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Language and Communication in the Sciences at the end of Secondary (Compulsory) Education: Summary and Conclusions

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1. Introduction

The following summary on language and communication in science education on the secondary level of schooling (grade 9/10) is based on four case studies which have been commissioned by the Council of Europe, namely the one on England (by Jenny Lewis, 2007a), Norway (by Stein Dankert Kolstø, 2007a), Germany (by Helmut Vollmer, 2007a) and the Czech Republic (by Tatiana Holasova, 2007).

These case studies are available in English and French. They are accompanied by two further expert studies resulting from the discussions of the *ad-hoc group on LAC in the sciences*, one on “Language for Learning Science: A Social Constructivist Perspective” (Lewis 2007b), the other on “Science Education for Citizenship - Through Language Competence” (Kolstø 2007b). Both documents are attached to the four case studies (see below).

One of the striking results of the four case studies is that there is *indeed a growing awareness about the importance of language learning and language use within subject-specific education* (here: the sciences). Communication in verbal and non-verbal forms is acknowledged in the educational frameworks and the new curricula of the four countries under scrutiny as a *key competence* to which the science-related subject areas clearly have to contribute. On the other hand, subject-specific language use and communication do not form a goal in themselves, rather they are closely linked to *what* is being communicated (the content or subject-matter) and *how* a specific concept or insight has been *processed* and *obtained* (the cognitive activities involved). The understanding of this language dimension (the close relationship between “Fachlichkeit” and “Sprachlichkeit”, Vollmer 2006b) in science education as in all non-linguistic subjects is only beginning to develop; it is not yet very far advanced. Even when subject-specific communication is identified explicitly and defined as a competence area of its own (as in Germany) it is not yet clearly structured or broken down into its respective components. Ongoing research is attempting to overcome some of these deficiencies, however.

In the documents analysed there is a clear tension between the role and use of *language* (especially relating to subject-specific terminology, the labelling of concepts etc.) and of communication (as the ability to exchange and learn in interaction with others). There is hardly any open or radical acknowledgement of the constructivity and the context-dependency of all science learning and use. Sometimes the term “language” is reduced to natural language (without explicit mention of visual or other semiotic forms of representation); sometimes the term “communication” is reduced to the *interactional dimension only* including subject-related argumentation (without explicitly including the use of language as a mediating factor in the construction of subject knowledge, the “language of the subject”, “language for (individual) learning”). The latter is often seen as merely language-based, not as truly “communicative”. Generally speaking, the relationship of linguistic and communicative requirements in science education to elements and

dimensions of communicative competence already existing as a result of learning and teaching the language of schooling as a subject (LS) is not at all a topic of discussion.

2. Language and Content, Language and Cognition, Language and Communication

It is remarkable, first of all, that in each of the four countries studied communicative competences are considered important in relation to subject-specific knowledge construction and learning, in some cases even as *part of* scientific literacy (e.g. Norway, Germany). The degree of explicitness, however, and the nature of this relationship between content (disciplinary) learning and language (discourse) learning is defined differently from country to country: whereas in England it is somehow self-evident that the linguistic skills in acquiring and using scientific concepts are to be learned alongside the subject-based notions and issues themselves, in Norway “*communication*” (the term is not used as such) is stated as an overriding key concept for the whole curriculum, including science education. It is subdivided into five “basic skills” (*Being able to express oneself orally and in writing, being able to read, to do mathematics and to use digital tools*), which are guiding the curricula for all subjects in the Norwegian compulsory schooling. These five “skills” (better rephrased as “competences”) are stated separately at the beginning of each curriculum, somewhat disconnected from the formulations of concrete competences to be achieved at the end of certain grades (in our case: grade 10). But it is understood that these skills are anchored and are to be developed in subject-specific terms. Thus it is implied that a citizen is not *scientifically literate* unless he or she is able to “talk, write and read science”, including the ability to deal with numbers and with mathematical approaches in that context (“do” mathematics) and to use digital tools where appropriate. The Norwegian science curriculum makes use of a range of different “verbs” which can be seen as cognitive operators implying or leading to communicative activities at the same time; they are closely linked to subject-matter knowledge and its acquisition.

In the Czech Republic, the structure of the new curriculum from 2007 is similar: “Communication” is explicitly defined as a key competence for all subject areas, but it is very little operationalised within the specific module(s) which relate(s) to the sciences. On the contrary, the module “Man and Nature”, comprising the basic notions and elements of physics, chemistry, biology and geography, *focuses strongly on the knowledge aspects* of each area and *less so on how* knowledge is constructed, communicated and used. The overall framework is such that most of the concrete decisions are left to the schools implementing this curriculum. It remains to be seen what will become of subject-specific communication in terms of required and measured outcomes.

In Germany, by contrast, communicative competence is stated as part of the science curriculum itself, based on a four-dimensional model of scientific literacy: it is *one dimension* of overall subject-specific competence in biology, chemistry and physics (the other ones being Subject-Specific Knowledge (*Fachwissen*), Procedural competence (*Erkenntnisgewinnung*) and Evaluation (*Bewertung*). The implementation of this binding national framework into so-called *core curricula* of the different provinces (*Länder*) is well under way. The communicative approach is reflected in the description of mental and linguistic-semiotic activities constituting the processes of acquiring subject knowledge, the mastery of which have to be demonstrated at the end of grade 9 or 10 (end of compulsory schooling for different groups of learners). Meanwhile, school-based research is trying to identify relevant sub-dimensions of subject-specific communication on a more empirical level: in biology, for example, the language-mediated construction of biological knowledge (*Wissensaufbau*) and the interactive exchange about this knowledge (*Wissenskommunikation*) are seen as two relevant components by now (see below).

Generally speaking, the relationship between cognition and language requirements in the context of science education becomes obvious in all four case studies: language is (at least in tendency) understood as a tool for developing and construction of conceptual knowledge (1); it is also seen as a tool for carrying out cognitive operations as learning activities and as

a means of expressing the results by interacting about them with others (2). Additionally, it is emphasised in all four countries - sometimes more, sometimes less - that science education has to be adequately *contextualised* so that it can be related to the experience and life of the students, thus helping them also to apply their new knowledge (personally, socially and professionally) and preparing them as future citizens, for participation in handling socio-scientific issues (3). This goal already requires an enormous extension in the definition of specific communicative competences (e.g. relating facts and assumptions, questioning degrees of certainty, positioning oneself based on underlying values, making reasonable suggestions for certain solutions etc.). It would have required just one step further to anticipate the need for *communicating and acting with others trans-nationally and globally* and not just nationally - *clearly requiring intercultural communicative competences in subject-specific contexts* (4). But this dimension is not yet present in the curricula studied, they more or less limit themselves to national boundaries in their goal-setting.

Based on these analytical insights, it is proposed to distinguish four different uses of language and communication, at least in the sciences, namely:

1. Language of the subject
2. Language for learning and exchange
3. Language for participation
4. Language for intercultural communication.

Although these distinctions are the results of observations from science education, they may also apply to the other subject areas under investigation (e.g. history and mathematics) or to non-linguistic, subject-specific curricula as a whole. They are therefore described in more detail in my overall comparative paper on LAC, entitled "Features of subject-specific language use and communication: A cross-curricular perspective" (Vollmer 2007b).

In looking at language/communication requirements in science education in England, Norway, Germany and the Czech Republic, we are dealing with quite different institutional settings and social structures. Also, the overall educational goals and dominant principles at work are not (fully) compatible, especially when it comes to defining the *relative importance of disciplinary versus communicative aspects and their relationship to one another*. Therefore, it is not easy to compare the findings so far, also for lack of an adequate theoretical framework in conceptualising and describing LAC. Nevertheless, we can summarise the results by country and see how far this will lead us to the formulation of a provisional framework for science education in Europe.

3. England

As Jenny Lewis describes in her case study, the National Curriculum for England specifies what must be taught from ages 5 – 16. It is arranged into 4 Key Stages (KS); in our context the Key Stage 4 (ages 14–16) is most relevant. At the end of Key Stages 1–3 all students are expected to sit identical, nationally set tests in English, Maths and Science (traditionally known as *Standard Assessment Tests* or SATS). At the end of KS4 (the final year of compulsory education) students sit a range of externally set, subject specific, exams.

"The first National Curriculum for England, introduced in 1989, was highly prescriptive and bureaucratic with a strong emphasis on competency and testing. Through a succession of revisions this curriculum has become more manageable, with less emphasis on competence and a greater emphasis on learning and the development of 'key skills' and 'thinking skills' such as literacy, numeracy, ICT and problem solving. Teachers are expected to integrate the development of these skills into their subject specific teaching. There is also an expectation that they will integrate the curriculum for Citizenship within their specialist teaching. Within the science curriculum a consideration of the social context of science -

including the social, ethical and moral implications of science - is also included" (Lewis 2007a).

Contrary to the primary level, at *secondary* level all science is taught by specialist science teachers who have a degree in science and some science specific teacher training. Lewis (2007a) informs us that initially there was an assumption that defining the content would be sufficient to bring about changes and improvements in the classroom. But it slowly became apparent that this was not the case and that secondary science teachers also needed guidance and support. "There is now an extensive range of support materials for secondary science teachers, much of it influenced by social constructivist and socio-cultural perspectives on science education, which gives explicit guidance on how to teach the science content. Originally developed and promoted as part of the government's Key Stage 3 National Science Strategy these materials are now being revised and extended to cover KS4 and science teachers are expected to be aware of and make use of them". These materials include an emphasis on 'Multiple intelligences' (meeting individual needs through a range of teaching strategies), on 'Diversity' (requiring differentiation) and on 'Assessment for learning' (integrating *formative* assessment of learning into all lessons, allowing teachers to monitor learning outcomes and adjust subsequent teaching accordingly).

In general, we can say that the focus in England is as much on *learning* as it is on *teaching*! The materials mentioned (as part of the *National Strategy* in-service support system) provide guidance on a range of teaching approaches designed to support the above and to encourage students to become more actively engaged in their own learning, including exemplar tasks and activities for students (examples are presented in the case study).

As of 2006, the science content relating to biology, chemistry and physics has been reduced to *one page of key concepts*, combined under the heading 'Breadth of Content'. The expectation is that these key ideas will be used to address the first part of the KS4 science curriculum – the 'How science works' strand. This strand replaces and extends 'Scientific enquiry' and includes *Data, evidence, theories and explanations, Practical and enquiry skills, Communication skills and Applications and implications of science*.

The *communication skills* are spelled out just in three bullet points, namely:

- recall, analyse, interpret, apply and question scientific information or ideas;
- use both qualitative and quantitative approaches;
- present information, develop an argument and draw conclusions, using scientific, technical and mathematical language, conventions and symbols and ICT tools.

Interestingly enough, as in all the other national curricula studied by the ad-hoc group on science education, there are also many linguistic and communicative requirements involved in the other areas or strands, but they are less explicit and more hidden (see, for example, the strand *Applications and implications of science*; Lewis 2007a). The activities listed there imply high degrees of critical thinking and of communicative exchange about these sensitive issues and evaluations/judgements; they are instances *par excellence* of the *third use of language in subject-specific contexts* defined above (3. *language for citizenship and participation*) (cf. also Kolstø 2007b).

As to the *Use of language across the curriculum* as one of the more *general teaching requirements* (which is not science-specific), it is merely stated that pupils should be taught to *recognise and use standard English correctly* – in writing, speaking, listening and reading. They should also be taught technical and specialist language and the *patterns* of language required for understanding and expression within a particular subject. A similar orientation is given for the *Use of information and communication technology across the curriculum* which includes 'opportunities to find things out from a variety of sources, selecting and synthesising information' and to develop 'an ability to question its accuracy, bias and plausibility'.

In her additional study on “Language for learning science – a social constructivist perspective” Jenny Lewis (2007b) demonstrates promising ways of helping students from all backgrounds and with different experiences to construct their own understandings and ideas, before they are led to more scientific views and explanations afterwards. In particular, she describes teaching approaches and strategies to bridge the gap between the scientific idea and a student’s existing ideas (in conceptual as well as in linguistic terms) and develop a better understanding of the science explanation - a process which can be described as ‘talking the science into existence’ (Ogdon 1996, see Lewis 2007b). This is especially relevant for students with little “academic” experience, e.g. for students with a migrant background or for native children from a low socio-economic background.

In sum, we have to acknowledge that next to the National Curriculum and its concise *Key Stages* there is a large volume of information available for science teachers in England. On the other hand, this country has increasingly moved away from a competence-based approach and narrow definitions of 'performance' - particularly in relation to skills. “This is based on earlier experiences and a recognition of the limitations and difficulties of such an approach. In the 1990's there was a strong emphasis on competencies and teachers were beset by tick boxes but eventually it was recognised that defining a competence, and recognising it when we saw it, was problematic” (Lewis 2007a). Nevertheless, there seems to be a rich resource base for describing what science-related communication means, how it could be integrated into subject teaching and how the materials available could be used in reaching this goal.

4. Norway

In Norway, five “basic skills” (which are communicative in nature, but are not labelled as such) are identified in the curricula for all subjects in Norwegian compulsory schooling. These are *Being able to express oneself orally*, *Being able to express oneself in writing*, *Being able to read*, *Being able to do mathematics* and *Being able to use digital tools*.

It is understood that these “skills” should be developed and attained in subject specific terms. Thus it is stated that a citizen is not e.g. scientifically literate unless s/he is able to talk, write and read science, including the competence to deal with numbers and mathematical approaches (“do” mathematics) and to use digital tools where appropriate.

On the level the science curriculum, these “key competences” or “communicative goals” (again not labelled as such) are broken down into a number of types of language use (including semiotic uses) which are to be developed and demonstrated in connection with subject knowledge by each and every student. Here are some examples from different topics in the integrated natural science subject curriculum for lower secondary school, grade 10 (cf. Kolstø 2007a, *italics added by him*):

- “*describe* the structure of animal plant cells and *explain* the main characteristics of photo synthesis and cell breathing
- *discuss* and *elaborate* on problems and issues in connection with sexuality, different sexual orientation, contraception, abortion and sexually transmitted diseases
- *carry out* experiments to classify acidic and alkaline substances
- *keep records* during experiments and field work and *present* reports using digital aids
- *demonstrate* protective and safety equipment and *comply* with fundamental safety procedures in natural science classes”.

The verbs used in the formulations of competences are of special importance and interest here as they signal *how* the basic skills are to be understood in the different subjects (namely as fundamental communicative abilities across the curriculum) and *how* the learners shall demonstrate these competences in concrete operational terms, in classroom

performance. As Kolstø (2007a) points out, these “verbs” (or operators) orient the classroom activities in content, procedural and communicative terms, but they also put constraints on what type of tasks and test procedures are conceived of as valid and appropriate in situations where the learners have to demonstrate their acquired competences for reasons of assessment.

According to Kolstø, the aims are formulated as descriptions of what learners should be able to do, nevertheless, the educational purpose of focusing on *competences* stays somewhat ambiguous. “One purpose is obvious: in this way, it shall be easier to make reliable and valid assessments of the learning outcomes (defined as performances along the lines of actions stated in the verbs, positively applying and communicating the acquired knowledge and skills). However, the general aim of the science curriculum is still scientific literacy (“allmenndannelse” in Norwegian, “Bildung” in German). Thus, it is also possible to interpret the focus on competences as “dispositions” or pre-requisites enabling different ways of participating in diverse contexts as future citizens. Based on this interpretation, it is possible to analyse the science curriculum as a list of generalised or potential situations the learners are supposed to be able to participate in and communicate in as scientifically literate citizens” (Kolstø 2007a).

As to the role of language, there is recognition that it is an inseparable part of competence in science. The new Norwegian curriculum is based on the assumption (as shared by most educators today) that understanding and the language used to express understanding are developed simultaneously and that the processes of knowledge acquisition and of language acquisition are inseparable. As a result (so Kolstø 2007a), “it is necessary for learners to ‘talk their way into a new topic’: teachers therefore need to engage learners in tasks where they can develop their understanding through talking and writing. Through expressing their everyday ideas or their rudimentary and provisional understanding, the learners can receive feedback and move forward in their construction of more scientific meaning and understanding. One general consequence of such a social-constructivist view is that a focus on the learners’ use of language is absolutely necessary for effective learning in science”.

But even more than that: As Kolstø rightly argues in his second paper, the expertise on “Science education for citizenship – through language competence”, the purpose of schooling, and learning in general, is to increase the learners’ knowledge and understanding, and thus their capacity for participation in different aspects of life. Participation always includes communication through different types of discourse and texts. Thus, the concept of scientific literacy needs to include the ability, as democratic citizens and as employees, to participate in situations which “somehow” include science issues. This linguistic or rather communicative competence in science focuses on the “ability to interpret discourse and texts through interacting with the uttered or written ideas. This presupposes knowledge about scientific concepts used, but is not limited to an understanding of words used or each single sentence. Interpretation presupposes the ability to interpret meaning based on recognition of e.g. tentative claims as tentative claims, of facts as facts, of evidence as evidence and conclusions as conclusions. In particular, it includes the ability to recognise how different kinds of discourse and texts are used for different purposes, and thus constitute different genres. Awareness of such differences in e.g. purpose, structure and kinds of reasoning is important for adequate interpretation and criticism. Consequently, if scientific literacy is taken to include the ability to participate in democratic processes as citizens, it should not only incorporate the linguistic competence needed to interpret scientific discourse and texts, but focus on this dimension explicitly since it does not develop automatically, merely by itself” (Kolstø 2007b).

From this participatory perspective and from a scientific literacy point of view, it is therefore interesting to see how language/communication and science are related in the Norwegian science curriculum of 2006. As indicated above, this relationship is not spelled out explicitly, rather it is assumed implicitly.

5. Germany

For the first time in the history of Germany with its 16 provinces (*Länder*), standards of education have been developed *on a national level* within the last years which would be binding for the federal states and all the schools in the whole country. For the sciences including Biology, Chemistry and Physics, the definition of standards to be reached by the end of compulsory education (grade 10) are based on an overall model of subject-specific competence, sub-divided into four competence areas or components, namely Subject-Specific Knowledge (*Fachwissen*), Epistemological/Procedural competence (*Erkenntnisgewinnung*), Communication (*Kommunikation*) and Evaluation (*Bewertung*).

These educational standards for the three science subjects at the end of compulsory schooling are far-reaching in that they explicitly acknowledge and identify “Communication” as one out of four equally important indispensable competence areas. Based on this official acknowledgement, communicative aspects of subject-specific learning are beginning to gain more attention in curriculum planning, in teaching and also in assessment (at least in the long run). Yet the process of acceptance by largely discipline-minded teachers is rather slow. Given the new framework of nationally defined competences in this area, the subjects are now responsible to support language learning as part of subject learning and thus to contribute their share in the development of an overall language/communication education across the curriculum for each and every learner.

On an abstract level subject-specific “communication” is defined identically in all three subjects of the natural sciences, but on a more concrete level this *competence area of communication* is spelled out in somewhat different ways (see the case study by Vollmer 2007a). Also, the formulation of the actual communicative standards to be reached within subject learning, varies in number and quality. Finally, the tasks developed for illustrating the competences in question indicate slightly different understandings of what is actually meant by subject-specific communication.

Nevertheless, all the communicative competences identified so far and the specific sub-components developed in subject-specific contexts are expected to be present and accessible for assessment at the end of grade 10. However, the issues related to the actual level of performance for a particular component (reference level) which should be reached by that time, are not explicitly addressed as yet. These considerations would imply some kind of developmental thinking and scaling along the lines of transparent criteria – a perspective which only unfolds slowly, but steadily (thanks to the founding of a national research institute for quality assurance in education, the so-called IQB in Berlin, agreed upon and financed by all the 16 *Länder*). The expectation that these reference levels can be described empirically as “standards” one day, is only partly satisfactory, however – it neglects the need to lay open the already pre-existing theoretical assumptions or underlying, largely implicit criteria by which we (as teachers, researchers, administrators or as representatives from other strands of society) assess the acceptability level of a specific communicative performance.

The introduction of subject-specific communication as an important competence area in science education has already led to a number of new follow-up activities and decisions. On the one hand, each of the 16 *Länder* is now active in implementing the expected outcomes set through the national standards on the provincial level, within so-called *core curricula* for secondary schooling. These include more concrete formulations of performance expectations, based on (intuitive, experience-driven, non-empirical) assumptions of competence development (see the example of Lower Saxony in Vollmer 2007a). On the other hand, didactic research has embarked on the transformation of the structural competence models and the specific standards to be reached by grade 10 into more developmental forms of thinking and modelling progress with the different competence areas. To that effect, many tasks are being developed and tested with the expectation that they represent certain levels of communicative demand which can only be met if certain

levels of competence have been reached and thus exist in a more or less stable way. In close co-operation with groups of teachers it is hoped to be able to define levels of reference and development (stages) on an empirical basis. At the same time large groups of teachers are in the process of becoming qualified in the area of task development and assessment.

In the German case study of one province (Lower Saxony) and one subject (physics, grade 5-10) we could show that the use of appropriate language was explicitly addressed under the heading of "Communicate and Document". But subject-specific language requirements were by no means limited to this area: they are also implicitly demanded in many other instances (without having been labelled as such). In the examples presented most of the *can do-statements* (verbs/operators) used to describe the competences in question (if not almost all of them) have a clear linguistic dimension to them; these competences can only be acquired and developed by using language and communication adequately and efficiently. This was even true for the competence area called "mathematise" and certainly for the competence area of "evaluation", which relies heavily on (verbalised) comparisons and the (verbal) support/justification of an opinion or a decision, as demonstrated.

The focus of the analysed core curriculum analysed in Lower Saxony is clearly on the *language of the subject* (type 1, the linguistic labelling and semiotic representation of subject-specific knowledge, see above) and to some extent on the *language of learning and exchange/interaction* (type 2, necessary for the (inter-)active acquisition of knowledge within school and the classroom context). The core curriculum is certainly less (if at all) dealing with what we have called the *language of participation* (type 3, the communicative competence required to critically reflect and question the use or usefulness of scientific results, their relevance and their limits, and for tackling or solving social issues in which they play a central role).

In sum, we can say that subject-specific language competences are spelled out in part as communicative competences (with the help of linguistic indicators), always in close connection with subject-matter content or controversial scientific issues. We could observe that communication in a wider sense (including the management of visual/non-verbal forms and representations) is seen as a necessary constituent or tool pervading most or all of the conceptual competencies in a subject like physics, their learning and their interactive teaching as well as their assessment.

6. The Czech Republic

In the Czech Republic a new curriculum has been developed on the national level, the results of which are laid down in a number of recent documents (partly translated into English, see Holasova 2007). These state the basic goals and principles for the future of school education in the country (from primary to the end of the secondary schooling). For the time being only the *Framework Education Programme for "Primary" Schools* (age 6 – 15) is available in English - the Framework for Secondary Schools (from age 16 onwards) is in its last phase before being approved by the Czech Ministry of Education; it will be built on parallel principles as the one documented by Holasová in her contribution (see below).

There are two most important features in the current Czech education reform: 1. The development of *key competencies* (especially *communication competencies*) and 2. the setting of the *educational strategies*. As Tatiana Holasova says in one of her e-mail commentary "The literacy and oral skills in all science subjects are provided on the basis of these strategies". The content of this "basic" education within the education framework is crudely divided into nine *educational areas*. For each educational area one or more subjects are responsible. In our case the focus is on a module entitled "Man and Nature" in which *Physics, Chemistry, Natural History (General Biology and Genetics) and Geography* are interlinked and for which they are jointly responsible. The teaching goals (expected outcomes) for this educational area are grossly stated on the national level, but mainly in

disciplinary terms; all the other relevant decisions are left to the local agents of education, to schools and teachers.

Whereas “communication” is clearly identified as a “key competence” next to five others (to the development of which all of the educational areas have to contribute), it remains unclear how this dimension will be implemented within the educational areas or followed through on the content level and how it will be assessed as an outcome, on the level of performance in concrete terms, in connection with subject-matter knowledge in science. Basically, all of these issues seem to be left to the autonomy of individual schools or groups of schools and their didactic creativity. So the good intentions of the new curriculum might not fully materialise as anticipated. But at least a general framework for a basic new education is set and educational goals (expectations) formulated, even if they are strongly anchored in disciplinary concepts of knowledge and skills. It can only be hoped that more room will be given in the future to specifications for securing communicative activities and competence development in science as much as in all educational areas, across the whole curriculum, as intended.

7. Subject-specific academic language use in the sciences

Language is the basis for developing subject-matter knowledge, at least in a social constructivist manner: This has two meanings - *one* relating to the social origin of scientific knowledge, the *second* relating to the social context of the learning. Language is necessary for identifying and naming concepts, for linking these concepts with one and another and for building up a whole new domain in cognitive and communicative terms. All of these processes are *not an addition to subject-matter learning*, they are *at the heart of it*; their success is highly dependent on the “appropriate” uses of language as defined by different (subject-specific) discourse communities on the one hand and by the school and the educational “games” on the other hand. Both operate on different conditions and conventions, both are mediated through a subject area and a subject teacher. It is the teacher who is responsible for the initiation of the learners into subject-specific ways of thinking and communicating, into forms of academic language use, for the transition from everyday notions and language use towards (pre-)scientific concepts and verbalisations. But the teacher is also responsible as a pedagogue for supporting the students in their own ways of comprehending, articulating and exchanging – however remote that may be from established forms of scientific discourse.

Certainly, the language competences needed and to be built up in non-linguistic subject areas like the sciences as well as across the curriculum are related to those already acquired in the teaching of the (school) language as a subject (mother tongue or second language education). But how far transfer of these available competences is possible or takes place in reality, remains to be seen. This would be a crucial area of empirical investigation since we know so little about these transfer potentials and processes. What it requires is a clearer definition and labelling of what the teaching of Language as Subject (LS) offers as outcomes at different grades or learning stages and what it is that can be used, expanded and further developed within subject-related contexts. Only then can future curriculum planning across subjects come in so as to support the networking of communicative skills and competences already available.

The basis of another type of transfer possibility, that between different science subjects themselves, lies in the fact that we are dealing here with specific ways of organising talk and structuring writing that can be generalised, namely through the use of *discourse functions* such as describing, naming, comparing, analysing, narrating – not to speak of more complex mental activities and their linguistic expression like experimenting, hypothesising, inferring/concluding, explaining or evaluating or any other specific communicative action like writing a report, presenting ideas/results to different audiences or arguing in a dialogue. These linguistic macro-functions have to be performed more or less in each of the science subjects, so that there is a chance of transferring them from one subject to the

other – provided the school and the subject teachers allow for such a cross-curricular approach.

8. From language skills to subject-based discourse competence

We have qualified elsewhere (Vollmer 2006a) the shift from language skills to communication in science education and the one from communicative competence in LS to that in subject-specific contexts as the *acquisition of new discourse varieties within one and the same language*. The focus is now not any more on general communication, on understanding, interpreting and producing general utterances or texts about life, experiences or cultural insights, but on more scientific topics, categories, relationships, on systematic insights and their relevance and impact for the personal, social and political reality of one's own. What takes place is *nothing less than the initiation into subject-specific ways of thinking and communicating*. The specific language-based competences needed in the different subjects do not automatically transfer from the pool of already existing language competences (mainly from language as a subject acquisition), nor do these competences suffice, provided they exist and can be validly identified. Rather, they have to be specifically developed, trained and expanded through conscious teaching efforts in each and every subject (here: the sciences), through the formulation of explicit requirements in the respective curricula and through ways of checking their stage of development (in terms of different types of assessment). These urgent needs have been acknowledged in the science curricula of the four countries under study and by the authors of the educational documents analysed here - in quite differing degrees, however, and in more or (sometimes) less concrete terms.

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