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Contents

SCIENCE STUDENTS AND THE LANGUAGE PROBLEM: SUGGESTIONS FOR A SYSTEMATIC APPROACH

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Abstract

Science students experience difficulties with the language of science all over the world. Students using a second/foreign language as a medium of instruction experience the additional difficulties related to such use. The overall combination of the language-related problems is probably the major cause of the difficulties students encounter in their approach to scientific subjects. The present work outlines a basic framework for a systematic and practically-oriented investigation of such problems, the main purpose of the investigation being the collection of information to be utilised in the preparation of auxiliary teaching material specifically designed to address the identified factors.

The Language of Science and the Learning of Sciences

The role of linguistic mastering in the learning of sciences and in the expression of the acquired knowledge has been the object of attention in many contexts. The general conclusion is that inadequate familiarity with the mode of expression that is typical of scientific communication, and that can be called the language of science, is the main cause of the difficulties students experience in reading science textbooks, in answering questions or in providing other types of explanation (Mallinson, Sturm & Mallinson, 1952; Lahore, 1993 and Castro, 1995).

The language of science has specific requirements: rigour, clarity, and simplicity. They are tools for communication effectiveness and like any tool, they demand the acquisition of a certain ability for an appropriate utilisation. The roles of clarity and simplicity are self-evident. The requirement of rigour is related to the nature of scientific knowledge: it demands that the choice of individual words and of the way those words are associated into sentences be strictly consistent with the characteristics of the system or phenomenon described and with the way in which we are able to know it (Mammino, 1995a and 1995b). Such requirements hold whichever the language utilised: this makes the language of science into a sort of language of its own, whose use must be learnt. Ideally, the education to the language of science should be an essential component of scientific education: it should generate the ability to identify all the pieces of information transmitted by a given text (including the implications associated with the use of the words chosen) and the habit to precision both in written and in oral expression. However, these objectives are not often pursued adequately, which may account for the difficulties students encounter in handling the language of science. Such difficulties concern all students, whether they utilise their mother tongue or a second/foreign language as medium of instruction. In the latter case, additional difficulties stem from the fact that the full identification of the information transmitted both explicitly, by the statements, and implicitly, by the choice of the individual words, becomes more laborious when these words belong to a language different from the mother tongue.

Studies Performed

The content of the present work is based on the outcomes of the two contributing experiences that will now be described briefly.

First Study

A study of the language used in science teaching material in Italy and of the difficulties Italian students encounter in relation to scientific texts/expressions. In this case, the difficulties are predominantly associated with insufficient familiarity with the language of science, since Italian

students (like all European students) use their mother tongue as medium of instruction. The study started in 1983, initially as a component of a systematic investigation aiming at identifying the details of the difficulties students encounter in their approach to chemistry, in view of the preparation of a student-friendly chemistry textbook (Mammino, 1994). It soon developed into an independent study. The collection of information was based mainly on interviews with students, co-reading of teaching material with students, analysis of students' written works, analysis of teaching material. It highlighted the relevance of the familiarity with the language of science for an appropriate understanding of science concepts. It also pointed out that the most frequent difficulties are associated with the use of common words in scientific contexts, in relation both to the choice of individual words and to the association of words (Mammino, 1996 a). The interactions with the students stressed the opportunity of interdisciplinary approaches (Mammino, 1995 a) and the potential advantages of the analysis of mistakes to highlight the practical aspects of the language of science (Mammino, 1996 b). The amount of material collected was sufficient for the preparation of a practical guide, mainly meant for science teachers and for higher-secondary and/or university students, and making large use of the analysis of mistakes as a tool for explanation, within a specifically designed approach (Mammino, 1995 b).

Second Study

A study with students using a second language as a medium of instruction at three different institutions in the Southern African region (University of Zambia, National University of Lesotho and, currently, University of Venda). It started in 1990 and it was mainly based on a systematic analysis of answers from students' written works (more than 2000 answers collected and compared), complemented by some personal interviews to verify the validity of the hypotheses about the causes of the mistakes analysed. Though it is often impossible to disentangle the linguistic component and the scientific/conceptual component of students' incorrect answers and to assign precise weights to each component in each mistake (Love & Mammino, 1997), the heavy role of the linguistic component appears evident. In addition, many incorrect conceptions stem from insufficient understanding

of the material read and this, in turn, can be traced to inadequate linguistic knowledge hampering its comprehension and interpretation. All this confirms that the weight of the overall language-related component of the difficulties encountered by students may exceed the weight of the other components altogether. The study also pointed out that the highest number of imprecisions is related to the use of common words in scientific contexts and to the way in which words are associated, while mistakes in the use of strictly technical words are considerably less frequent.

A comparison of the two sets of information thus collected offers the opportunity for an attempt to evaluate the aspects related to the general difficulties students encounter with the language of science and the aspects more specifically related to the use of a second/foreign language as medium of instruction. The hypothesis that the former might have a heavier weight than the latter seems probable. It is supported: (a) by some significant similarities in the mistakes from the two contexts; (b) by the observation that, in either context, the imprecisions are more often related to the use of common words and their association; (c) by the observation that even students who have a good every-day mastering of the language that is the medium of instruction may encounter considerable difficulties in reading or writing science texts; (d) by recent material collected for another investigation (Mammino & Cardellini, unpublished).

Scope of the Present Work

Effective measures to enhance the students' familiarity/mastering of the language of science would involve the design of ad hoc pedagogical approaches and auxiliary teaching material. The author's previous experience highlights the significance of a systematic investigation, identifying all the relevant aspects and their details, for such design to meet the specific needs of the subject area and of the context considered. A general approach to the design in relation to the information collected/available was developed on the occasion of the preparation of Mammino 1994 and Mammino 1995b; the description of its framework/features would however exceed the scope of the present discussion.

The current work presents the main aspects so far identified for the language issue: they are both features of the overall language-related problem and areas of investigation; their ensemble constitutes a basic framework for a systematic and practically-oriented collection of information, of the type that can be utilised as starting basis for the design of approaches and material. Contexts in which a second/foreign language is the medium of instruction are targeted. Following the outcomes described in the previous section, the use of the language of science is considered as having the central role in the language-related components of the teaching/learning of science subjects, and the analysis of the aspects specifically related to the use of a second language focuses mainly on the ways they influence/affect the use of the language of science. For simplicity's sake, the most relevant aspects and the approaches to their investigation will be first discussed individually, under two separate sections, to better stress their roles in the use of the language of science and the features that may arise from the use of a second language, respectively. Their interactions/overlap will then be considered. Since concrete cases are most commonly concerned with such interaction/overlaps, this part of the discussion will be substantiated by a number of examples from students' answers. The level of instruction targeted is the tertiary level. However, suitable modifications may be elaborated/introduced to adapt the approach to other levels. Some information about the measures found more convenient is also added.

Aspects Related to the Use of the Language of Science

The aspects discussed in this section concern all educational situations, including those in which students use their mother tongue as medium of instruction. They are:

Students' awareness of the fact that the mode of expression in the sciences has specific requirements. The degree of awareness varies considerably from one situation to another; however, it appears that many students have never been told of these requirements explicitly, nor have they been trained, even indirectly, to pay attention to the precision of the expression as an essential part of scientific knowledge. The aspect is conveniently checked through questionnaires asking simple, direct questions about what students

think/know of the language of science and its requirements (an example is presented in Mammino, 1995c). Measures aiming at increasing the awareness may include practical tools, like the analysis of mistakes showing how linguistic imprecisions result in the transmission of incorrect information (Mammino, 1995b and 1996b; Love & Mammino, 1997) and a more theoretical level, in which the requirements of the language of science are presented in relation to the scientific method in general.

**Students' acquired familiarity with the language of science. This familiarity implies both the capability of: identifying all the information transmitted by the text, on reading, and that of providing answers conforming to expression precision. As far as the former aspect is concerned, the following options have been found to be convenient sources of information: (a) an oral approach involving group discussions after reading selected texts; (b) personal interviews involving the discussion of selected texts; (c) written analysis of selected texts, often complemented by personal interviews discussing the features of the analysis provided; (d) submission, to the students, of statements containing one or more language-of-science mistakes: students are asked to identify the mistakes and to discuss them briefly, possibly providing correct formulations that should replace the incorrect ones; (e) a consideration of the frequency with which students realise the presence of rigour inadequacies in their study material. Information on the students' ability to choose precise words in relation to the system or phenomenon of interest, and to associate them into sentences giving correct descriptions of either, is mainly provided by the analysis of their answers in their routine work. Since the two aspects just considered overlap, to a considerable extent, with the aspects associated with the knowledge of the language that is the medium of instruction; the details will be comprehensively discussed in the section devoted to this overlap.

The other requirements of the language of science, i.e., clarity and simplicity, may also be the object of investigation aiming at evaluating the students' ability of providing clear statements and/or descriptions and of avoiding excessive complexity in the building of sentences (the attempts to write long, complex sentences, often result in the loss of internal logic of the

sentence itself: this is not rare among students using their mother tongue, but it occurs more frequently with students using a second language, due to the specific difficulties associated with such use).

Students' Familiarity With Technical Words

Another essential aspect of scientific communication is the use of technical words, i.e., of the words denoting the objects, phenomena and characteristics that are studied by a given discipline. It may be convenient to rate the students' knowledge of these terms at the three following levels:

(a) limited to the mere knowledge of the existence of a specific technical term;

(b) including the knowledge of its meaning and the capability of explaining it;

(c) including the ability of using it correctly in those descriptions of systems or phenomena in which the concept expressed by that term has a role.

A preliminary study carried out among science students at the National University of Lesotho showed that nearly all students comply with level (a), while the extent to which they master levels (b) and (c) varies widely depending on some characteristics of the terms considered, like, e.g., the degree of complexity of its definition and the frequency with which it is encountered. However, a more systematic identification of the features of technical terms that may influence the students' acquisition of familiarity with their use is still to be completed.

The conforming of the teaching material to the language of science. The effectiveness of the reading/learning stage is also conditioned by the actual conforming of the teaching material (textbooks, handouts, etc.) to the requirements of the language of science, above all, precision. Insufficiently rigorous statements may transmit imprecise information, which may result in confused understanding and/or generate misconceptions. It is observed that even students who are not adequately familiar with the requirements of the language of science may realise that some formulations do not convey a

clear or correct meaning, though, in most cases, they are not able to identify the imprecisions and mistakes clearly (some examples are discussed in Mammino, 1995-96 and 1996c). The negative influence, on the effectiveness of the reading/learning stage, of insufficient clarity or simplicity in the teaching material is self-evident. Furthermore, the teaching material, constituting a model students tend to follow, indirectly influences their tendency to comply with the requirements of the language of science.

Aspects Related to the Use of a Second/Foreign Language

Several aspects of the difficulties related to the use of a second/foreign language as a medium of instruction have been objects of investigation (e.g., Love, 1990, 1993a, and 1993b; Zepp, 1981; Report of the NUL/Kellog workshop). There is obvious consensus on the fact that an inadequate mastering of the second language affects all the aspects of the students' work, from the reading/learning stage to the stage when they are asked to prove their knowledge (the core of the acquisition of scientific knowledge, i.e., conceptual understanding, lying in between these two stages). It is self-evident that an appropriate use of the language of science, requiring a full knowledge of the meaning and uses of individual words and of their association, automatically requires a good mastering of the language in which concepts and descriptions are expressed. For investigation purposes, it is significant to identify/evaluate the details of the influence/effect of the inadequacies in the knowledge of the second language on the use of the language of science. The current section will be concerned more specifically with the evaluation of those aspects of the second language that are more relevant to the use of the language of science. The analysis of the students' answers suggests the following three major areas of concern/investigation:

The Knowledge of the Meaning and Use of Individual Words

The knowledge of words is the first step towards the possibility of using a language. Previous studies (e.g., Zepp, 1981) have highlighted the occurrence of situations in which the number of words, belonging to the second language, with which some students are familiar is too small for those students to be able to understand the meaning of several sentences.

Such a problem may persist even at tertiary level. In some instances, even the meaning of words that the lecturer tends to consider as common domain may not be known. When one of these words plays a key role in a sentence or in a whole explanation, the meaning of that sentence or explanation remains ununderstood. An example concerning a single sentence may be provided by the question *What is the ultimate source of energy for living beings?* Many students did not answer the question because they did not know the meaning of the word *ultimate*. An example concerning a whole explanation is provided by the case of students failing to understand the role of the ionic atmosphere because they did not know the meaning of the verb *to shield* (Mammino, 1995c).

On the whole, this aspect is not easy to investigate. Students may not feel comfortable towards asking the lecturer for the explanation of individual words. Moreover, they may not be fully aware that difficulties in understanding a text may be related to insufficient knowledge of the exact meaning of one or more words (such hypothesis being also supported by the low rate of dictionary consultation in comparison with the predictable needs of persons having to understand texts - including complex ones - in a foreign language). The analysis of students' written answers in their routine work provides only partial information as far as the knowledge of words is concerned, because of the tendency to avoid the use of words whose meaning is not known or familiar; definite information can be obtained only when one or more words are used incorrectly and the nature of the mistakes clearly highlights insufficient knowledge of their meaning/s, or when further checking may serve as confirmation. A viable option for the investigation is offered by exercises focusing on the use of common words that are relevant in the sciences. The selection of these words may be conveniently based on the outcomes of the analysis of the mistakes in the students' answers and it should preferably respond to certain criteria of systematicity (e.g., by grouping words that are frequently interchanged, like *correct*, *precise*, *exact*, or words that may be antonyms, like *continuous* and *discrete*). Preliminary experiments, limited by now to group discussions, confirm that the option can be considered promising and worth of further exploration.

The familiarity with the building of sentences. This familiarity involves the ability to analyse sentences on reading/listening and to build correct sentences on speaking/writing. Both aspects are not purely linguistic: They are also related to the knowledge of the basic aspects of logic in its role of providing guidelines for the analysis of the various pieces of information available on a given issue and for the identification of their interrelationships. Such identification is the necessary preliminary step both for a correct and complete understanding of the information transmitted by a text and for a correct expression of the information/knowledge acquired. On the other hand, it is practically impossible to untangle the two factors contributing to the difficulties students encounter in analysing and/or writing sentences: the factor linked to the knowledge of the bases of logic and that linked to the knowledge of a given language and of the tools it provides for the expression of the various logical relationships. For this reason, it would not be strictly rigorous to speak of logic-related aspects and of language-related aspects as if they would constitute two independent sets that can be analysed separately; it is more rigorous to say simply that the problems related to the analysis/building of sentences can be investigated mainly from the point of view of the logical aspects or mainly from the point of view of the language aspects, according to the principal focus of interest in a given moment, but without under-rating the fact that the two sets of aspects are inextricably intermingled. The current section is mainly concerned with the language-related point of view.

In the reading/learning stage, the dominant roles are played by the ability to fully grasp the information conveyed by the association of two or few words with specific functions and by the ability to analyse sentences and identify the pieces of information conveyed, the relevant features of each piece and the relationships between the various pieces. When this ability is not adequate, the main risk is the misinterpretation of part of the information transmitted by the text; in extreme instances, the misinterpretation may concern the entire description of a system or phenomenon, or the entire presentation of a model. The ability can be checked by asking students to analyse texts with increasing degree of internal logical complexity. The analysis of sentences can also be suggested when students inform that they do not understand the meaning of a given statement or text. It is true that, in

the majority of such cases, students fail to provide an analysis if they are not guided, and may often not know how to proceed to it; on the other hand, they can perform it if guided through it by a set of questions highlighting each relevant point in the appropriate logical order. Such exercises enable an approximate evaluation of the students' ability and/or difficulties towards the analysis of sentences; at the same time, the guided analysis has turned out to be an effective tool for explanation in several instances, besides helping students acquire some experience in it. The students' written answers in their routine work provide the most reliable and direct information about their ability to construct sentences and about the type and extent of the difficulties they may encounter.

The Specificity of the Transition From One Language to Another

The analysis of students' mistakes shows some patterns pointing to an insufficient awareness of the specific features of the differences between the mother tongue and the second language. However, this aspect has not yet been the object of an attention adequate to its relevance and role. The characteristics of the transition from one language to another are specific, because they depend on the characteristics of the two languages involved, the main aspects concerning the correspondence between individual words and the rules for associating words into sentences. A comprehensive and detailed discussion would require considerable space and it will, therefore, be the object of a separate work.

Overlap/Interactions Between the Two Sets of Problems

Within second/foreign language contexts, the categories of problems identified in the previous sections are usually associated both with the difficulties related to the use of the language of science and with the difficulties related to the use of a language different from the mother tongue. It is not easy, or maybe even possible, to evaluate the weight of each of them, many mistakes resulting from the co-occurrence of the two sets of difficulties, in various proportions. Therefore, the analysis of each mistake may initially identify the more probable category to which it belongs and then consider the possible components and contributing factors in a sort of comprehensive way.

The current section will present a rapid analysis and/or discussion of a number of examples of incorrect answers, grouped according to the categories mentioned above. The examples have been selected because the linguistic component has the dominant role in the mistake, this either being evident from the nature of the mistake or having been confirmed by interviews with the students concerned. They are simultaneously meant to constitute examples of data collected and to illustrate each of the categories considered.

The Knowledge of the Meaning and Use of Individual Words

The role of this knowledge in the reading/learning stage has already been discussed . On writing, the choice of the correct individual words depends on the simultaneous knowledge of the meaning of those words in the language utilised and of their roles and uses in the language of science. The most common incorrect choices concern the term/s denoting the object/s of interest and/or the verb describing the situation, process, or action considered.

Incorrect choices of words more commonly involve:

(a) words which are familiar from common language, but which have specific, or even technical meanings in the language of science;

(b) words that are encountered more frequently, and therefore end up having a sort of dominant role when the student tries to recall memorised sentences;

(c) common words with very a general meaning, that are used in place of the more precise words students do not remember or do not feel sufficiently familiar with (the most typical example being probably the verb *to have*, utilised in the majority of the situations in which students do not know a more precise verb).

The consideration of few examples may be sufficient to illustrate these aspects. .Examples 1 to 4 are concerned with the choice of nouns, examples 5 to 7 with the choice of verbs.

Example 1

> Colligative properties are those properties of a system that depend on the amount of particles, not their identity or nature.

Example 2

> Colligative properties are properties of substances that are dependent upon the numbers of particles of the substance that are present, irrespective of the nature of these particles.

Example 3

> No process is possible in which the sole result is the transfer of heat directly to work.

Example 4

> A Daniell cell consists of two half-reactions that are separated but connected by a salt-bridge. In each half-reaction there is an electrode.

In example 1, the word *solution* has been replaced by the word system, which leaves the object of interest unidentified In example 2, the more generic word *substance* has been used in place of the word *solution* and afterwards in place of the word *solute*: This results in an incorrect identification of the objects of interest. In example 3, the word *transfer* has been used in place of the word *conversion*, having a key role in the expression of the concept (the second law of thermodynamics). In example 4, half-reaction (name of the process) is used in place of half-cell (name of the object).

Example 5

> The phase rule is defined by f=3-p.

Example 6

> A process is reversible when it can be expressed in infinitesimal modifications of a variable.

In both cases, the confusion concerns verbs related to the methodological aspects of sciences. The verb *to define* (usually associated with the establishing of conventions of whichever type) has been used in place of the verb *to express* (the appropriate one for the mathematical formulation of a statement). The more general verb *to express* has been used in place of the precise verbal form (reversed by) describing the action concerned, the most probable reason being failure to recall the precise verb. However, the mistake also points to an insufficient knowledge of the meaning of the verb *to express*.

Example 7

> A mole is a quantity of a compound which has 6.02x1023 molecules of that compound.

The verb *to have* is the one that is used most frequently in replacement of a variety of more precise verbs. In this example, it has been used in place of the verb *to contain*.

The Association of Words and the Building of Sentences

Two main aspects may be taken into account: the association of two or few words with specific functions and the way all the words are associated into sentences. The latter is related to the logical interrelationships between the various pieces of information available or of interest and it can, in turn, be subdivided into two streams: the building of individual sentences and the association of constituent clauses into a complex sentence.

The association between two or few words may concern key aspects like the appropriate association of the verb with the subject, of the adjective with the noun, of the adverb with the verb, and of the various kinds of specification with the objects to which they are related. Examples 8 to 11 involve incorrect subject/verb associations, examples 12 to 14 involve incorrect

adjective-noun associations, examples 13-19 concern the identification of a "belonging" relationship.

Example 8

At the boundary lines, the chemical potentials of the two phases coexist.

Example 9

The diagram would become faster if a catalyst is added.

Example 10

At low pressure, the trend of the compressibility factor behaves ideally.

In each of these cases, a verb that is typical of the description of systems and their behaviour has been associated with a subject denoting not a system, but an element of our description: actually, the two phases coexist at the boundary lines of a phase diagram, while their chemical potentials are equal; the reaction considered (and not the diagram representing its proceeding) becomes faster; the gas (and not a mathematical trend) behaves ideally).

Example 11

Electrolyte is a solution that can dissociate fully in solution.

In this case, the incorrect association is due to an incorrect identification of the subject (the subject of the verb dissociate should be compound, not solution).

Example 12

The higher the temperature, the greater the collisions between molecules.

Example 13

When temperature is increased, the molecules are more violent.

Example 14

A collision is effective when the reaction is violent.

In example 12, an incorrect adjective is utilised (a collision is not qualified as great/greater, but as more or less violent). Examples 13 and 14 make use of the correct adjective *violent*, but the association with nouns (molecules and reaction respectively) is incorrect.

Example 15

A catalyst lowers the activation energy of a rate of a reaction.

Example 16

The concentration of the rate constant decreases exponentially with time.

Example 17

Zinc has a higher tendency than silver to be in an oxidised state because it has a negative sign.

Example 18

In order to be effective, the collision should have the proper orientation.

Example 19

The changes accompanying a state function depend on the initial and final states.

These examples contain incorrect specifications of the `belonging' of a certain characteristic to a certain object. In examples 15 and 16, the specification is expressed directly through the preposition *of*, but the characteristic or phenomenon considered is assigned to an incorrect `possessor' (the activation energy is a characteristic of the reaction, not of its rate; the concentration is a characteristic of the reactants, not of the rate constant). In examples 17 and 18, the relationship has been expressed through the verb *to have*, but the identification of the subject with respect to the object is incorrect (not zinc, but its electrochemical potential, has a negative sign; the orientation concerns the colliding molecules, not the collisions). In example 19, the relationship of belonging has not been identified (the changes considered do not accompany a state function: they are changes of a state function).

Mistakes concerning the association of words into sentences are rather frequent, even in the case of simple sentences consisting of one or two constituent clauses. In several instances, it appears that students mainly attempt to assemble words from the sentences they had tried to memorise on a given topic or issue (memorisation being the most common response to linguistic difficulties, besides often being a habit acquired in pre-university education). This is the case of the following examples:

Example 20

> Colligative properties means that the magnitude of the substance does not depend on the nature of the solute, but on the number of particles.

Example 21

> Colligative properties are the substances whose properties depend on the number and magnitude of the solutes in the solution and not on the nature of the solutes.

Example 22

> A process is reversible when a change is brought about by an infinitesimal variable.

Example 23

> Increased temperature increases the products and reduced temperature reduces endothermic reactions.

Example 24

> A molecule of ideal gas occupies the same volume as the total gas.

On the other hand, such answers show that students did not analyse the sentences after writing them, to check their actual meaning. Experiments in which students were guided in the analysis of their own wrong answers showed that they became aware of the mistakes. It may be considered worth investigating to what extent the absence of independent analysis of their own sentences may be related to a rather diffuse lack of independence in the study approach.

As already stated, it is difficult to untangle and evaluate separately the two language-related contributing factors in mistakes like the ones presented in the previous examples, i.e., inadequate knowledge of the language of science and inadequate knowledge of the second/foreign language used as medium of instruction. Some partial information may be obtained from a comparison with mistakes encountered in situations in which students use their mother tongue as medium of instruction. On one hand, some mistakes parallel or logically analogous to those in examples 1, 2, 4, 5, 6, 6, 9, 10, 12, 15, 17, 18, have been found in material examined in Italy. This would suggest that their main component is the inadequate familiarity with the language of science (though an insufficiently deep knowledge of the mother tongue may not be totally excluded for part of the Italian material, in relation to the well known general deterioration of linguistic knowledge). On the other hand, mistakes like the ones reported are considerably more frequent in the case of students using a second language, which confirms that the foreign language factor has a relevant weight and therefore requires specific attention/addressing. No reference terms have yet been identified for a rough evaluation of the relative weights of the inadequate knowledge of the second language and of the inadequate familiarity with the bases of logic as contributing factors to the incorrect building of sentences.

Discussion and Conclusions

It is considered that an overall practically-oriented approach to the language-related difficulties encountered by science students should involve:

(a) the identification of the most relevant categories of language-related difficulties encountered in a given educational situation, and the search for the most frequent and/or most probable causes underlying them;

(b) the outlining of a comprehensive and detailed picture of the situation (including the interactions/overlaps between the identified types of problems).

(c) the utilisation of this information for the designing of pedagogical approaches and of auxiliary teaching material specifically tailored to help students overcome the difficulties.The operational suggestions of the previous discussion concern objectives (a) and (b). They may be completed by the additional remarks that a systematic investigation should ideally:

(i) make use of the students' routine work, since it corresponds to the situations when students try to do their best to provide optimal answers/descriptions/discussions. Some questionnaires may then be designed to obtain additional information on specific issues, when this is likely to be relevant. (b) involve more than one course, including some advanced ones (last year and/or postgraduate courses). The presence and extent of language-related difficulties in such courses has seldom been object of investigation. However, experience has shown that such difficulties may be present, and even relevant (Mammino, 1995c). The extension of the investigation to advanced courses, besides contributing to the completeness of the overall picture, may provide information on possible relationships between language-related difficulties and the increase in the complexity of the material to be studied.

The approach is currently being utilised for an investigation continuing and extending the previous ones. It is reasonable to predict that the information it is enabling to collect will be sufficient for the preparation of specifically designed teaching material. The approach is presented at this stage because it is considered that the possibility of comparison/discussion with other researchers/specialists may have a `checking' role and may contribute to a better evaluation of the features and weights of a number of aspects. This, in turn, may contribute to an enhancement of the role of `providing solutions', which is considered an essential component of the overall approach.

References

Castro, E.A. (1995). Escribir sobre quimica para aprender quimica. *Panamerican Newsletters, 8* (4), 8-9.

Lahore, A.A. (1993). Lenguaje literal y connotoado en la ensenanza de las ciencias. *Ensenanza de las ciencias, Il* (1), 59-62.

Love, A. (1990). Teaching communications skills to science students at tertiary level in Zimbabwe. *ALLA Congress,* Thessaloniki.

Love, A. (1993a). Language for specific purposes in an English as a second language situation: why, what and how? In Brekke M. et al. (eds), *Applications and Implications of Current LSP Research*, Bergen, Fagbokforlaget, 408-417.

Love, A. (1995). Imprecisions in the writing of science students. *Proceedings of LASU Conference*, Harare.

Love, A. & Mammino, L. (1997). Using the analysis of errors to improve students' expression in the sciences. *Zimbabwe Journal of Educational Research, 9* (1), 1-17.

Mallinson, G.G.; Sturm, H.E.; & Mallinson, L.M. (1952). The reading difficulty of textbooks for high school chemistry. *Journal of Chemical Education, 29*, 629-630.

Mammino, L. (1994). *Chimica Viva*. G. D'Anna, Firenze, Italy.

Mammino, L. (1995a). L'educazione al linguaggio della scienza. *Nuova Secondaria, 5*, 83-85.

Mammino, L. (1995b). *Il linguaggio e la scienza*. Societa' Editrice Internazionale, Torino, Italy.

Mammino, L. (1995c). Teaching/learning theoretical chemistry at undergraduate level. *Southern Africa Journal of Mathematics and Science Education, 2* (1&2), 69-88.

Mammino, L. (1995-96). Algunas reflecciones sobre el rigor conceptual y formal en la ensenanza de la quimica. *Anuario Latinoamericano de Educacion Quimica, 2* (8), 375-384.

Mammino, L. (1996a). Le parole comuni nel linguaggio scientifico. *Nuova Secondaria, 6*, 76-77.

Mammino, L. (1996b). L'analisi degli errori come strumento didattico. *Nuova Secondaria, 10*, 75-76.

Mammino, L. (1996c). Precision in wording: A tool to facilitate the understanding of chemistry. *14th International Conference on Chemical Education*, Brisbane.

Mammino, L. & Cardellini L. (unpublished). *Studying students' understanding of the interplay between the microscopic and the macroscopic descriptions in chemistry.* Submitted for publication.

Report of the NUL/Kellog workshop on improving English language performance in Lesotho secondary/high schools, 21-22 Dec. 1995, Faculty of Education, National University of Lesotho.

Zepp , R.A. (1981). Relationships between mathematics achievements and various English language proficiencies. *Educational Studies in Mathematics, 12*, 59-70.

Zepp, R.A. (1982). Bilinguals' understanding of logical connectives in English and Sesotho. *Educational Studies in Mathematics, 13*, 205-221.