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LANGUAGE AND SCHOOL SUBJECTS

LINGUISTIC DIMENSIONS OF KNOWLEDGE BUILDING IN SCHOOL CURRICULA

N° 2

Items for a description of linguistic competence in the language of schooling necessary for learning/teaching sciences (at the end of compulsory education)

An approach with reference points

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LIST DOCUMENTS WHICH PROPOSE ELEMENTS FOR THE DESCRIPTION OF LINGUISTIC COMPETENCE FOR SPECIFIC SCHOOL SUBJECTS

1. *Items for a description of linguistic competence in the language of schooling necessary for teaching/learning history (end of obligatory education)*

   An approach with reference points - Jean-Claude Beacco

2. *Items for a description of linguistic competence in the language of schooling necessary for teaching/learning sciences (end of compulsory education)*

   An approach with reference points – Helmut Vollmer

3. *Items for a description of linguistic competence in the language of schooling necessary for teaching/learning literature (end of compulsory education)*

   An approach with reference points – Irene Pieper (in preparation)

Items for a description of linguistic competence in the language of schooling necessary for teaching and learning science (at the end of compulsory education) - An approach with reference points

This text presents a procedure to help in creating a curriculum for the teaching of science (biology, chemistry and physics) which explicitly takes into account the discursive and linguistic dimensions of this subject area. It proceeds through successive stages, for which there are corresponding inventories of references, from the level of educational goals in the teaching of science to the identification of linguistic elements which it is particularly important to systematise in the classroom in order to manage the corresponding forms of discourse.

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Introduction

In recent years there has been an increasing awareness of the role of language competences for science education in school as a prerequisite for learners to benefit fully from the curriculum and to participate in situations with a science dimension outside of school. Learning science does not only involve new concepts, explanations and arguments, but also new ways of making meaning and of interacting with others using these concepts, explanations and arguments. Learning science thus involves a new way of perceiving, analysing and communicating.

Science has developed specific types of discourse (genres) suited for specific purposes. While textbooks largely contain *consensual* science (providing an overview of certain topics), the experimental report usually presents a new claim backed up by empirical evidence. Scientific texts might include facts, hypotheses, claims, evidence, arguments, conclusions etc. In order to interpret a scientific text in adequate terms, the reader needs to be able to identify a hypothesis as a hypothesis, facts as facts, evidence as evidence etc. This interpretation is guided by awareness of the author's intention and the purpose of the text, awareness of the audience for which it is/was written and the conventions at work in the discourse community. All of these aspects influence the types of discourse under consideration, and how they are produced and understood.

It should to be stressed from the beginning, however, that science education in school has developed forms of discourse of its own, for speaking and writing and especially for classroom interaction, which relate to the social situations outside school, but which are not identical with them. The discursive forms which are school-based are only valid within the confines of that institutional setting, yet they prepare the learner for active participation as a future citizen.

In order to develop appropriate curricula for science education, it is therefore necessary to identify and name the language competences involved in science teaching and learning with precision and clarity, both the discourse related to science education as well as the use of science in society. In particular, they have to be explicit with respect to the language needed (a) for acquiring knowledge, (b) for interacting and negotiating in the classroom, (c) for evaluating outcomes as well as procedures of gaining new knowledge and (d) for critical reflection on scientific issues and the way scientific knowledge is used in private life, in the work place and in society as a whole.

This paper proposes an approach for specifying the language competences in such a way that they can be taught by a systematic method, integrated with the teaching of subject-based knowledge. This is illustrated here with reference to the teaching of the "sciences" irrespective of whether this term is used or individual subject labels like biology, chemistry or physics[1].

The paper presents

- an overall approach for the description and categorisation of the competences needed for successful learning/teaching in science education
- open-ended reference points (in the form of inventories/checklists) which are to be completed by users, according to the specifics of the respective educational system and the languages in which teaching is conducted.

The purpose of these reference points is to help users in:

- identifying the linguistic activities present in the subject under consideration;
- specifying the forms of the language of learning/teaching required in mastering the varieties of discursive content attached to the subject and the forms of communication necessary for imparting and acquiring subject-related knowledge and skills.

The overall scheme of the approach is as follows:

(1) inventory and description of the educational values targeted by science teaching practices;
(2) inventory and description of the social situations of communication involving science in the learners' social environment;
(3) inventory and description of some basic /the expected scientific knowledge structures;

[1] This text draws on earlier work prepared for the Prague Conference (8-10 November 2007) of the Council of Europe, written up by Helmut Vollmer (University of Osnabrueck, Germany), Stein Dankert Kolstø (University of Bergen, Norway), Jenny Lewis (University of Nottingham, GB) and Tatiana Holasová (Research Institute of Education, Czech Republic); see Vollmer 2007b.

(4) inventory and description of the existing in-school communication situations for the acquisition and construction of basic knowledge and procedures in science.
The choices to be made among these possibilities lead to the definition of the purposes and objectives of education in science within compulsory schooling.

Based on steps (1) to (4) it is then possible to create:
(5) inventories and descriptions of the specific linguistic, discursive and semiotic characteristics of relevance for the types of discourse involved in science teaching and learning practices; these characteristics deserve to be taught in their own right in this subject area.

In other words, what is proposed here is a common procedure, whatever the language of instruction in question is, whether the learners' first language or an additional language acquired to a standard of proficiency of at least level B2, according to the Common European Framework of Reference for Languages (CEFR).

1. Educational Values and Science Education

All teaching pursues educational goals over and above the expertise and learning which are both its substance and its aspiration.

The role of languages of education in schools is to structure and assist the training and education of social actors and the development of the individual to their full potential as individuals. The aims of this training/education are shared by the Member States of the Council of Europe as the basis for living in society in Europe.

Schooling is responsible for preparing future citizens and developing their potential by giving them the necessary tools for all aspects of life in society (personal relations, occupational activities, leisure activities, etc.) and by enabling them to understand the basic values of human rights, democracy and the rule of law and make them part of their personal ethics.

The languages of Europe are inter alia a means of acquiring knowledge, of engaging in exchanges about this knowledge and how to make use of it with others who may have different understandings of these issues.

As a consequence, the goals of science education include not only the mastery of the *basic structure* and of specific *items of knowledge* within science, but also a more general goal of *understanding science*, and of developing a framework for understanding the specific questions addressed and the answers given by the natural sciences and their related disciplines; everyone should understand the contributions and limitations of the sciences to knowing the world. This is epitomised in the notion of the *development of a scientific mind of enquiry* as a general characterisation of the intended outcome of science education in school.

This goal for science education involves first the development of 'investigative skills': e.g. planning an investigation, proceeding accordingly, collecting data and interpreting these – including the handling of various kinds of nonverbal or semiotic forms of information like graphs, statistics, formula etc.. Second, it involves the development of evaluative as well as reflective competences in a critical analysis of ideas, procedures and evidence in science as well as applications and uses of science in its social context. This implies comprehension and discussion of the following questions:

- how are scientific knowledge and insights gained, how are "discoveries" made;
- how are scientific ideas agreed and disseminated;
- how do scientific controversies arise;
- how can scientific work be affected by the social, historical, moral or spiritual context in which it takes place;
- how do these contexts influence whether ideas or findings are accepted?

Where there is agreement that science education should not limit itself to the reconstruction or transfer of knowledge, but should equally consider the power and limitations of science in addressing societal issues, including uncertainties and ethical problems in scientific knowledge and its application, the following may be included in science education:

•	use of contemporary scientific and technological developments and their benefits and risks;
•	consideration of how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions;
•	(un)certainties in scientific knowledge and ideas, how these change over time, and the role of the scientific community in validating these changes

The specifications of values also include material for definitions of more general abilities, for example: to analyse and interpret information critically and responsibly, through dialogue, through the findings of scientific evidence and through open debate based on mutual respect and rational argumentation. They offer a path to the specification of cognitive and linguistic competence, as outlined below.

In more general terms, the principal goals assigned to science education thus include:

-	to make a contribution to educating responsible and active citizens and fostering respect for all kinds of differences in evaluation on a basis of understanding scientific issues and possibilities of solving them;
-	to encourage recognition and understanding of different interpretations of the same issue and their relative legitimacy, building trust between peoples, by accepting multiperspectivity in scientific research and explanations;
-	to play a role in the promotion of fundamental values such as rational exchange of positions and opinions, tolerance, human rights and democracy;
-	to be a fundamental component in the construction of a Europe based on a common cultural heritage, with a humanistic and a scientific orientation, working towards the development of a knowledge society in which conflictual factors are accepted;
-	to be an instrument for the prevention of crimes against humanity and securing the quality of human existence.
-	to be part of an education policy that has a direct effect on the personal, professional and social experience and decision-making of the learners, with a critical and enlightened view on building tomorrow's Europe together, by participating in solving local as well as global issues and leading a satisfying private life, with a spirit of mutual understanding and trust;
-	to allow the nurturing in learners of the intellectual ability to analyse and interpret information critically and responsibly, through dialogue, through the findings of empirical evidence and through open debate based on multiperspectivity, especially regarding controversial and sensitive issues;
[...]	

In sum, science education is based on socio-critical values raising question of relevance, of contextualisation and possibly of reduction of the science content (concentration on key concepts, on core content(s), on exemplary procedures, embedding science teaching into the learner's own experience and relevance for everyday life) vis-à-vis the limited time given and the need to include dealing with socio-scientific issues (personal and societal issues with a science dimension) in the classroom. Only this will prepare learners for the application of scientific knowledge and for scientific reasoning outside school, in life, participating actively as citizens in this area.[2]

[2] See particularly the contribution of Kolstø 2007b. These broad and critical teaching goals will require science teachers to provide differentiated tasks which allow students to work at their own level, at their own pace, in their preferred learning style. Such a teaching approach should challenge the most able learners while also supporting the less able ones: in order to do this, science teaching would have to be (more) student-centred, partly even individualised, actively engaging students in the development (construction) of their own knowledge by starting from their preconceptions; the teaching would have to bring out these representations and the knowledge that learners already have if one wants their later construction of knowledge to be sound and solid (cf. Giordan 2007 or DeVecchi/Giordan 2002 for science education in France). (This might be dealt with in more detail in another module).

2. Science education and citizenship

It is the obligation of education to develop in learners a scientific mind and outlook on life and to prepare them to cope effectively with situations and social activities in which science is involved, being a subject area with highly significant relevance to human engineering, to technological innovation, to health and security and to ideologies of man-made progress concerning productivity, efficiency, quality of everyday life as well as increasing mastery of the environment.

Science education relates to situations in the private as well as in the public domain. There are immediate insights and applications of science possible in everyday life and there are global issues at stake like climate change, sustainability and biodiversity or local issues ranging from energy supply to food additives. Such issues call for personal or political decisions, but also have a *science dimension* that needs to be considered. In democracies it is important that citizens engage in debate and decision-making processes, and that schools prepare future citizens for such participation.

The science dimension of such issues leads to the need for *scientific literacy* :

> Scientific literacy is the capacity to use scientific knowledge, to identify scientific questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity (OECD 2007).

In addition to this focus on understanding and decision-making, science education for citizenship involves preparing students for active, informed, critical and responsible participation in issues and situations where scientific insights the quality of this participation.

Science education for citizenship thus aims to empower learners to be wiling and able to engage with socio-scientific issues by enabling them to read and listen to scientific information and arguments with understanding, examining and evaluating this information and the argumentation critically, and to contribute to discussions and decisions in a competent, informed manner.

This empowerment is founded on a broad knowledge base:

- a thorough understanding of the main explanatory stories in science (e.g. particle model of matter or germ theory of diseases)
- insights into the nature of science, including social processes in science whereby the reliability of claims from the frontier of science is discussed and evaluated
- insights into the contextual dependencies of science, especially science–society interactions, including science policy issues, ethical aspects of science, the role of funding in research and issues of dissemination of selective research results.

and four competences, all involving communication and language – the ability to:

1) bring out and formulate one's own conceptions, representations and existing knowledge
2) retrieve, read and interpret scientific information,
3) examine, discuss and negotiate information and arguments critically,
4) make deliberate/considerate decisions and communicate/disseminate their own points of view.

2.1 Contexts requiring scientific literacy competences

In order to define the nature of these competences, it is necessary to consider contexts in which they might be used.

Retrieve and interpret information

Citizens increasingly search for authentic scientific information on such matters as children's illnesses. Information and viewpoints are to be found in the media, newspapers, TV, radio, the Internet or libraries, where citizens access texts written in scientific genres e.g. expositions of findings, reports of experiments, and executive summaries. They also get information through professional consultancy, e.g. from their medical doctor and from energy-saving advisors. Understanding, relating and interpreting this information from the manifold sources is at the basis of all communicative competence in this respect.

Examination of information and arguments

Examination of information and arguments involves, first, analysing the reasoning e.g. through discussing the assumed or constructed meaning with peers or professionals. Secondly, the trustworthiness of the author, institution or source of the information/viewpoints needs to be examined, e.g. through inspecting competence, affiliation, merits, possible vested interests, ideological orientation etc. Thirdly, the scientific reliability of claims and arguments needs to be examined, e.g. through comparing views of different experts, inspecting evidence and references provided, and comparing them with consensual science.

Decision-making and dissemination of viewpoints

Based on the processes of acquiring information and examining views and arguments critically, citizens might contribute to debate through posing questions, giving observations, sharing and exchanging arguments and viewpoints with others. A range of platforms and channels are available for this, for example entering into discussion with friends and colleagues or engaging with the agendas of NGOs. This may be oral or written communication of views e.g. through letters to newspapers, blogs or private websites or by contributing to texts produced by NGOs in the form of brochures, web-articles, press releases, etc.).

Examples of contexts in which these competences operate include:

Political agendas where scientific knowledge or assumptions are used for persuasive purposes to define e.g. ‘progress’ or ‘security’ and justify actions to be taken e.g. dealing with atomic power or pandemic threats, reduction of CO2 emissions etc.;
Exchanges between citizens which pre-suppose “general knowledge” of a scientific nature;
Family and neighbourhood contexts where personal knowledge and evaluations are passed on or mixed with “expert” knowledge and opinions;
Accounts in the media of technological breakthroughs, celebrations of “great scientists”, expansion of knowledge about the universe, etc. or of actual or potential misuses of scientific discoveries
Reading both general and specialist science press and didactic publications etc.);
Watching different kinds of entertainment both fictional and documentary – films, television programmes, theatre - with a scientific content e.g. re-enactment of scientific discoveries
Using sources of reference such as websites ;
Visiting museums, exhibitions and similar sites on natural science and technology;

Some of these situations are intrinsic to social life, to politics and to active citizenship, others pertain to media use, accessibility to knowledge and the formation of opinions or even interest/lobby groups. They involve different forms of communication: oral/aural, written and audiovisual reception, oral interaction, etc. This reference list may be supplemented and used as a guide to the identification of language skills and capacities which should be part of a science syllabus.

2.2 From social situations to types of discourse

For situations of “scientific communication” it is possible to develop descriptors from an analysis of the characteristics of the types of discourse employed in those situations.

For example, *learning to understand scientific documentaries (on television)* involves a discourse type in the popularisation of scientific knowledge and problem definition, based on aural and visual reception (cf. *Common European Framework of References for Languages*: “4.4.2.3.: understanding TV programmes and films; understanding a documentary”: B2).

At this point, we distinguish between *cognitive skills* underlying discourse and *linguistic/semiotic skills* which are visible on the surface level. In section 5 – we will demonstrate how cognition and verbalisation are closely linked to one another.

Science-related cognitive skills include the ability to

identify types of sources used/academic sources
identify reasoning, based on data/clues
notice the strategies/devices applied to give popular appeal: e.g. dramatisation, “experts” versus laymen, activating elements/substances etc.
identify and distinguish already known and new knowledge

place the presentation into a broader context (larger issues, concepts, structures)
evaluate representational forms chosen specific to the media in question
identify simplifications, generalisations, lack of data, allusion to academic controversies, unbalanced solutions etc.
understand whether a particular bias is being conveyed
…

Linguistic and semiotic skills include the ability to

understand the goals and commentaries of the moderator;
understand interviews and explanations;
read maps, diagrams, tables;
interpret editing, framing and emphasis;
notice the definitions given directly or in the voice-over;
distinguish description from comment;
distinguish objectified discourse from judgement (particularly unrealistic, moral etc.);
…

Once the social situations of communication have been characterised and the types of discourse they (primarily) involve have been identified and exemplified, it becomes possible to single out and focus on particular perspectives and linguistic features in the teaching and learning of science in school itself.

3. Subject-related competences

A certain command of science as a form of knowledge is an educational goal in itself. Therefore, a list of specifications of scientific knowledge is called for (section 3.1), while a survey of the cognitive resources (e.g. thinking skills) needed to learn/teach modes of in-school and social discourse has to be developed as well (section 3.2).

3.1 Checklist of components of scientific knowledge structures

These are the basic knowledge structures which it is hoped learners will acquire from their science lessons and be able to apply it in social situations of communication. It consists of knowledge of different types and orders:

Three levels of scientific knowledge can be identified: *general* categories and knowledge like 'elements' or 'concepts', *specific* categories and knowledge relating to structures and relationships and *specific knowledge linked to developments* and their dynamics.[3]

general categories and general knowledge: *concepts, elements, principles*	• biological, chemical, physical phenomena • basic concepts and notions • principles and facts • elements, matter • data, description, demonstration • rules, regularities • [...]
specific categories and knowledge: *relationships, structures*	• structure, organisation; • interpretation and comparison; • (types of) relationships, • causation, causes, interaction • system(s), features and functions • […]
specific categories and knowledge: *developments*	• Chronology, temporality, • event, trend, evolution; • continuity, change, break, "progress"; • laws of conservation and transformation

[3] See the formulation of standards of education in Germany for biology, chemistry and physics (Vollmer 2007a3).

	• knowledge of general scientific schemes and processes over the long term (for example: evolution, mutation, "survival of the fittest"...) • understanding these processes, the built-in mechanisms and the influence of mankind on these developments etc. • understanding the events and driving forces that have structured the present situation • [...]

The three subjects of biology, chemistry and physics share many basic concepts and ideas, but also differ in some of their guiding principles and in their terminology.

The compilation of science teaching syllabi which comprise specifications in terms of knowledge can accommodate the traditional tendency to design syllabi focused on specific *areas* of knowledge, while outlining at the same time specific *structures* of knowledge plus understanding the *development* of knowledge over time. The grid above is intended for scrutiny of the diverse nature of the knowledge meant to be taught. Its chief purpose is to emphasise that these various forms of scientific knowledge presuppose different types of discourse (or discursive forms) in what is said by the teacher and the textbook or other types of material:

- basic scientific knowledge should be disconnected from its ordinary connotations and interpreted afresh in its experiential and historical perspective, also of a philosophical nature;
- structural knowledge can be defined in different ways/debased, in which case its primary meaning must be restored;
- knowledge about the dynamics of scientific development can give rise to different interpretations and basic beliefs about the nature of the cosmos, the world, the universe and what holds it together. Thus the teaching of such knowledge has to draw upon historical comparison.

3.2 Checklist of components of methodological competences in science

The expertise and strategies that have to be taught to learners for successful application of their knowledge, have already been defined as "scientific literacy" (see above). In order to foster sound judgement, critical analysis and evaluation as well as open-mindedness and other virtues, it is important to develop "cognitive skills" or "procedural expertise" in science, such as ability to handle and analyse different forms of information and documents, arrive at balanced, responsible conclusions, and see other points of view or interpretations of the same data set(s). Scientific literacy thus consists of several components of knowing how to proceed in relation to given tasks and goals which could be summarised under the heading of "scientific proficiency". This procedural capacity can be broken down into a number of relevant competences, including being able to:

formulate relevant questions about the available documents/data source;
examine potential sources of information and distinguish between primary and secondary sources;
assess such sources in terms of validity, possible bias, accuracy and reliability;
use the sources available to identify relevant information to answer certain questions;
analyse and structure this information on a particular topic/issue and relate it to existing/prior knowledge;
contextualise the information by relating it to information already available about the period, the actor, the transmitter of knowledge;
scrutinise the available source materials for rational justification and rank them in terms of their significance;
Acknowledge that scientific inquiry and findings are not value-free;
recognise one's own perspective, bias and prejudice and take account of them when interpreting the available evidence;
acquaint oneself with the history of science as a particular form of the construction of knowledge;

When related to the above mentioned three types of knowledge, the respective inventories for epistemological or procedural competence could look like this:

Relating to certain *items/objects of knowledge*

Identify an element/a topic/ a concept (e.g. by marking, highlighting, copying etc)
Name the term(s) for …(as an act of memory)
Write the captions of (e.g. a diagram)
Label the components of a graph (with or without choices given)
Describe (orally or in a written form) …
Summarise …
Explain

In connection with *knowledge structures*, systems and functions to be understood and reconstructed, here are a few examples of possible descriptors:

Name	different flowers/flowering plants, distinguish their organs/parts …
Describe	the functions of the organs contributing to digestion
describe (by exemplifying and illustrating)	the make-up of a sense organ
Explain	the adaptation of mosquitoes to the living conditions of their environment

For initiating or checking the understanding of the notion of *development* in scientific thinking possible descriptors could be:

Describe	In simple terms the process of mitosis and explain its meaning
Describe	the development of plants
Identify and name	fossils as proof for evolution
Describe	the restructuring of the landscape by human beings through an example

In principle, all types of descriptors involving cognitive-linguistic operations for demonstrating areas and degrees of acquiring and understanding scientific concepts and findings on the basis of individual work and individual responses serve the function of becoming aware of the new knowledge gained, its relationship to prior knowledge, the questions still open and the aspects not yet fully understood. Therefore, a large number of discourse activities and formats as well as descriptions relating to them and guiding them are possible.

By way of a summary, we can state that methodological competence consists of knowledge *and* skills necessary for the acquisition of the different types of subject knowledge. This can be expressed in the following summarising table[4]:

Practical and enquiry skills includes to be able to:

- plan to test a scientific idea and test it, answer a question or solve a problem;
- collect data from primary or secondary sources, including using ICT sources and tools;
- work accurately and safely, individually and with others, when collecting first hand data;
- evaluate methods of collection of data and consider their validity and reliability as evidence;

Students are to learn

- how scientific data can be collected and analysed;
- how interpretation of data, using creative thought, provides evidence to test ideas and develop theories;
- how explanations of many phenomena can be developed using scientific theories, models and ideas;
- how questions can be identified that science cannot currently answer, and others that science cannot or does not want to address

[4] See Level 4 of the Science Curriculum in England, reported in Lewis (2007a)

It is only when these procedural dimensions are addressed in science education, that learners are empowered to become active for themselves, responsible for their own learning, and critical thinkers rather than uncritical consumers, acting on the results and applications of their scientific knowledge and participating in relevant debates i.e. follow, but also influence, either individually or collectively, such debates as critical citizens.

In these inventories, we have not yet identified the level of abilities that are actually within the learners' grasp at different stages in time and how to build on them. In other words, we still need to clarify how these capacities can be developed over time and how they connect with each other so that the planning of a realistic path for their acquisition can be attempted, above all according to the cognitive development of learners at school.

4. In-school communication situations relating to science teaching and learning

We now have to switch from communication in society and from the objectives defined in terms of scientific knowledge and procedural competence to the *types of teaching and learning in school.* The latter have to be informed by the former: the forms of communication that are used in science education must be linked to those present outside school. Yet, school-based education also follows its own rules and conventions.

We can in general distinguish between several different phases or types of learning activities in the classroom, and this is also true for science education. Each of them involves different cognitive-linguistic demands and challenges:

4.1 Checklist of classroom activities in science education (for subject learning/teaching in general)

It is possible to distinguish the following types of learning/teaching activities within the science classroom:

4.1a Activation, acquisition, structuring and storing of scientific knowledge

4.1b Presentation, negotiation and discussion of new (as well as old) knowledge
4.1c Evaluation of knowledge and the ways by which it was gained

4.1d Reflection about the uses and limits of scientific knowledge and the validity of the world view accompanying it.

4.1.1 Activation, acquisition, structuring and storing of scientific knowledge

As already mentioned, science teaching practices are structured according to a finite repertoire of learning/teaching activities. Such forms of teaching vary according to educational traditions and the methodological choices made in the syllabi or by individual teachers l, all of which structure the teaching. It is important to list the approaches and typical situations of scientific communication used in the different activity areas.

The first area or type of pedagogical activity i.e. the activation, acquisition, structuring and storing of scientific knowledge involves the formation of new concepts and the expansion of already existing knowledge, again taking into account the spontaneously offered conceptions of the learners and their necessary transformation. Certain learning/teaching situations are most common here like:

presentation by the teacher (including general information, interpretations and comments, analysis of primary sources, explanation of terms and concepts, etc.) using visual aids (maps, diagrams, data tables, reproductions of evidence, etc.) (OP, AuR and WP[5]);
teacher-learner interaction about the presentation and/or data (OI);
learners reading and studying a/the textbook (WR);
Finding information (WR and WP; note-taking on the part of the learner);

[5] Coding of communication activities based on the CEFR: **R** = reception; **P** = production; **I** = interaction; **O** = oral; **W** = written.

analysis and summary of text files (WR and WP);
reviews of books, television programmes (WP or OP);
reaction to a film featuring a scientific issue/controversy watched as a class (OI);
activities run as projects (linking different competences, for example, making a promotional pamphlet or film about medical issues or those of the environment): individual and/or group research;
introduction to scientific methodology: e.g. gathering data through observation and experimentation, collation, analysis and commentaries (OR), interpreting tables (WR)
production of texts relating to personal preferences and decisions (WP) based on scientific knowledge and interpretation; explaining features, preparing suggestions or solutions (WP);
restructuring a text for a particular purpose: for example, extract key points from a science text to produce notes; to convert information found on the web into an information leaflet (e.g. for use in another context or in real life)
[...]

Specific language competences needed in this area/phase of learning would be

From the perspective of biological knowledge as a *system*, learners would be expected to
- describe cells as spatial units which consist our of several components
- explain the meaning and influence of selective environmental conditions for an ecological system
- describe or characterise / understand a number of different nutritious cycles/chains and networks
- list what a cell consists of - name and illustrate its components
- (after having done a small experiment) answer the question: "Why is there a space of air necessary in a jar inhabited by a snail, some branches and water?"
- making/giving a summary of a scientific fact, insight or text (with uses of visual representations (OR and/or OP).

4.1.2 Presentation, negotiation and discussion of new (as well as old) knowledge

This activity normally covers a large part of science education: it is above all the opportunity for learners to plan and speak coherently, to link ideas and sentences, to consider the audience and their prior knowledge and to construct common ground, before presenting a finding, giving an interpretation or delivering a message.

Some of those activities designed to develop learners' subject-specific communication skills might include the following:

share or question ideas: for example, working in small groups to agree on an explanation of a phenomena or the correct scientific explanation for an observation, for an open question
present individual work or the results of group work (OP) based on notes, powerpoint slides, posters, graphs, etc.;
understand a presentations, the goal, the findings, procedures, the discussion of results (OR)
explaining and/or justifying a question, an investigation, procedures chosen, interpretation of data, conclusions drawn etc.
Contributing to a whole class activity (e.g. collecting ideas, points, elements, expectations (e.g. in the reaction of two or more chemical substances)
Role-play: take a particular role (e.g. that of a local farmer in a debate about genetically manipulated crops), study this role/the arguments and present the farmer's case to the class
Relating pros and cons of a certain issue to one another (OP and OI)
Organising a debate (with adverse positions/multiperspectives) (OI) – if on the basis of texts or notes (WP)
Moderating a (formal) discussion
[…]

4.1.3 Evaluation of knowledge and the ways by which it was gained

This phase or type of learning/teaching activity is closely linked with the one under 4.1.2 and could be integrated into it. However, it may be helpful to deal with this area of learning explicitly and separately, since it helps understand how certain findings in science come or came about, a representative a certain data base is, how much generalisation or analogy is involved in certain interpretations, what the degree of validity or certainty is concerning controversial or unresolved issues.
This stage of classroom learning heavily draws on the epistemological competences already dealt with in section 3.2:

Evaluate methods of data collection of data reduction
Re-analyse the design chosen for a specific experimentation,
Consider the reliability and validity of certain (empirical) observations, findings, studies
Identify and differentiate scientific claims, evidence and conclusions in an utterance or text
Identify inferences drawn and deductions made in detail
Check the convincingness of certain arguments as evidence
Interpret the epistemic status of statements correctly (as presented in an oral or written discourse).
[…]

4.1.4 Reflection about the uses and limits of scientific knowledge and the validity of the world view based on it /accompanying it.

This phase of science education provides possibilities of linking explicitly what is being acquired and learnt in the classroom to social situations of communication and decision-making outside of it, as listed in section 2.

List and discuss possibilities of energy saving in the private household/for air traffic
Evaluate benefits, drawbacks and risks of certain technological developments (e.g. safety measures in powerful, energy-consuming cars, production of mass medication etc.
Argue for and against the alleged/supposed “threats” of genetic manipulation (e.g. in food, in animals, in human beings etc.)
Consider the implications (advantages, dangers etc.) of atomic energy production
Reflect on the role of “experts” in certain law cases or decision-making bodies
Consider how decisions involving science and technology are made, including those that raise ethical issues
Reflect about the social, economic and environmental effects of such decisions as well as chances to influence them individually or as a group (e.g. ways of contributing to the rescue of the tropical rain forest, from protests to consumption behaviour).

4.2 From classroom situations to discursive forms

All of these types of science teaching and learning activities can be described in terms of linguistic capacities and types of discourse. For situations of “scientific” communication, it is in fact possible (as started in 2.2 above) to develop descriptors from the characteristics of the discursive style used in those situations.

4.2.1 Example 1

Giving a (prepared) presentation to the class
This type of discourse relates to oral production (see CEFR 4.4.1.1.: addressing audiences), based on notes, slides or a whole manuscript in written form. This involves:

science-related cognitive skills such as the ability to:

Read and summarise relevant documentation;
Locate the different sources of information;
Adapt an existing historical discourse;
Interpret primary data;
Interpret quantitative data;
Report the opinion of professional historians;
Give and support one's own point of view, explaining its source and nature;
Highlight the gains and the problems;
[...]

linguistic and semiotic skills such as the ability to:

State a plan, a scheme of presentation or "narration";
"Give clear, systematically developed descriptions and presentations, with appropriate highlighting of significant points" (Descriptor B2 in the CEFR p. 58);
Emphasise the stages of the presentation as it unfolds;
Present and organise the linguistic commentary of tabulated data, a diagram, etc.;
Make the presentation attractive: manage voice and intonation;
React with restraint to objections or criticism from class or teacher;
Answer questions concerning the findings and/or the procedures applied afterwards;
Assess one's own performance (without or with the help of others);
[...]

It will be noticed that in the example given the same descriptors can be used as those in the CEFR, devised for foreign languages, to the extent that it describes a group of discursive forms employed in science (addressing an audience). Yet not all are relevant, even in this case, as the CEFR takes no account of learners' ages. Thus, the descriptor B2 (CEFR p. 60): "Can depart spontaneously from a prepared text and follow up interesting points raised by members of the audience, often showing remarkable fluency and ease of expression" might not be suitable for ALL 15-16 year old learners, at an age when compulsory education often ends. Likewise, the level C1 and C2 descriptors can furnish material for descriptions but probably cannot be adopted as such.

4.2.2 Example 2

Planning, doing and evaluating an experiment
This type of discourse requires many considerations, plans and cognitive decisions which will have to be documented (verbalised) either immediately or later (less preferred).

science-related cognitive skills involved include the ability to:

- plan to test a scientific idea, answer a question or solve a problem;
- formulate an assumption, a hypothesis
- collect data from primary or secondary sources, including using ICT sources and tools;
- use both qualitative and quantitative approaches;
- work accurately, either individually or with others, when collecting first hand data;
- document the on-going results and the procedures chosen
- prepare data in such a way that you can check the hypothesis (either visually or with mathematical means)
- design the structure of a report
- …

linguistic and semiotic skills include the ability to:

- recall, analyse, interpret the scientific information gained
- relate the findings to your assumption or hypothesis
- make a table of contents and write a draft version of the report
- present information coherently
- develop an argument and draw conclusions, using scientific, technical and mathematical language, conventions and symbols and ICT tools;
- write the correct terms and variable names in the captions (e.g. of a table)
- edit the report (be as accurately and convincing as possible)

5. Specific linguistic and semiotic competences needed for science education

So far we have identified and exemplified

- social situations of science-related communication (2.1. checklist)
- and the corresponding types of discourse (2.2.)
- and the components of scientific knowledge structures (3.1. checklist)
- the ingredients of epistemological competence in science (3.2. checklist)
- in-school situations of communication with a scientific goal/content (4.1. checklist)
- the corresponding types of discourse in science lessons in school (examples in 4.2.).

Based on these different steps (and their underlying principles) it is now possible to single out and generalise specific linguistic competences suited for science teaching and learning, aimed at imparting knowledge and expertise as well as instilling social communication skills. As already demonstrated, for learners these cannot be restricted to command of specialised terminology or the ability to piece together elements of scientific knowledge, even where these may be clear and logically derived from data. The necessary linguistic competences involved in science education, also involve complex thinking and discourse skills and ways of relating the two via lexical, grammatical and textual choices.

To describe these linguistic competences in more general terms, we shall adopt a subject-based model of *capability* and *communication,* arranged in four sets of components, the first three of which form what is strictly speaking linguistic communication competence:

- strategic component/competence (see 5.1.)
- discursive component/competence, mastering types of discourse) (5.2.)
- formal component/competence (5.3)
- interdisciplinary/cross-curricular competences, not peculiar to science teaching: these will have to be dealt with in another module.

5.1 Strategic competence

General communicative ability includes a psycho-cognitive component termed *strategic* that controls observable linguistic behaviour in order to generate, produce and understand texts. “Strategies are a means the language user exploits to mobilise and balance his or her resources, to activate skills and procedures, in order to fulfil the demands of communication in context and successfully complete the task in question in the most comprehensive or most economical way feasible depending on his or her precise purpose.” (CEFR p. 57).

In the CEFR the strategies are situated at the same level as communicative activities (as oral/written interaction [OI/WI], oral/written production [OP/WP] and aural/written reception [AuR/WR]). This level of specification allows teachable actions to be defined in terms of planning, execution, evaluation and repair[6], which seem independent of the languages and discourses used. We shall proceed from these specifications to describe the communication proficiencies needed to teach/learn science.

[6] CEFR, 4.4.1.3. for OP/WP, 4.4.2.4. for OR/WR and 4.4.3.3. for OI/WI.

Oral and written production[7]		
	General activities	Activities in the school setting of science teaching and learning
Planning	Locating resources	Identifying the relevant information sources
	Preparation and/or rehearsal	Producing successive tentative versions of the text to be produced. Verifying its length (if WP).
	Consideration of the recipient and audience	Taking account of the audience's receptive capabilities, level of knowledge and status, etc.,
	Adaptation of message	Transposing, paraphrasing, summarising, mentioning, quoting and commenting on source texts
Execution	Building on prior knowledge Trial (experimentation)	Reliance on existing texts of the same kind as the one contemplated Making successive provisional versions of the text to be produced.
Evaluation	Checking of results	Testing through listeners' reactions (if OP) the intelligibility to an outsider not directly addressed (if WP)
Repair	self-correction	Improving self-correction through an external evaluation
Aural and written reception[8]		
	General activities	Activities in the school setting of science teaching and learning
Planning	Framing (selecting mental set, activating schemata, setting up expectations)	Identifying type of discourse and its potential contents
Execution	Identifying cues and making inferences	Working out the meaning of technical terms or scientific deductions from language knowledge and scientific knowledge
Evaluation	Hypothesis testing: matching cues to schemata	Matching up the interpretative hypotheses and developing critical sense
Repair	Revising hypotheses if required	Reconsidering one's position about a theory, explanation, validity of data and their interpretation

It is obvious /plain that the specifications of the CEFR relate more to reading as comprehension than as interpretation or critical response. For languages of instruction, the comprehension strategies need to be re-interpreted as a function of the knowledge in the discipline (in this case, critical comprehension).

[7] According to CEFR. p. 53.
[8] According to CEFR. p. 65.

Spoken and written interaction[9]		
	General activities	Activities in the school setting of science teaching and learning
Planning	Framing the issue (establishing a line of approach) Judging what can be presupposed Planning moves	No relevant descriptors in the CEFR, since the interactions between teacher and learner or among learners occur in the language of schooling. But it is necessary to understand what is expected of the classroom interactions whose aim is to provide insight into the knowledge presented and which are not ordinary social interactions. It is thus important to know their implications for imparting knowledge.
Execution	Taking the floor Co-operating (interpersonal) Dealing with the unexpected Asking for help	These specifications are altogether relevant in the context of debates, discussions and arguments staged in class about scientific questions
Evaluation	Monitoring (schema, praxeogram) Monitoring (effect, success)	No particular specificity to the science-related verbal styles in or out of class
Repair	Asking for clarification Giving clarification Communication repair	Relevant as regards terminology, foreign borrowings, knowledge and patterns of scientific reasoning and explanation...

These descriptors of strategies, as may be seen, need specifying if possible, as far as types of communication with "scientific" content are concerned. This reference grid should be considered provisional. From a pedagogical standpoint, the descriptors of planning, which relate to the learners' preparation of the statements (oral or written) should no doubt be more developed than those concerning monitoring or correction (except in the case of OP or WP).

These strategic abilities are valid for all subjects taught, so a comparison with the terms in which they are specified for history, mathematics or art (e.g.) is called for.

5.2 Discursive competence

The concept *type of discourse* (or *discursive form*) has been used to denote the forms taken by communication as practiced in a given social situation and communication community. The types of discourse are specific discursive forms identified as such by a standard name and certain characteristics (physical location, type of participants, medium, etc.) of the situations where they occur: lecture, news item, observation, dispute, myth or prayer, etc.

The texts that pertain to a given type tend to follow the conventions typifying these discourses; the conventions concern not only contents but also the structure and/or verbal forms of realisation/productions. A text is more or less consistent with the discursive form whose specific outcome it is. The types of discourse themselves are more or less strained and formalised (lecture *versus* casual conversation).

The concept of discourse type is less abstract than that of textual type (narrative, descriptive, imperative, expository, persuasive, etc.). Typologies of this kind have never really been adequate for

[9] According to CEFR. p. 73.

describing classes of texts since it is readily acknowledged that *most actual texts correspond simultaneously to several types*. This typology may nevertheless be used to denote the style (or discursive regime) adopted by certain segments of texts: for example, in the "film/book/record/review" discourse type in written media, there is often a segment at the beginning which has a descriptive or narrative tone (film); the texts then continue with a segment with an evaluative purpose, before summarising and highlighting the main points.

One aim of plurilingual and intercultural education, hence of languages in learning/teaching, is to broaden learners' discourse repertoires (in some/all of the languages of their language repertoires) in relation to their initial experience/proficiency in types of discourse and to give them the opportunity for new experiences (through texts and documents including non-verbal forms of representation) of the diversity of disciplines, academic cultures and of otherness..

As in every other subject, science syllabi may be specified according to discourse type:

- types seen as already entering into the learners' repertoires (textbook, scientific documentary, illustrations of (abstract) relationships and functions, info brochures, etc.)
- types present in the learners' social environment (periodicals: general-interest press, science-based journals; websites, expert debates, moderated public and/or political discussions, etc.)
- types to which a certain form of exposure is sought by science teaching.

For the purpose of choosing the types of discourse with which learners are to be familiarised, attention needs to be paid first to the academic status of statements of "facts" and of popularised science reports. These are very diverse in nature because of the role assigned to them in diverse texts in the public domain which have some connection with the natural sciences. For example, with respect to written scientific reports, it may be deemed important for learners to be brought into contact with:

- academic/disciplinary discourse types written by specialists for specialists (articles, communications, monographs, theses and the like);

- types produced by specialists, presenting new knowledge meant for and made accessible to the ("educated") general public;

- types used in popularisation in book form or as TV features by professional scientists, knowledgeable amateurs and authors specialised in scientific dissemination;

- journalistic discourse types of the press specialising in science issues;

- journalistic discourse types of the ordinary daily press relating to scientific questions and debates (reviews of published books, accounts of "discoveries" and/or issues of health and security, interviews with scientists like biologists, medical doctors, with interested laymen, etc.);

- educational discourse in the form of science textbooks, summaries for school learners, multi-media presentations on film or video;

- the encyclopaedic discourses of dictionaries, encyclopaedias, wikipedia / the internet in general, etc.;

- the direct testimonies recorded for example in autobiographies, recollections and personal diaries, statements of representatives of interest groups, etc.;

- fictional or "literary" works of a scientific nature: novels, films, TV series, etc.;

The choice of the discourse types which it is considered learners should experience and partly even produce (either by way of simulation or by way of (local) participation), depends on the general choices already described above (values, social situations of communication, scientific knowledge, status of knowing, controversies involved, etc.) but may be fine-tuned in the light of descriptors relating to:

- the nature of the instructional activities which are to draw upon these texts (WR, OI...)
- the expected degree of competence or proficiency for each (see sections 3 and 4)
- the proximity or familiarity of the types compared to those already experienced by the learners
- the interest (or motivation) which these discourse types may arouse
- the necessity of dealing with certain discourse types due to their importance and impact outside school.

Characteristics peculiar to the discourse types may also be used as a basis for decision-making on the following levels:

- length of the texts pertaining to them
- predictability (as to layout, form of paragraphs and phraseology)
- complexity (no. of items linked, nominalisations, embedded constructions)
- use of explicit headings and subheadings, summaries, etc.
- use of graphics, illustrations, maps, diagrams, etc.

These inventories lend themselves as a basis for decision-making about the discourse types suitable for science education in school and as a checklist for evaluating the traditional materials and discourse types used so far in different parts of Europe. The inventories are helpful and appropriate to guide choices in planning curricula and compiling teaching programmes which may differ, yet which are based on similar categorisations of discursive forms.

5.3 Formal competence

Lexical/terminological competence has already been dealt with as part of scientific knowledge in section 3.1. The attention paid to proficiency in spelling, morphology and syntax, although it may take up a lot of time in the teaching activities, should not mean that the activities relating to discursive competence can be neglected. They are of equal importance. In addition to both, a more formal competence of handling the macro and micro structures of the discourse types involved plays a decisive role: this involves the capability of linguistic expression of cognitive processes underlying the analysis (comprehension) and the construction (production) of concrete discursive forms (or texts). .

4.1.5 Pragmatic and cognitive categories

The conventions of form recurring in types of discourse (i.e. the linguistic and structural deliveries of the texts) may thus be described by means of categories unconnected with the syntax of the sentence.

These may be categories like speech acts/language functions or, on a higher, more abstract level, *discourse functions*. These analytical categories applied to texts (and also or alternatively to the *cognitive processes*) are to be understood as the discursive representation of both the cognitive processes and their linguistic realisation (in the sense of enactment) brought into play for the development/exposition of knowledge.

These discourse functions mark cognitive operations *and* their verbal performance at the same time; they are at the interface between cognition and verbalisation, they include operators (or terms) such as:

Analyse	*illustrate/exemplify*
argue	*infer*
assess	*interpret*
calculate	*judge/evaluate/assess*
classify	*correlate/contrast/match*
compare	*name*
describe/represent	*outline/sketch*
deduce	*prove*
define	*recount*
distinguish	*report (on) a discourse*
enumerate	*summarise*
explain	*specify* [...][10]

[10] See the extended list in Vollmer et al. 2008 which was arrived from the analysis of modern science curricula (and other subjects) for grade level 9/10 in Germany.

Among these many discourse functions, there are some which are more basic or comprehensive and relatively distinct from one another in terms of cognitive operations and discursive forms involved (they might be called *macro functions*), while others may appear under several macro functions and serve a number of them, not just one (these might be called meso and micro functions – for our purposes we just refer to them as *micro functions*).

Among the macro functions, there are at least the following ones:

1. SEARCHING (explorative function)
2. NAMING/POINTING (indexical function)
3. DESCRIBING (referential function)
4. NARRATING (narrative function)
5. EXPLAINING (relating function)
6. ARGUING (argumentative function)
7. EVALUATING (evaluative function)
8. NEGOTIATING (interactive function)
9. CREATING (creative function)

Among the many micro functions, we could list the following ones:

Asking questions
Questioning
Guessing…
Identifying
Classifying
Labelling
Collecting
Selecting
Reporting
Summarizing
Presenting
Sequencing
Relating
Structuring
Contrasting
Hypothesizing
Predicting

These micro functions operate on a lower level than the macro discourse functions, but they also describe and specify both cognitive *and* verbal activities at the same time.

4.1.6 Discourse functions in science education

In science education, all of the macro functions mentioned above would play an important role in characterising academic discourse in this subject area, whereas a specific subgroup of cognitive/discursive operations/processes on the micro level would be prominent only in specific contexts such as:

- *reporting /recounting* (on an experiment)
- *classifying* (objects, phenomena, processes)
- *defining* (an element, an interaction between substance, a concept like energy)
- *representing* (textual or factual data)
- *interpreting* (generated or given data)
- *matching* and/or *contrasting* (data and interpretations)
- *deducting* (interpretations/conclusions from data)
- *justifying* (chosen procedures, deductions, ethic decisions)
- *embedding* (an observation/a finding into a larger structure)
- *reflecting or weighing* (arguments for and against …)
- [...]

For each of these operations it is possible to identify the linguistic resources needed for their enactment, with likely variation between discourse types. It may be assumed that the above “words” (verbs, verbal operators) referring to cognitive operations have equivalents in all languages and that an attempt could be made to compile transposable inventories (for different languages and different subjects).

To compile such inventories of forms required to express the cognitive-discursive operations occurring in given types of discourse, one ought to use again the *Descriptions of language-specific reference levels in the CEFR*[11] *as much as it seems feasible.*

4.1.7 Examples with possible descriptions/descriptors

In the following two examples will be given, involving descriptions or descriptors and the identification of the linguistics forms and resources associated with them.

[11] Available, or being produced, for English, German, Spanish, French, Italian, Greek, Portuguese... (see www.coe.int/lang → Reference Level Descriptions)

Example 1: ***Summarizing***

In one or more specified types, the learner is capable of:

- reproducing (W or O) some of the ideas/points in the text (minimum level)
- reconstructing the major ideas of a text, close to the source itself (intermediate level)
- producing (W or O) in an autonomous way a concise representation of the major ideas of a text (advanced level)

A summary appropriate to the types in question would make use of some of the following linguistic resources:

- close analysis/comprehension of the original text
- identifying the key words or expressions
- finding synonyms and/or hyponyms/
- using etymology and/or lexical inferencing (for difficult words)
- formulating the main idea per paragraph and/or section
- paraphrasing (while leaving out less relevant information)
- creating super-ordinate terms as a means of densifying the content
- using subject-specific conventions/appropriate terminology
- naming the overall topic (e.g. by way of title or in the introduction: *the text is about…*
- linking and sequencing ideas in verbalised form
- constructing semantically dense sentences (without necessarily being complex in syntactical terms)
- choosing appropriate cohesive devices
- use of descriptive and reporting verbs
- editing the summarising text as to correctness, coherence, audience, message etc.
- [...]

Example 2: ***Defining***[12]

In one or more specified types, the learner is capable of:

- recognising (W or O) (minimum level)
- and/or producing (W or O) (intermediate level)
- improvising/creating/proposing (OI/WI) (advanced level)

A definition appropriate to the types in question would be realised by making use of some of the following linguistic resources:

- through a series of examples
- through one or more comparisons
- through contrast
- by paraphrasing
- through hypernyms/hyponyms

[12] This example, translated from French, has been offered for history, but could easily apply also to the sciences and to mathematics12.

- by giving a translation
- through etymology
- through internal characteristics
- by relating the term to concepts or a theory…
- [...]

Such inventories make it possible to move from the specifications of strategic/discursive competence to the definition of the required linguistic forms.

4.1.8 Linguistic categories for the description of discourse types

Discourse types can be described by using speech acts and/or cognitive operations or, as suggested here, by using *discourse functions* which link cognition and verbalisation, since a specific discursive form is a verbal object, yet governed by cognition underlying it. Discourse functions (on the macro as well as on the micro level) are distinct from utterance, text, speech act, type of text, etc.; their verbal conventions may be apprehended

- as relatively stable types of utterances, in the case of highly restrictive types, set phrases, etc..
- as the relatively stable or predictable general scheme or elements of their structure, which may be broken down into stabilised successions of speech acts or cognitive operations (for example, the series: represent, interpret, match...)
- as the preferential forms, in a given type, with which to deliver them. This conformity determines the appropriateness of the utterances (and not their accuracy or grammatical correctness), that is their compliance with common “rules” on the acceptable makeup of discourse types.

These conventions may be described on the basis of various general linguistic categories (= independent of individual languages), such as:

- forms of actualisation of the speaker (for example, in English: *I/me, we, one,* impersonal, passive, reflexive, etc.);
- forms of actualisation of the person addressed;
- presence/distribution and expected forms (in a given type) of assertive, appreciative, ethical and other formulations;
- presence/absence/distribution and forms of meta-discursive indications (statement of text plan, etc.);
- standard form of certain paragraphs;
- discursive tone (serious, humorous, personal touches, etc.).
- […]

All descriptive categories used when analysing a discourse may serve as a starting-point for descriptors of formal mastery, especially with respect to reception or production. Nonetheless it has to be taken into account that:

- texts of the same discourse type comply to varying degrees with the (often unstated) model underlying it;
- discourse types themselves may be conventional to varying degrees either as a whole or in some of their constituent parts (for example, the beginnings of scientific articles may be quite conventional/predictable while those of newspaper articles are fairly unpredictable).

This specification of forms should be underpinned by the expected language skills in other subjects taught and in language as a subject. This requires cross-curricular cooperation and planning.

5.3.4.1

For example, to state a plan (in OP) there would be descriptors such as:

In one or more given types, the learner is able to

- recognise (W or O) (minimum level)
- produce (W or O) (intermediate level)
- improvise/create/propose (OI/WI) (advanced level)

a statement of plan appropriate to the types under consideration (here, presentation to the class), by activating some of the following linguistic resources:

[Highlight the structure of the forthcoming discourse]

[statement of the general schema]

- I am about to speak of/examine/deal with the question/the issue of...
- I shall talk about...
- My topic is…

[each point introduced by means of cohesive devices, but without using a predictable sequence (such as *firstly, secondly, thirdly*)... which is readily considered "clumsy" in English]

- first of all, first, to begin with, etc.
- next, then, as the second point
- the following point
- ...
- a final aspect is…, etc.
-

[announcement of the end]

- lastly, to conclude, to finish, in conclusion

5.3.4.2

Another example would be "Writing a report about a scientific experiment in the classroom" – with descriptors such as:

The function of "Reporting" (W) requires

- the description of goals/purpose, actions and processes in a sequential form and in a mode as objective as possible (minimum level of all reports)
- the identification and description of (different) results (intermediate level)
- perceived implications and possible consequences (advanced levels of a scientific report).

Language-wise "reporting" requires the use of a rich repertoire of qualitative and quantifying vocabulary, especially adjectives, noun phrases and verb forms, in addition to knowledge of the right terms for the equipment and the procedures undertaken. A report is basically written in present tense, the sentence type and mode are indicative. In contrast to other types of reports there is no link to the statements or positions of others and thus no use of indirect speech necessary.

Given the type of discourse under consideration (here, written scientific reporting), some of the following linguistic resources will have to be activated:

[Highlight the structure of the forthcoming discourse: Introduction]

- In the following, I will write/report about…
- The report is about…
- My topic is about…

[statement of the general goal of the experiment]

- The purpose of the experiment was… to find out whether/in how far/…how much…
- The experiment was to examine/to deal with the question/the issues) of...
- In the experiment I looked at...
- We were asked to observe… /find out…

[name necessary subtopics like: setting up of the experiment, carrying out/performing the experiment, observing and documenting the results; each point introduced by means of paragraphs with cohesive devices: contrary to oral presentations (see 5.3.4.1 above) the use of a predictable sequence (such as *firstly, secondly, thirdly*)... is also acceptable]

- first of all, first, to begin with, etc. was set up…
- next, then… sth. was started/initiated…
- the next step was ….

- ...An observation sheet had been prepared for…
- It could be seen/observed that…
- As a result (we can say/we have…)/ It showed that…
- Finally,…, etc.

[announcement of the success/failure of the experiment and/or of the end (of the report)]

- So, the experiment was…
- As to the goal of the experiment,…
- The experiment showed that…
- To conclude, to finish, in conclusion…

Inventories of this type may be common to different languages and to different disciplines in some respects, but they necessarily comprise language-specific realisations owing to their morphological and syntactic structures and the diversity of discursive forms in the classrooms, in a country, in a discipline.

6. Summary and Perspectives: Thresholds and stages of development

So far we have looked at language competences involved in science teaching and learning in general and made suggestions how to identify and describe them for use in the classroom and for curriculum planning. We did not deal with issues of how these language competences can be taught in a systematic way, integrated into the teaching of subject-based knowledge. Nor did we deal with issues of quality in mastering these competences (levels of performance, levels of expectation, defining standards or thresholds) nor with different stages of development in working towards and reaching the set goals (in view of age and/or school grade). This would require some developmental model in relation to an unfolding set of linguistic competences over time. In the past, we have rather concentrated on describing two particular levels of achievement or points in this process, that of the end of primary education and that of the end of compulsory education, also called ISCED 1 and 2 (= International Standard Classification of Education, developed by UNESCO).

From the categories set out above it will have to be decided by the users and member states which thresholds of knowledge and language skills (concerning science-related discourse types) the learners should possess, according to:

- expected levels of proficiency (OI, OP...)
- types of discourse to be mastered (for reception or production)
- cognitive operations or discourse functions which they must be able to recognise or deliver
- forms for delivering the above, which they must know how to handle correctly and appropriately.

In the long run, only empirical studies of the applications of these forms in real classrooms and under real production conditions (e.g. formal tests or examinations by learners who have taken courses of this kind) will show whether the results hoped for are actually achieved and whether the expectations and demands laid down in curricula were met and justified. But these and other issues will have to be dealt with in a separate paper.

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