*' which is rooted in fundamentally different ways of viewing reality so expressed. '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.

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 universality is more likely 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 undoubtably is a force operating in certain circumstances, but its generalisation rests questionable.

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, '§témoin§' being translated as 'standard'. At least the

Harrap's 'New Shorter French and English Dictionary (1978) gives for the English 'control' the French §'témoin'§. 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 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. 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 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.

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