Issues in the Planning of a Multilingual Explanatory Dictionary of Chemistry[1] for South African Students

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Abstract:. Developing human potential and actively promoting science and technology are among the priorities of the present South African government. Significant progress in these areas can only be made if relevant education and training are provided timeously. Surveys conducted by overseas as well as local researchers indicate that mother-tongue education is one of the measures to improve learning. While mother-tongue education at secondary and tertiary level is at present not provided to speakers of African languages, compromise solutions have to be offered, such as multilingual explanatory special-field dictionaries. By providing linguistic and encyclopedic information in English, Afrikaans and two or more of the African languages the concepts of the subject-field are made accessible via the language(s) of wider communication as well as via the mother tongue of the student. Although there are many difficulties and potential pitfalls awaiting terminographers and special-field experts who attempt a project of this nature, substantial preliminary work that has already been done with regard to a quadrilingual explanatory dictionary of chemistry indicated that this ideal is not out of reach. The compilers believe that successful completion of the project, as well as favourable results, will verify the hypotheses that served as points of departure for the project.

Keywords: CHEMISTRY, EXPLANATORY DICTIONARY, MULTILINGUAL DICTIONARY, TERMINOGRAPHY, PEDAGOGICAL DICTIONARY, SPECIAL-FIELD DICTIONARY, SCIENCE AND TECHNOLOGY, TRANSLATORY DICTIONARY

Opsomming: Aspekte van die beplanning van 'n meertalige verklarende Chemiewoordeboek vir Suid-Afrikaanse studente. Die ontwikkeling van menslike potensiaal en die aktiewe bevordering van wetenskap en tegnologie ressorteer onder die belangrikste prioriteite van die huidige Suid-Afrikaanse regering. Betekenisvolle vooruitgang op hierdie terreine kan egter slegs gemaak word indien relevante onderrig en opleiding tydig voorsien word. Ondersoeke deur sowel oorsese as plaaslike navorsers het getoon dat moedertaalonderrig een van die maniere is waarop groter sukses met leeraktiwiteite behaal kan word. Aangesien moedertaalonderrig op sekondêre en tersiêre vlak tans nie vir sprekers van die Afrikatale beskikbaar is nie, moet kompromie-oplossings aangebied word, byvoorbeeld die voorsiening van meertalige, verklarende vakwoordeboeke. Deur linguistiese en vakkundige inligting in Engels, Afrikaans en sommige van die Afrikatale aan te bied, word toegang tot die konsepte van die betrokke vakkundige terrein verleen deur middel van sowel die breër kommunikasietale as die student se moedertaal.

Hoewel daar vele probleme en slaggate op die leksikograwe en vakkundiges wag wat so 'n projek aanpak, het die werk wat reeds in verband met 'n meertalige verklarende Chemiewoordeboek gedoen is, getoon dat hierdie ideaal tog haalbaar is. Die samestellers is daarvan oortuig dat die suksesvolle afhandeling van die projek, asook gunstige resultate, die hipoteses sal verifieer wat as vertrekpunte vir die studie gedien het.

Sleutelwoorde: CHEMIE, MEERTALIGE WOORDEBOEK, PEDAGOGIESE WOORDEBOEK, TERMINOGRAFIE, VAKWOORDEBOEK, VERKLARENDE WOORDEBOEK, VERTALENDE WOORDEBOEK, WETENSKAP EN TEGNOLOGIE

1. Introduction

Recently published Government policy documents on transformation (e.g. the *White Paper on Reconstruction and Development* (1994), *South Africa's Green Paper on Science and Technology* (s.a.) and the *White Paper on Science and Technology* (1996)) strongly emphasise education and training in the fields of science, engineering and technology. This process of developing human potential through access to information is not merely a measure to redress imbalances created by the past political system, but also a way to empower the people of the country and to stimulate the economy.

This article argues that multilingual, explanatory special-field dictionaries can be implemented to realise these objectives by providing easy access to new or incompletely learnt concepts[2]. For those who have expressed scepticism about terminographical work for the African languages (cf. Louwrens 1997; Mutasa 1996[3]) there is the consolation that the dictionary type in question does not exclude participation in scientific and economical domains by means of a language of wider communication such as English (cf. Cluver 1996: 1, 7). By selecting English as the source language of the main lemma list and by also providing accessible definitions in English, such a dictionary could indeed contribute towards improving the user's proficiency in the English special language for that specific subject-field.

In the subsections below the relationship between the objectives of terminology and terminography (the domains concerned with the documentation of special languages), and the needs which gave rise to the dictionary concept in question, will be expounded.

2. Objectives of terminography

According to Cluver (1989: 8) "the primary objective of terminographical work is (thus) to ensure, firstly, that each identifiable technical concept is clearly named by a technical term, and that the concept is adequately described in a definition". "Secondly," he adds, "terminography attempts to ensure that the term and its definition are accepted by all or the majority of the practitioners of

a specific subject field." A third objective of terminographical work is, in his opinion, deduced from the second, namely to ensure maximum clarity and exactness in technical or scientific communication.

Cluver, however, criticises this view of terminography as a "traditional" or "structuralist" view which only focuses on the documentation, systematising, defining, standardisation and recording of technical terms in dictionaries, thesauri or term banks — thereby restricting the scope of the discipline to fully-standardised languages with well-developed terminologies (cf. Cluver 1989: 10). He advocates a sociolinguistic approach (cf. Cluver 1989: 9) according to which terminography is not only concerned with standardisation, but also with the elaboration of the technical vocabularies of developing standard languages. The development of technical vocabularies should, however, never be an end in itself, but rather (according to Cluver 1996: 1) an instrument for the speakers of that language "to gain access to modern information and technology that is needed for them to become independent members of the modern information society". Cluver (1996: 1) further asserts that "this objective includes enabling people to gain access to learning institutions via their own language".

A third contribution that the creation of terms in the vernacular of the people can make, according to Cluver (1989: 9; 1996: 1), is the promotion of nationalism by enhancing the status of the language with its own speakers. This could again lead to increased unity within the speech community, provided that the speakers are ready to put their vernacular to use in "prestigious" spheres where only a majority language such as English has heretofore been considered appropriate (cf. Cluver 1987: 27). Rey (1995: 52) echoes this view by contending that "the specific task of terminological intervention is to improve the quality of linguistic communication and the relations between speakers and their language".

These extended views of the objectives of language elaboration and functional expansion by means of terminology takes into account systematic and normative considerations as well as sociolinguistic and ideological concerns. All of these views, however, focus primarily on the naming aspect of terminology, and not on cognitive functions. Terminographical work with regard to developing languages also include the formulation of definitions in the mother tongues of the people, which may serve as vehicles of conceptualisation and possibly also as starting points for technical communication in the vernaculars of the people of South Africa. This dimension is implicitly reflected in Rey's (1995: 105) multi-faceted motivation for comprehensive terminological work in developing languages:

> From this viewpoint the analysis of the terminological needs arising from cultural, didactic, scientific and technological change depends on specific sociolinguistic factors. In some cases there is not even an admission of needs and the languages concerned are confined by historical circumstances to other functions, their speakers being obliged to learn one of

> the dominant languages of the respective subject-field. Each language is capable of naming everything; it is a political decision whether people are allowed to develop terminologies in their mother tongue, or in a 'national' language, or whether they have to resign themselves to borrowing a vehicular language for a particular subject field. The impression that certain languages cannot supply the needs of conceptual structures is purely ideological.

3. Terminographical needs of African language-speakers

3.1 Pedagogical needs

According to the *White Paper on Science and Technology* issued by the Department of Arts, Culture, Science and Technology in 1996, democracy (participation of all the people of the country in all public domains — AC) is dependent upon the availability and accessibility of information:

> Democracy implies being aware of choices and making decisions. The extent to which this is possible depends largely on how much information is available to the people and how accessible it is (1996: 50).

Considering the low grades in science and mathematics achieved by matriculants of underprivileged backgrounds during the almost three years since the official demise of apartheid, one realises that the current system of education is not yet geared to meet the requirements of a science and technology-oriented South Africa. It seems that mother-tongue speakers of African languages continue to experience immense difficulties in mastering the empirical and the natural sciences, thereby remaining outside the mainstream of economic activity.

The hypothesis that language is one of the most important stumbling blocks in gaining access to the natural sciences is verified by a survey that Kwesi K. Prah undertook in 1992 among university students of Botswana, Namibia, Swaziland-Kwaluseni, the Western Cape, the Transkei and Lesotho (Prah 1995). Regarding knowledge of different languages, the answers to his questionnaire indicated that all the respondents knew English, 79% knew other languages apart from English and/or Afrikaans, and 58% were familiar with three or more languages. For the overwhelming majority of the students from the different universities, the language they knew best was their mother tongue. About 14% of the students indicated that they had problems studying in English (which is of course a subjective perception, and the percentage may not be an accurate reflection of the realities). The following categories of responses were given to describe the types of problems faced by students studying in English:

- Poor teaching of English at primary and secondary school levels
- Primary and secondary education were received in Afrikaans-medium schools
- Writing pace in English too slow for lectures
- Problems with English spelling
- Problems with English grammar and syntax
- Textbook-English complicated
- Problems with pronunciation
- Language problems undermine concentration in class
- Limited vocabulary
- Frequent need to translate from mother tongue to express ideas

To the question "If science and technological studies were taught and conducted in your mother tongue, do you think you could find your studies easier?" more than 59% indicated that studies would be easier if the programme were conducted in the mother tongue. Questioned regarding the wider societal benefits they could foresee if modern scientific and technological ideas were rendered into African languages, the statistically leading views of the respondents were the following:

- The rural masses will be rapidly educated
- Africans will gain more confidence in their cultures and history
- Africans will become inventive
- African society as a whole will come to understand scientific and technological ideas
- The power and influence of the present elite will be diminished
- Africans will do better in their studies
- There will be wider and broader job markets
- African languages will be greatly enriched
- There will be a great increase in African scientists and technicians

These statistics compare well with the findings of a preliminary survey on the medium of instruction used in science classes at a number of high schools in Pretoria where Northern Sotho is the mother tongue of most of the pupils. It became evident that teachers quite often switch to the vernacular during science lessons and practical sessions, primarily for two reasons:

- the teacher "feels more comfortable when presenting classes in the mother-tongue", which may probably indicate that he/she is not proficient enough in English to give a precise and clear explanation of a particular concept, procedure, etc.;
- many pupils are not proficient enough in the second language (English) to follow explanations, instructions and arguments, and to express themselves in English.

It is therefore not surprising that more than 80% of Prah's respondents chose "very much so" on a five point scale in answer to the question "Do you think the task of rendering and translating modern scientific and technological ideas into African languages should be a key national issue?"

On the basis of Prah's (1995) survey among university students, as well as the preliminary survey conducted among secondary school teachers of science in Pretoria, it is assumed that mother-tongue education could play a major role in providing access to science and technology. It is further believed that multilingual explanatory special-field dictionaries could serve as important learning aids during the secondary and tertiary phases of education, especially if the emphasis is placed on clear and simple conceptual definitions in the mother tongue. Such explanations could assist students in the process of conceptualisation which has, due to the apartheid education system, not developed naturally in many speakers of African languages.

There are, however, those who argue that term creation (translatory activities) is a prerequisite for explanatory activities such as teaching and defining. Matšela (1987: 80) is but one of the scholars who seems to hold such an opinion:

> One of the major problems of introducing into African languages the teaching of such subjects as Agriculture, Biology, Chemistry, Physics, Mathematics, Engineering, Linguistics, Philosophy, Psychology and the like, is the lack or dearth of relevant specialized technical terminologies in those languages.

This view seems logical if it is assumed that a person needs at least a partially developed special language to undertake actions such as teaching or defining. On the other hand none of the terms used in dictionary definitions for pedagogical purposes need to claim terminological status. Furthermore, if non-standardised terms or terms of different styles and registers are used in definitions there ought not to be any objection to entering them as surrogate equivalents in the macrostructure of a multilingual dictionary in order to avoid lemmatic gaps. Such forms could be clearly marked (by means of a specific graphic symbol) to indicate their temporary status.

Another danger that could be associated with focusing solely on the translatory aspect of terminological work for the African languages is that a proliferation of "artificial" terms could be coined by terminographers and special-field experts, which may be rejected entirely by the speakers of the language in question. Rey (1995: 18-22) warns that a mere desire to describe (for instance by large-scale coining of translation equivalents — AC) "would condemn terminology to impotence, or to the modest state of a translation or documentation aid, when in reality it is an indispensable body of knowledge for satisfying a fundamental need which precedes all social planning".

In a domain such as chemistry there are also the requirements of international standardisation organisations, such as IUPAC (International Union of

Pure and Applied Chemistry), that have to be considered when assigning terminological status to linguistic forms. According to Alain Rey (1995: 14) the differentiating descriptive systems and the organisation of relevant characteristics in modern chemical nomenclature are based on "a knowledge of processes and functions and no longer only on characteristics which can be described in terms of space and appearance according to their place in a table". These universal guidelines are not to be ignored.

Regardless of whether a terminographer places the main emphasis of his / her work on defining or term-creation, all morphological and syntactic coinings, borrowings, meaning transfers and indigenised terms (transliterations), etc., should be tested widely for their acceptability with mother-tongue speakers, as well as for their true reflection of the internal structure of the subject-field. The editorial team of any multilingual dictionary in South Africa should therefore include mother-tongue speakers of the languages in question who also have profound knowledge of the subject-field in question.

3.2 Economic needs

As mentioned above, two of the primary aims of the Reconstruction and Development Programme of the South African Government are redressing the past unequal distribution of resources, and developing science and technology for economic purposes (see chapter 3, paragraph 3.13.2, of the Government's *White Paper on Reconstruction and Development* of September 1994).

This view is broadened in the *Green Paper on Science and Technology* which characterises science, engineering and technology (SET) as the "absolutely vital components of economic and social progress", the development of which is largely dependent on the educational sector. The *Green Paper* assigns great importance to interaction and co-operation between industry, scientific councils, universities and state departments in order to create a coherent system that will contribute towards achieving the national, social and economic goals of the country (p. 7). Prominence is given to the creation and maintenance of a "scientific infrastructure" which will provide a trained work force as well as the necessary hardware and software. It is stressed (p. 15) that apartheid education has denied black people access to science-based careers, resulting in the current situation "that there are few black engineers and technologists, and not enough black students studying for postgraduate qualifications in these fields". Quick and effective action has to be taken to diminish the imbalances regarding the way SET is practised in schools, colleges, technikons and universities. "We must therefore stop considering terminology as being limited to conceptual and linguistic analyses recorded on cards or in databases," stresses Rey (1995: 53). "The social, political and economic connections are essential because they create ... financial support."

In the following subsection the relationship between user-needs and terminographical principles, as pertaining to the quadrilingual[4] dictionary of chemistry discussed in this article, will be expounded briefly.

4. Special user-needs and the gradedness of terminographical principles

Two of the most important steps in the planning of a special-field dictionary are considering the users and functions of the intended dictionary (cf. Bergenholtz and Tarp 1995: 19). These considerations must include:

(a) the text types for which the dictionary is intended;
(b) the user-groups the dictionary is aimed at; and
(c) the communicative function of the dictionary, namely reception, production and/or translation.

4.1 Text type

According to Bergenholtz and Tarp (1995: 18) the text corpus of the dictionary must be composed in such a way that it corresponds with the text types to be encoded or decoded by the users. First of all the fact should be recognised that scientific and technical language exhibit "different degrees of expertise". To structure the principle of technical gradability the following text types (applicable to specific user-groups) are distinguished by Bergenholtz and Tarp (1995: 19):

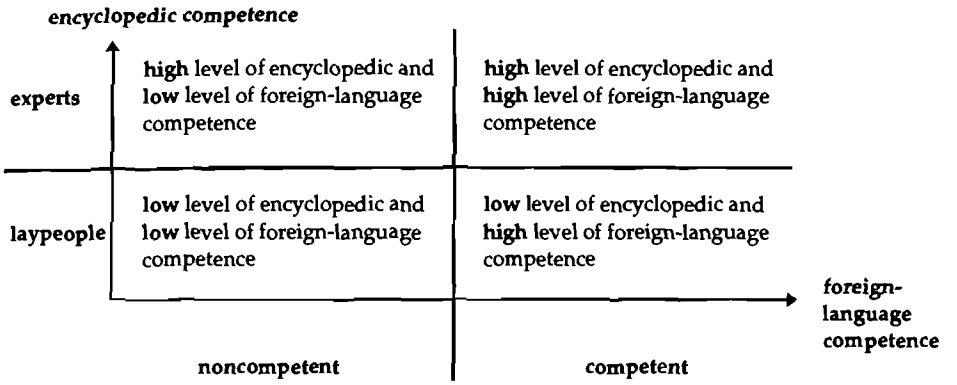
(a) from expert to expert (expert language, such as used in scientific journals — AC)
(b) from expert to semi-expert (the language for special purposes (LSP) of textbooks, etc.)
(c) from semi-expert to semi-expert (jargon and the language used in texts by experts from related areas)
(d) from semi-expert to layman (the language used in popularised texts with scientific or technical topics)

Textbooks for senior secondary pupils and undergraduate university or technikon students could be categorised under (b) above, if it is argued that "semi-experts" also include "semi-laymen". This text type should then play a central role in the collection of data for a dictionary which is to fulfill the terminological needs of the mentioned user-group. If the study matter comprises a specific textbook or textbooks the terminographer and the expert(s) representing the subject-field should systematically check the alphabetical index of such a publication. The metalanguage of a dictionary compiled for the tertiary education

sector (semi-experts) and the secondary education sector (ranging from semi-experts to almost laypersons) should moreover not be more complex than that of the prescribed textbook(s).

4.2 User-group

Besides text types and functions which have to be considered, every technical dictionary must be compiled with a specific user-group in mind. When a dictionary aimed at a foreign target language is compiled, two important factors have to be taken into account, namely encyclopedic knowledge (knowledge of the subject-field) and foreign-language competence. Using binary values with regard to these parameters, yet recognising that the transition between the different types is fluid, Bergenholtz and Tarp (1995: 21) distinguish four main user-types:



Although communication in technical and scientific fields ideally requires that "the user already possesses the configuration of knowledge which determines the role of the term in a structured system ... the limiting case of this restriction is, of course, the requirement that a new term be learnt at the same time as new knowledge, which may include the addition of one or two additional dimensions to an imperfectly learnt concept" (cf. Sager, Dungworth and McDonald 1980: 75). In the case of undergraduate South African students with fragmented knowledge of the conceptual system of the subject-field, even more than one or two additional aspects of the concept might have to be learnt together with a term.

Presenting information in an accessible format for the student with incomplete encyclopedic and second-language competence seems to be one of the problem-solving agents in the current situation, but may require certain concessions from the lexicographer. Two of the basic terminographic requirements, namely precision and economy, might have to be compromised in order

to accommodate the third, which is appropriateness (Sager, Dungworth and McDonald 1980: 206 ff.).

Economy may have to be compromised by presenting more encyclopedic information, and even duplicating conceptual information by using illustrations which partially overlap with the conceptual information supplied verbally. Furthermore, the lexicographer(s) may deem it necessary to label certain information categories explicitly by means of symbols or abbreviations. In a subject-field such as chemistry *empirical formulae, symbols, synonyms, opposites* and *abbreviations* might need labelling in order to facilitate unambiguous transfer of information. Such explicitness is, however, uneconomical in terms of dictionary-space and will necessarily have an influence on the price.

The principle of precision may have to be relinquished partially in order to attain understandability, transparency and lucidity (i.e. accessibility). Precision is a concept that should be given content with reference to the situation, which include *inter alia* the level of scientific and technological communication, the intention of the encoder, the competence of the decoder, etc. (cf. Swanepoel 1990: 27). However, given the fact that scientific and technical dictionaries are aimed at providing an accurate picture of a highly structured conceptual field, precision is only negotiable in as far as standardisation is maintained; in other words as long as the definition remains "universally understood" within that specific subject-field (cf. Sager, Dungworth and McDonald 1980: 207). This aspect will be discussed again later with regard to specific examples in the dictionary project described here.

4.3 Communicative function of the dictionary

The third consideration to be taken into account is the communicative function(s) which the dictionary is intended to fulfil, namely that of production (native language or foreign language), reception (native language or foreign language) or translation (into or from a foreign language), and the information categories that will support the intended function(s).

Bergenholtz and Tarp (1995: 25) warn that where a specialised dictionary is designed for users with different mother tongues, an integration of the above functions presents problems. The problems are magnified when the user-group is heterogeneous with regard to encyclopedic and second-language proficiency. Such is e.g. the case with South African undergraduate students of the natural sciences who come from diverse educational backgrounds and language groups, having to conduct their studies entirely through English or Afrikaans.

The following section will deal with problems faced by the terminographer who wishes to compile a scientific dictionary for pedagogical purposes aimed at a heterogeneous user-group such as outlined above.

5. Problems regarding the overall planning of a multilingual explanatory dictionary of chemistry for pedagogical purposes

5.1 Data-collection

According to Bergenholtz and Tarp (1995: 90) a dictionary may be empirically based on introspection, existing literature and/or texts.

5.1.1 Introspection

Introspection indicates that the lexicographer relies solely on his/her own competence. Special-field dictionaries do, however, require a more differentiated competence as a basis of introspection, since general-language competence cannot automatically be translated into special-language competence. Introspection should, therefore, also involve active participation by experts in the subject-field (cf. Arntz and Picht 1989: 224). According to Wiegand (1990: 2207) one special-field expert should not alone decide which terms to include as lemmas in a general dictionary. This principle is just as valid for special-field dictionaries: in the case of a subject-domain such as chemistry it is important to involve at least one expert on each of the main fields, namely organic, inorganic, physical and analytic chemistry. The contributions of the various experts must be mentioned explicitly in the outside matter of the dictionary, as they are the persons who are ultimately responsible for the scientific correctness of subject-field (encyclopedic) information included in the dictionary. Lexicographers and terminographers can only intervene in an auxiliary capacity, e.g. advising on linguistic appropriateness (cf. Rey 1995: 58). If a multilingual dictionary is planned the introspective approach requires the participation of a considerable number of lexicographers, preferably mother-tongue speakers of the languages in question.

The "plural" form of introspection is multispection, which entails that questions have been asked of a large number of informants. In a multilingual country where different major languages enjoy different statuses and have different functions multispection could be used for more than one purpose: firstly to legitimise a dictionary among the speakers of the various language groups involved, secondly to keep in touch with linguistic realities (e.g. by not recklessly coining equivalents where terms already exist and already enjoy a measure of standardisation in the relevant linguistic communities), and thirdly continuously to monitor the relevance and usefulness of the dictionary with regard to the communicative functions it has to perform and the level at which these functions have to be performed. In the case of special-field dictionaries intended for the senior secondary and tertiary levels, lecturers and teachers should be included in multispection so as to ensure that the dictionary stays in tune with the encyclopedic and the linguistic proficiency of the user-group.

5.1.2 Existing literature

According to Bergenholtz and Tarp (1995: 93) part of the empirical basis of an LSP dictionary may not only be the utilisation of existing literature, primarily dictionaries and encyclopedias, but also other reference works, such as handbooks, textbooks, scientific articles and monographs. The use of existing dictionaries has the advantage of being fast, but the method cannot be considered reliable if the lemma list of the dictionary consulted is not checked against the present stage of development of the subject-field in question as well as the scope intended for the dictionary in preparation. This does, however, become less of a problem if consultation of existing literature is combined with multispection which includes careful scrutiny by experts and other role-players in the subject-field.

Although it may not be necessary to state titles that have been used only a few times, the dictionary front matter should contain a list of the most frequently consulted sources. The preliminary research for the dictionary project described in this article revealed that in some existing dictionaries of chemistry there are only very vague references to sources used. The editor of the *Dictionary of Chemical Terminology in Five Languages* for instance only states in the preface that "the dictionary was compiled on the basis of the contemporary literature in chemistry and related disciplines in the relevant languages (handbooks, monographs, encyclopedias, scientific journals, various IUPAC and ISO publications, etc.)". In other dictionaries the requirement of "proving the source" (one of the principles of dictionary-making on which H.E. Wiegand places a very high premium) is completely ignored, such as *Longman Illustrated Dictionary of Chemistry* which mentions Arthur Godman as the sole author/editor/compiler without reference to any co-author or written sources that were consulted. It is hard to believe that one single lexicographer could have had the lexicographical, linguistic and encyclopedic proficiency to compile an entire special-field dictionary.

5.1.3 Texts

Building up a text corpus which is statistically representative of a particular subject-field could be regarded as the most reliable empirical basis. This is, however, a time-consuming, costly and labour-intensive operation which few multilingual countries in Africa can afford. Furthermore many of the terms of the exact and the natural sciences have fixed scientific definitions determined by international standardisation organisations, such as IUPAC. Such terms need not be represented in a citation corpus in order to elicit their meanings, but corpora could be helpful in determining the collocability of such terms if illustrative examples are given in a dictionary. If one takes into consideration that there is no (or almost no) existing literature on the natural sciences in any

one of the African languages, text corpora are not the answer to all the questions.

In the current South African situation, with special reference to the making of a multilingual explanatory dictionary of chemistry, a combination of the above-mentioned methods seems to be advisable, namely scanning textbooks and other authentic study material, verifying this material by comparison with existing dictionaries of chemistry, and making use of multispection. The latter could *inter alia* include:

1. delimitation of the macrostructure by requesting departments of chemistry from a wide spectrum of universities and technikons to comment on a preliminary term list;
2. identification of the criterial conceptual features for each terminological category;
3. determining information categories by making use of the metalexicographic knowledge of lexicographers combined with knowledge of the subject-field and its requirements;
4. deciding whether to include existing terms in the African languages that are not completely consistent in terms of IUPAC requirements, or rather to form transliterations of English terms, but risking rejection by speakers of the languages; and
5. testing coinages in the African languages among students as well as professional chemists with an African language as their mother tongue.

5.2 Problems regarding general organisation

In most traditional dictionary typologies, distinctions such as monolingual roughly correlated with explanatory, and bi-/multilingual correlated with translatory. Special-field/technical correlated with encyclopedic and general correlated with linguistic. Apart from these accepted distinctions and correlations, technical/scientific unambiguously entailed standard and excluded learners'/pedagogical.

The increased emphasis on user-orientation has, however, caused the borders of the traditional typological categories to become fuzzy, permitting the combination of dictionary functions. Certain subject-fields are seemingly better suited to typological hybridisation than others. Bergenholtz and Tarp (1995: 72) say in this regard:

> On the whole, it is much easier to combine mono- and bilingual encyclopedic and linguistic functions in scientific and technical dictionaries than in dictionaries of law and economics, the reason being, of course, that the former are not culture bound and therefore do not have to provide com-

parative encyclopedic information, as do bilingual dictionaries for culture-dependent LSPs.

Smit (1996: 65) is strongly in favour of hybrid dictionaries for special purposes, but following Wiegand (1988a: 751) she suggests that the purposes of the dictionary should be made clear, preferably in the title and the subtitle of the dictionary and/or in the dictionary introduction.

Apart from the advantages of multilingual dictionaries — namely the combination of several bilingual dictionaries into one, the possibility of comparing different languages, and saving space — multilingual dictionaries are liable to reach excessive proportions and the danger does exist that the microstructure may become extremely complex. The introduction of semantic/pragmatic information such as definitions and usage examples should therefore be carefully considered before they are included in the dictionary plan of such a dictionary.

Another organisational aspect to be considered carefully is the choice of a language of explication, i.e. the language of continuity used for headings and texts belonging to the outside matter of the dictionary. On the one hand, one could argue that English is the obvious choice in South Africa, being widely regarded as the national language of the country, the second language of most dictionary-users, the primary medium of instruction, and the international language of science and technology. On the other hand, using English as the pivotal language could be interpreted as a violation of the democratic language rights of the speakers of the other languages represented in the dictionary. The dictionary could resultantly fail as a facilitator of language equality.

A related problem concerns the decision on whether the dictionary should be bi- or unidirectional, or primarily unidirectional with some bidirectional characteristics (cf. Bergenholtz and Tarp 1995: 55-56). One variation could for instance be a monolingual English defining dictionary, to which has been added a multilingual dimension in the form of equivalents as well as reverse word lists, e.g. *Dictionary of Chemical Terminology in Five Languages.* Reverse word lists here serve only the purpose of directing the user to the appropriate English lemma, in other words they are only reference lists. A second type could be a multilingual explanatory dictionary with English serving as the language of lemmatisation in the primary word list and in which all the linguistic and encyclopedic information supplied for English lemmas are also supplied for the translation equivalents. Reverse word lists for the other three languages could then be supplied after the primary word list. This is the model chosen for the dictionary discussed in this article. A third variation would be a multidirectional, multilingual explanatory dictionary, providing the same information as the second type above, but allowing access to all microstructural information via the terms of each language at the appropriate alphabetic position in a specific section. A dictionary of this type obviously contains much redundancy,

and is also not advisable where some of the languages in question do not yet have fully standardised terminologies.

5.3 Issues regarding data-fields (information categories)

5.3.1 Scope of the discussion

It is obviously not possible to give a full account of all the problems relating to data-fields that were encountered during the first phases of the *Quadrilingual Explanatory Dictionary of Chemistry* (henceforth abbreviated as *QDC*). I shall therefore restrict the discussion to a few specific problems. Furthermore, since the empirical work (data-collection and -processing) on Sepedi[5] and IsiZulu have only just begun, I shall concentrate on issues related to the treatment of the English terms and their definitions. The focus will primarily be on the needs of the intended user-group coupled with an evaluation of the extent to which metalexicography and existing dictionaries of chemistry address these needs. The dictionaries concerned are *McGraw-Hill Dictionary of Chemical Terms* (henceforth M-HDCT), *Glossary of Chemical Terms* (henceforth *GCT*), *Dictionary of Chemical Terminology in Five Languages* (henceforth *DCT*), and *Longman Illustrated Dictionary of Chemistry* (henceforth *LIDC*).

5.3.2 Issues relating to form

Traditional monolingual science dictionaries provide very little linguistic information. This may be ascribed either to the fact that many dictionaries of science and technology have been designed by experts in the subject-field without any linguistic background or interest in grammar, or to the fact that experts, especially in culture-independent subject-fields such as the natural sciences, may consider grammar as less important and not crucial for communication in a scientific or technical domain. One could argue that successful communication does, after all, not depend on correct grammar, but on economy, conceptual precision and accessibility.

Although it may be true that the transfer of information about a specific factual domain is the most important aspect of terminography, a dictionary of the type in question is not adequate without linguistic information such as part of speech, morphological formation, contextual information and information on linguistic and stylistic usage (i.e. labels indicating frequency, temporal markedness, preference, etc.). Brief attention will be given to issues regarding (linguistic) form.

(a) Syntactic and morphological information

For a learner with low second-language proficiency the listing of derivations can be useful, also from a morphological point of view. Of the above-listed

dictionaries only *LIDC* supply part of speech, e.g. **acid** (*n*). As a bonus to the user with low second-language proficiency *LIDC* supplies, at the end of the article, derived forms of the lemma belonging to other syntactic categories, e.g. **acidify** (*v*) and **acidic** (*adj*). It will, however, still have to be established how this issue should be handled regarding the African languages.

Morphological information in a dictionary of chemistry for semi-experts could also include affixes such as *di-* and *-lysis*, and combining forms such as *allo-, amphi-, morph-, -therm, ortho-* and *-philic*. Sublexical lemmas could either be listed alphabetically in the back matter of a special-field dictionary or as part of the main lemma list. Firstly, their inclusion could explain opaque terms of Greek or Latin origin for the user, and consequently make them easier to remember. Secondly, they could serve as keys to the decompositional interpretation of complex terms which have not been entered as lemmas. Although *LIDC*'s categorisation of sublexical lemmas into "prefixes" and "suffixes" (affixes), and "word parts" (combining forms) is quite arbitrary, the mere inclusion of a comprehensive, fully defined list of sublexical lemmas is commendable.

(b) Linguistic labelling

Linguistic labelling is the explicit marking of deviations from the major part of the terms described in the dictionary. The deviation may be of different types, such as frequency (e.g. *rare/rarely used*), systematicity (e.g. *trivial name*) and the temporal deictic centre (e.g. *old/obsolete*). For a learner such information is extremely valuable as it explicitly encourages or discourages use of a specific term.

Unfortunately none of the above dictionaries seem to have a clearly defined and consistent policy on labelling. None of them for instance supplies any list of labels in the outside matter of the dictionary. *LIDC* does, however, provide usage information in some cases. **Alcohol** is for instance defined as "trivial name for ethanol". Unfortunately *ethanol* has not been entered as a lemma and the user is left without a conceptual definition. He/she is also not informed that *ethanol* is the preferred IUPAC term. Although *M-HDCT* implicitly refers to *ethanol* in the definition of **alcohol**, no indication is given of the usage restriction on the latter.

In the case of **metalloid** it is only *GCT* that explicates the usage restriction by opening the definition with "An obsolete term formerly used to ...". *DCT* furnishes the synonym *semimetals* in brackets after the lemma **metalloids**, and then includes the following semi-implicit usage information as a "*Remark*" in small print after the definition: "Term was used to denote non-metals."

A consistent way of treating usage-restricted terms in a pedagogical special-field dictionary may be to define a small set of labels in the front matter and then to use them systematically for marking lemmas as well as synonyms

(supplied in the synonym field). The lemma **olefin** could for instance be followed by its part of speech (*n*), then by a usage label (*old term*)/(*trivial name*), after which a cross-reference "*See* **alkene**" could be given. On its part the lemma **alkene** could be followed by the part of speech, the appropriate conceptual definition, the empirical formula C_nH_{2n}, and the synonym *olefin*, labelled as (*old term*) or (*trivial name*).

(c) Nonlinguistic forms

According to Sager, Dungworth and McDonald (1980: 277) "special languages are able to compress information both syntactically and lexically". In the vocabulary of chemistry this process is *inter alia* facilitated by the creation of abbreviations such as *E* (energy), STP (standard temperature and pressure) and *amu* (atomic mass unit), letter symbols such as Ω (ohm) and Fe (iron), and by the combination of letters and numbers into short designations (chemical formulae) such as H_2SO_4 (sulphuric acid) and NaCl (sodium chloride). Although these compressed forms may at face value be adding to the text density of a special-field dictionary, they are actually more semantically transparent than their linguistic counterparts which often (especially the trivial names and semi-trivial names) give no indication of the number of atoms present in a specific compound. Compare for instance *sulphuric acid* with its formulaic equivalent H_2SO_4. Formulae have, moreover, become internationalised "so that they can no longer be said to belong to any particular language" (Sager, Dungworth and McDonald 1980: 79). Such forms actually respond to the need for eliminating the references created by one language (cf. Rey 1995: 55). Furthermore the use of acronyms, symbols and other abbreviations facilitate "the most obvious economy" (Sager, Dungworth and McDonald 1980: 316), and also reflect the internal structure of the discipline more precisely (cf. Sager, Dungworth and McDonald and 1980: 320). However, other than their treatment in general bi- and multilingual dictionaries of chemistry, these compressed forms need to be entered consistently into separate data fields. As proposed above, the field name or an abbreviation thereof, e.g. *symbol* or *symb.*, could be printed in the dictionary to facilitate clarity and unambiguous information transfer.

5.3.3 Problems relating to meaning

(a) The definition

According to Rey (1995: 42) the terminological definition is a compromise between the lexicographical definition and an encyclopedic description. Definitions in the natural sciences are especially problematic in the sense that "the objects are always remodelled constructions which have however to satisfy

conditions which can only be defined by experience and observation." This fact entails that new dictionaries for the natural sciences can never completely rely on the definitions of existing dictionaries, and that thorough introspection by special-field experts is an absolute requirement.

(i) Types of definitions

The literature on conceptual definitions in terminography reflect different foci, such as the degree of correspondence between the content of the definition and the content of the concept, and the nature of the conceptual features used in the definition. Resultantly various definition typologies have seen the light, as *inter alia* reflected in Arntz and Picht (1989), Bierwisch and Kiefer (1969), Cluver (1989), Dahlberg (1976, 1978) Felber (1985), ISO (1969), Mönke (1978) and Swanepoel (1990).

Swanepoel (1990: 165-166) regards the following definition types as important for terminography:

- the intensional definition (defining a term by mentioning the genus concept as well as those features distinguishing it uniquely from other concepts at the same level of abstraction)
- the extensional definition (the enumeration of species which are at the same level of abstraction, or of all objects belonging to the concept defined)
- the contextual definition (definition by way of an example from actual usage, often a full-sentence containing the term and equating it implicitly with a descriptive definition (cf. Picht and Arntz 1989: 68))
- the operational definition (describing a process or operation by which the referent of the term is realised)
- the ostensive definition (the use of illustrations)
- the synonym definition (the description of the concept by using a synonym)

While the point of view expounded in this article is that conceptual definitions should — in terms of contents, scope and style (cf. Bergenholtz and Tarp 1995: 145) — be prepared with the intended user in mind, the appropriateness of the first four definition types given above will be discussed briefly with regard to *QDC*.

From a stylistic point of view, taking into consideration the intended users' low encyclopedic proficiency as well as their low proficiency in English, contextual definitions seem to be the most appropriate for *QDC*. In a multilingual dictionary already carrying a load of translatory information, a contextual definition may facilitate economy by fulfilling the roles of both definition and illustrative example. By including contextual information the dictionary could then also be useful for encoding activities. The following example from *QDC* shows the advantage of using this type of definition:

amphiprotic *adj.* An amphiprotic solvent has both acidic and basic properties.

Apart from its conceptual content the user may also learn from the definition that the adjective *amphiprotic* often co-occurs with the noun *solvent* (although it sometimes also co-occurs with *molecule, substance* and *material*).

The contextual definition does not stand in opposition to either the intensional, extensional or operational definitions. In terms of the features included, a contextual definition may belong to any of these types.

In a subject-field such as chemistry, nouns denoting objects and substances are usually defined intensionally, e.g.

anion *n.* An anion is an ion with negative charge.
barometer *n.* A barometer is a device used for measuring atmospheric pressure.
colloid *n.* Colloids are particles that are larger than normal molecules, but are nevertheless small enough to remain suspended in a dispersing medium for an indefinite period.
enzyme *n.* Enzymes are proteins that act as catalysts in biochemical reactions.

Simple but concise definitions like the above, however, often provide too little conceptual information to enable the student with low encyclopedic proficiency to conceptualise adequately. In such cases it may be necessary to supplement the intensional definition with either an extensional definition[6], or with an illustration, or both. The compilers of *QDC* found that a quasi-extensional definition (naming a few prototypical examples of the concept in question) could in most cases be integrated elegantly with the intensional definition by using ***e.g.*** as a linking-device:

base metal *n.* A base metal is an ordinary metal that is oxidised by air and reacts with mineral acids, e.g. iron, lead, tin, zinc.
enzyme *n.* Enzymes are proteins that act as catalysts in biochemical reactions, e.g. rennin, diastase, amylase, pepsin, zymase.
gas *n.* Gas is one of the states of matter with a definite mass but no definite volume and no definite shape. A gas expands to fill the volume of its containing vessel, e.g. hydrogen (H_2), carbon dioxide (CO_2), methane (CH_4).

In this way the abstractness of the definition can be decreased to some extent. In a number of cases, however, it was found that extensional definitions could not be linked to intensional definitions by means of a conjunctive device, in which case it was decided simply to juxtapose the two definition types:

ferromagnetism *n.* Ferromagnetism is a property of certain solid substances which causes them to be strongly attracted by magnetic fields. Well-known ferromagnetic materials are the elements iron, cobalt and nickel and many of their alloys.

It may, however, be argued that the first sentence of the above definition is not actually of the intensional type, but of the operational type. Operational definitions are especially useful for defining the concepts of variables, functions, states and processes, as illustrated by the following examples from *QDC*:

potential energy *n.* Potential energy is the energy that an object possesses as a result of its position with respect to another object and is equal to the work done in reaching that position.

reaction rate *n.* Reaction rate is defined in terms of the decrease in concentration of reactant molecules or the increase in concentration of product molecules with time.

According to Arntz and Picht (1989: 67) the operational definition shows strong parallels with the intensional definition while the different "operations" may be viewed as differentiating features (differentia). The compilers of *QDC* decided to separate intensional and operational definitions from extensional definitions by keeping them in different data-fields; not only because of the mentioned similarity between intensional and operational definitions, but also to separate conceptual information pertaining to the distinctive features of a concept from information pertaining to subordinate or instantiating concepts (extensional information). It was argued that this measure could also make computer searches more exact.

(ii) The inclusion of technical terms in definitions

A question concerning the foreign-language competence of target-users (if it is assumed that they would prefer to use the English definitions as well) is to what extent the metalinguistic vocabulary of definitions could or should be simplified for pedagogical purposes. Cluver (1989: 105), following Hutchinson and Waters (1987), seems to be of the opinion that scientific language may be simplified in cases when nontechnical explanations of technical concepts are required, such as in science journalism, and that a core vocabulary for definitions should be identified. However, in the majority of cases where the lexicographers involved in the *QDC* project felt that a technical term could be substituted by a more general term, some special-field experts were of the opinion that simplification led to incorrect or vague information transfer. Compare the following definition of **gel**:

gel *n.* A gel is the dispersion of a hydrophilic colloid in water. The result appears to be solid but it is easily deformed.

The lexicographers suggested that *hydrophilic* be replaced by *soluble*, as *hydrophilic* is treated as follows in the *Collins English Dictionary*:

> **hydrophilic** *adj. Chem.* tending to dissolve in, mix with or be wetted by water: *A hydrophilic colloid.*

The chemists were, however, adamant that the particles of a colloid are per definition **not soluble; but they attract water and are wetted by it**. Furthermore, some of the experts were of the opinion that the term *particle(s)* is too vague to be used as a substitute for *colloid* and that relinquishing precision in this case would result in a loss of necessary conceptual information.

Also in the case of **strong acid** chemistry experts felt that simplifying the definition would result in incomplete information transfer. According to them a formulation such as "A strong acid is an acid of which the molecules easily undergo chemical changes in solution" is not at all synonymous with "A strong acid is an acid with a high degree of dissociation in solution" (although *dissociation* means "a reversible chemical change of the molecules of a single compound into two or more other molecules, atoms, ions or radicals").

Possible ways of getting around the problem of a metalanguage containing technical terms are to provide paraphrases of difficult terms in brackets after these terms, or to use a type-face/symbol to indicate that such a term is defined elsewhere in the dictionary. *LIDC* uses a system of indicating cross-references by means of up or down arrows. If any term is immediately followed by (↑) or (↓) the user knows that it is entered as a lemma elsewhere in dictionary and can be looked up.

Frequent use of bracketed paraphrases within a definition could however result in large-scale duplication of information, and a proliferation of symbol markings could result in the text becoming too busy. The latter could also be frustrating as the user has to look up multiple lemmas in the dictionary before he/she is able to interpret the definition of the original term.

There does not seem to be a quick and easy solution to this problem, especially in the case of higher-niveau terminology. Each and every problematic case requires careful introspection by lexicographers and chemists.

(b) Usage examples

A text-field seldom found in traditional special-field dictionaries, especially dictionaries of science and technology, is that of the usage example. None of the dictionaries of chemistry mentioned in this article provides explicit contextual examples such as collocations, competence examples or citations. However, the fairly elaborate and encyclopedic definitions in *GCT* and *LIDC* often implicitly provide usage information, especially collocations. Compare the definition of **initial** in *LICD*:

> **initial** (*adj*) the first part of a process, the first event in time, e.g. the first reading on a burette is the *initial reading*, taken before the contents (↑) are run into a flask; the mass of a substance before it undergoes (p. 213) a chemical change is its *initial mass*; the first temperature recorded in an experiment is the *initial temperature*. (author's italics)

Here *initial reading*, *initial mass* and *initial temperature* not only have an encyclopedic function, but also a linguistic function.

As demonstrated in paragraph 5.3.3(a)(i) above, the consistent use of a contextual definition style compensates for an absence of explicit usage examples by embedding the term in a syntactic structure. Although the inclusion of separate usage examples could be useful, one should (with regard to a multilingual dictionary for South African students) keep in mind that almost no written special-field texts exist in the African languages, and that mere translations of usage examples taken from authentic English texts could result in highly artificial constructions. Furthermore contextual information is seemingly not so important for culture-independent subject-fields such as chemistry as it is for culture-dependent fields such as law and music.

6. Conclusion

This article intended to give an overview of the role multilingual explanatory special-field dictionaries could play in providing educationally disadvantaged South African students with access to information on science and technology. The linguistic and the encyclopedic proficiency of target-users, as well as the needs and preferences of the particular linguistic community were identified as key issues in determining the structure and content of such a dictionary.

Although the initial phases of compiling a *Quadrilingual, Explanatory Dictionary of Chemistry* have been completed satisfactorily, the acid test will seemingly be the measure of acceptability with which it is met, and its usefulness in attaining the goals and objectives of government, industry, education and the people of the country.

Notes

1. The dictionary project referred to in this article is a joint project of the Chemistry Division of the Suid-Afrikaanse Akademie vir Wetenskap en Kuns and the Departments of Afrikaans and African Languages of the University of Pretoria.
2. The term concept is used throughout the article to denote "A mental construct for classifying the individual objects of the outer or inner world by means of a more or less arbitrary level of abstraction" (ISO, Recommendation R704: 1968, revised 1986).
3. Louwrens is not against the development of terminologies in the African languages. He does however argue that "terminographic work in the African languages stands in danger of

becoming a wasteful endeavour if the language issue is politicised to the extent that linguistic diversity is subjected to the ideal of nation-building" (1997: 251).

Mutasa regards the African languages in their current usage as mere "vernaculars", restricted to traditional contexts such as occupational guidance, traditional medicine, ancestor worship and general conversation (1996: 26). He seems to regard the creation of terminologies as a prerequisite for using these "vernaculars" as media of instruction for subjects such as mathematics, medicine and chemistry (1996: 30).

4. The four languages to be included in the first edition of the dictionary are English, Afrikaans, Sepedi and IsiZulu.
5. The use of "Sepedi" instead of "Northern Sotho" in this article can be motivated by the fact that the standard language — such as represented by most textbooks, grammars and general dictionaries — is based on the Pedi dialect.
6. A true extensional definition explicates the entire conceptual scope of the term by naming all the immediately lower concepts in the hierarchy, e.g. "The planets of the solar system are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto" (cf. Arntz and Picht 1989: 66).

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