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Contents

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

Helmut J. Vollmer

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*), Epistomological/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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The National Science Curriculum for England, age 14-16

Jenny Lewis

Background on the National Curriculum

The National Curriculum for England specifies what must be taught from ages 5 – 16. It is arranged into 4 Key Stages (KS): KS1 = ages 5 – 7; KS2 = ages 7 – 11; KS3 = ages 11 – 14; KS 4 = ages 14 – 16. 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.

Science in the National Curriculum

The National Curriculum for Science defines the science content to be taught at each key stage but for the most part says little about how it should be taught. Since few primary teachers are science specialists the need to provide additional support and training for them was always apparent. In contrast, all science at secondary level is taught by specialist science teachers who have a degree in science and some science specific teacher training. Initially there was an assumption that defining the content would be sufficient to bring about changes and improvements in the classroom. 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' – individuals learn in different ways and teachers need to use a range of teaching strategies which offer all students some learning experiences that meet their individual needs e.g. visual, kinaesthetic, auditory.
- Diversity - within any classroom individual students have a diverse range of needs and teachers need to differentiate their teaching in ways which address these needs.
- Assessment for learning – *formative* assessment of learning should be integrated into all lessons, allowing teachers to monitor learning outcomes and adjust subsequent teaching accordingly.

The materials also 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. For example:

- Explanations: there is clear guidance on how teachers can structure their explanations of the science in ways which will help students to understand; there is also guidance on how teachers can support students in developing their own explanations.

- Models and modelling: this includes all aspects of modelling but focuses on talk and language; it suggests – identifying and making explicit the subject specific language or types of text; modelling the use of language e.g. in constructing an argument; modelling the features of different text genres.
- Questioning: this makes explicit the different uses of questioning; identifies ways of making questioning more effective; suggests how to use questioning to promote thinking; considers how to help students to raise their own questions.
- Reading and writing: development of subject specific vocabulary; reading for information; text restructuring.

Science at KS 4 (14 – 16)

Until this academic year (2006/7) the KS4 science curriculum was split into four sections – biology, chemistry, physics and scientific enquiry. Scientific enquiry comprised 'investigative skills' (planning an investigation, collecting and presenting and *interpreting* data – including graphs, *evaluating* evidence) and 'ideas and evidence in science'. The 'ideas and evidence' strand explicitly focused on science in relation to its social context and included:

- how scientific ideas are agreed and disseminated [for example, by publication, by review];
- how scientific controversies can arise from different ways of interpreting evidence [for example, Darwin's theory of evolution];
- ways in which scientific work may be affected by the contexts in which it takes place [for example, social, historical, moral and spiritual] and how these contexts may affect whether or not ideas are accepted.
- To consider the power and limitations of science in addressing industrial, social and environmental questions, including the kinds of questions science can and cannot answer, uncertainties in scientific knowledge, and the ethical issues involved.

Teachers were not expected to teach 'ideas and evidence' as a discrete unit but to integrate it into their teaching of the science content – for example, when considering Darwin and the theory of evolution, Galileo and the planets or applications of gene technology.

This year 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:

- how scientific data can be collection and analysis;
- 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;
- that there are some questions that science cannot currently answer, and some that science cannot address

Practical and enquiry skills:

- plan to test a scientific idea, 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;

Communication skills:

- 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;

Applications and implications of science:

- about the use of contemporary scientific and technological developments and their benefits, drawbacks and risks;
- to consider 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;
- how uncertainties in scientific knowledge and ideas change over time, and about the role of the scientific community in validating these changes.

There are, in addition, some *general teaching requirements* which should inform the science teacher's approach:

Inclusion: providing effective learning opportunities for all pupils

- Setting suitable learning challenges (this supports the governments 'every child matters' agenda by encouraging personalised learning which meets the needs of the individual student)
- Responding to pupil's diverse learning needs (this particularly refers to differences in social, ethnic or linguistic background, including travellers and refugees); in particular, create effective learning environments which ensure motivation, provide equality of opportunity through diversity of teaching approaches, use appropriate assessment approaches and set personalised targets for future learning
- Overcoming potential barriers to learning and assessment for individuals and groups of pupils - this particularly applies to pupils with English as Another Language (EAL) and with Special Educational Needs (SEN).

Addressing the above requires science teachers to provide differentiated tasks which allow students to work at their own level/pace/preferred learning style (see Sears *et al*, 2001). It should also challenge the most able while supporting the less able. Implicit within this is the expectation that the teaching approach will be more student centred, actively engaging students in the development (construction) of their knowledge.

Use of language across the curriculum

In all subject areas 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. For example, a student might be asked to draw on formal science texts to produce a newspaper article or a leaflet for a doctor's surgery or to present the arguments for and against a particular application of science.

Use of information and communication technology across the curriculum

This includes 'opportunities to find things out from a variety of sources, selecting and synthesising information to meet their [the student's] needs and an ability to question its accuracy, bias and plausibility'.

Critical commentary by the author

Part of the problem in trying to produce this report was the volume of information available in England. I was finding it difficult to select!

There is also, perhaps, a difference in expectation. While our teachers and students are perhaps the most tested in the world and there sometimes seems to be no end to the demands placed upon them in terms of what they must teach/learn, we have increasingly moved away from a competency 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. Questions included: is it a formative or a summative assessment? If formative, how is relative development defined? What level of confidence is required - how often does it need to be demonstrated before it can be claimed? For example: does competence in word processing mean that you can open and use a Word document; that you know how to use all the facilities within 'Word'; that you regularly and successfully use all the facilities within Word? The more we tried to define the competence the longer our tick lists grew! I think that perhaps it is important, in the context of language across the curriculum, for the Council of Europe to be aware of, and learn from, past experiences in the UK in relation to competency based learning/assessment.

In relation to communication skills, there is no set list of competences which define performance - as far as I am aware. The expectation is that opportunities for the development of communication skills should be included within all subject areas including science. This is encouraged through National Strategy training, Ofsted inspections [by the Office of Standards in Education] and the assessment regime (questions may expect students to use their communication skills). Activities designed to develop students' communication skills would include:

- present work in their own words in a range of formats (poster, PowerPoint, presentation, discussion): for example - being asked to take a particular role in a discussion (e.g. the role of a local farmer in a debate about GM crops), to research this role and to present the farmer's case during discussion;
- share or question ideas: for example - being asked to work in small groups to agree an explanation of a phenomena or the correct science explanation for an open question
- to restructure 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 for use in a doctor's surgery

In all cases the emphasis is on communication for a particular purpose and teachers would be expected to make that purpose clear within their learning objectives for the lesson and to set a task which could achieve that purpose. A common strategy to support students in such tasks is the use of DARTs (Directed Activities Related to Texts, cf. Wellington & Osborne 2001 or DfES 2004b). The DfES document identifies the following DARTs: *reconstruction activities* (text completion, diagram completion, table completion, sequencing of disorganised text, prediction) and *analysis activities* (underlining or highlighting, labelling, segmenting, diagrammatic representation, tabular representation). Wellington and Osborne, under their heading 'recording and construction' (2001, 46) include: construct diagrams to show content and flow of text e.g. flow diagram or branching tree diagram; construct tables from information given in a text, choosing their own headings; using text to answer teacher set questions; use text to prepare questions for peers or teacher; identify key points within text and summarise.[1]

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[1] The author is currently working on a teaching sequence for *Genetics* at Key Stage 4 which she is producing for the *National Strategy*. It contains some examples of how such DARTs might be embedded into a science lesson. It is not ready to be published or quoted yet, but it provides some useful examples set within a science context.

The role of language and citizenship in the Norwegian science curriculum

Stein Dankert Kolstø

1. Introduction

In Norway a new curriculum reform is being implemented from autumn 2006 onwards. The reform is coined *Knowledge Promotion*, and all learning objectives are formulated as competences that the pupils shall be able to demonstrate in test situations at the end of certain stages in formal compulsory education (after year 2, 4, 7 and 10). From the discussions in the committee reports on which the reform is based (Dep. 2003 & 2004), it is clear that the notion of competences in the reform is inspired by the *concept of functional literacy* and the definition of competence in the OECD and the PISA project.

Another important feature of the reform is the identification of five "basic skills" across all subject specific curricula which are actually aspects or components of communicative competence and to which *all* subjects contribute. These five "basic skills" (see box 1) are to be understood, developed and achieved 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.

Box 1

Basic skills as identified in curricula for all subjects in Norwegian compulsory schooling

- *Being able to express oneself orally*
- *Being able to express oneself in writing*
- *Being able to read*
- *Being able to do mathematics*
- *Being able to use digital tools*

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 competencies in concrete operational terms, in performance. In box 2 a few examples of formulations from different topics in integrated natural science subject curriculum for lower secondary school are presented (Dep. 2006 & 2007, *italics* added).

Box 2

The aims for the education is that the pupil shall be able to

- *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

One can see that the curriculum makes use of a range of different verbs which can be seen as cognitive demands, as mental or physical activities or as communicative requirements/expressions at the same time. Obviously, there is a difference between *describing* and *discussing*, and between *explaining* and *demonstrating*. These verbs (also called "operators") orient the classroom activities in procedural and communicative terms, but they also put constraints on what type of tasks and of test items/procedures are valid in situations where the learners' competences shall be assessed.

Interestingly enough for our LAC context, many of the verbs explicitly state or imply that the competencies shall be demonstrated through the learners' use of language. Moreover, the variation in the verbs used implies that the learners shall be able to use their language, i.e. their academic language, for different scientific purposes.

2. Language and school science

Although the aims are formulated as descriptions of what learners should be able to do, the educational purpose of focusing on *competences* remains somewhat ambiguous. One purpose is obvious: in this way, it is 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 leading to/enabling/explaining 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 scientific literate citizens.

In our context, it is also relevant to ask what role is given to language competence in science specifically in the new Norwegian science curriculum. Language is used by the teacher or in textbooks in their explanations of scientific knowledge, and the learners obviously have to understand the language used to explain and contextualise new ideas. However, does/might language also constitute an integrated part of learning on a deeper level?

In the tradition of Piaget, language is seen as secondary to understanding; first comes understanding, before this understanding is expressed in linguistic terms/using language. Today most educators hold that understanding and the language used to express understanding are developed simultaneously and that the processes of knowledge acquisition and language acquisition are inseparable. As a result (of this view), 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/pre-concepts 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.

However, in the last decades there has been an increased recognition of language as an inseparable part of competence in science. According to the social-cultural perspective on education, 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 competence, in science, focuses on 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 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.

From a linguistic perspective and from a scientific literacy perspective, it is therefore interesting to see how language and science are related in the new Norwegian science curriculum. What are the foreseen situations where students are supposed to apply their acquired competencies as future citizens? What are the views inherent in the science curriculum on the possible role of language for effective learning, and for social participation?

3. The role of language in the new Norwegian science curriculum

Interestingly, the *Knowledge Promotion* reform includes the idea that teachers will have full freedom to choose the teaching and learning strategies and activities they judge to be useful and efficient in order for their pupils to attain the competences formulated in the different curricula. Nevertheless, in the science curriculum it is stated that "*Basic skills are integrated into the competence aims where they contribute to the development of the competence in the subject*" (Dep. 2006) and that "*Arguing for one's own assessments and giving constructive feedback is an important element in the natural science subject*" (Dep. 2006). Thus, the curriculum *does* include a few explicit hints for the science teacher about efficient learning and the importance of learners' talking and writing in science. Obviously, it is not taken for granted that all science teachers are yet aware of the importance of learners' talking and writing for effective learning in the science classroom.

The introductory section of the curriculum (*The objectives of the subject*) focuses on preparing the learner for participating in contexts which include science and scientific expertise. Accordingly, students' *readiness and* will to engage in science-related issues and develop/form a *considered view* on them, is emphasised as an important outcome of *knowledge on, understanding of and experiences in nature*. Moreover, the subject *shall provide/give (oneself) the basis for participation in democratic processes* and other situations where science and scientific expertise is involved. In addition, the possibility of understanding *various types of scientific texts, methods and technological solutions* is stated as an important basis for further learning, both in future educational activities and in the workplace as much as in one's recreation time. Thus, the relevance of the subject is justified by indicating two areas of future possible application for the students: further studies and participation in debates on science-related issues. In our context, it is interesting to observe that the *competence in understanding different types of natural science texts* is mentioned specifically.

When the main subject areas in the curriculum are presented, knowing the names of different scientific phenomena and measures/quantities are mentioned as important. Critical assessment of science-related information in the media is also pointed to as a possible/potential focus. Referring to the nature of science and practical aspects of science, communicative processes in science (i.e. *discussions* and *argumentation*) are explicitly included. However, the curriculum does not go into detail as to what kinds of sub-competencies are needed for reading different types of scientific texts or participate in different types of science-related discourses. This will have to be spelled out in the future, however, either by teachers and/or teacher educators.

The new curricula have a specific section where the five "basic skills"/fundamental competences (see above, Box 1) are explained for each specific subject. In the science curriculum the general focus is on what is denoted as *"important skills in the natural* *science subject*". The text states that these basic competences include the ability to "*present and describe one's own experiences and observations from nature*" and "*ability to formulate questions and hypotheses*". Moreover, it is stated that "*written reports from experiments, fieldwork [and] excursions […] are an important part of the work*". These descriptions imply that the learner is supposed to learn and do what a scientist does as a scientist – at least to some extent. Whether this purpose is to be understood as important for democratic citizenship or further studies or both, is open for discussion and for the teachers to interpret/decide.

When focusing on *reading* as a basic competence, the curriculum states that reading in science means the ability of "*collecting information, interpreting and reflecting on the content of natural science texts, brochures, newspapers, books and information on the internet*" and also "*reading manuals, recipes, tables, various graphs and symbols*". Here we see that the anticipated/foreseen contexts of application and participation, are situations/texts encountered in everyday life as citizens and at the workplace.

The explanations of basic skills in *mathematics* and in the *use of digital tools* include the ability not only to read, understand and exploit such sources of non-verbal information, but also to actively "*prepare tables and graphs*", use "*models from the real world*" and "*critically assess internet-based information*". These competences again support the focus on preparing learners for participating in situations involving science and written scientific representations.

Following the presentation of "basic skills"/fundamental competences, there is a long section presenting *learning objectives*. As already mentioned, these are formulated as competences, more specifically as mental and physical actions or as linguistic performances that the learners shall be able to demonstrate. Looking at the verbal operators used in the formulations of these objectives, one can conclude that most objectives involve communication. This focus on communication is consistent with the emphasis put on the five "basic skills" (students' ability to participate in oral and written communication in each subject).

In the science curriculum for the lower secondary school (until grade 10), the most frequently occurring verbs (in the English translation, Dep. 2007) are *explain, describe* and *elaborate on* (30 out of 62 verbs altogether). These verbs, and several others used (*provide examples, provide an overview, discuss* and *present reports*), do not state specifically whether the competency is to be demonstrated orally or in writing/in a written manner. In fact, only two competencies are specified in this regard (i.e. *keep records* and *talk about)*. In addition, several competencies are not directly related to linguistic actions. These competencies concern practical or procedural competencies in the subject (14 instances, including *plan, carry out experiments, demonstrate, observe, measure and comply with safety measures*) and what might be denoted as purely/largely cognitive competencies (six instances, including *choose* (publication method*), identify views, assess, examine, evaluate process*). But again, all of these have linguistic/communicative correlates because they would not be observable/identifiable and assessable otherwise. Surprisingly, no learning objectives address reading competency explicitly: it seems to be taken for granted as a prerequisite for more productive ways of demonstrating subject-specific knowledge and understanding.

The implicit contexts of participation in the long section on learning objectives are situations where the students, as future learners or citizens, are to explain scientific notions, concepts and theory or demonstrate experiments. Only a few learning objective include competencies on a higher taxonomic level, like *discuss*, *assess, examine, evaluate process.* Compared with the section on the "basic skills", we see that the focus on text comprehension and production has weakened, and the anticipated/foreseen contexts of participation are less specific, less obvious.

4. Conclusions: Citizenship, language and learning

The analysis presented above reveals that the new Norwegian science curriculum does *not* give the teacher descriptions/or orientations on new methodologies, on how the *teaching ought to be done*. The document focuses on the competences to be achieved by the (average) students at certain points in time, at certain stages of development (defined as the end of school years 2, 4, 7, and 10). It is nevertheless indicated that social interaction in the classroom where students engage in scientific discourse and communication is important for effective learning in science.

The strong focus on the students' abilities to *describe, explain* and *elaborate on* scientific topics signals that students need to be able to communicate their scientific understanding. The *Knowledge Promotion* reform focuses on these competences, on functional literacy and on lifelong learning. We may therefore conclude/anticipate that the students should be able to communicate their scientific understanding not only at school examinations, but also in different situations throughout life. Surprisingly, competences in *reading scientific texts or media texts with a science dimension*, are only mentioned when the "basic skills" are explained – they are not spelled out as specific competences which the students are to acquire and demonstrate in concrete terms. Such competences could easily be tested within the format of the oral exam prescribed. This exam even includes specific tasks to be worked on during a certain preparation time and then presented to the examiners: comprehension tasks could easily have been included so to demonstrate subject-specific reading comprehension explicitly.

A reasonable interpretation of the *more implicit view of language competence* in the curriculum is the following: It is probably assumed that when the student has acquired the five basic skills, and is able to *describe, explain* and *elaborate on* scientific topics in particular, s/he has acquired the necessary basis for interpreting different types of scientific texts and examine science-related information critically, both at school and in different situations throughout life. In fact, knowledge about different types of scientific texts and reading and writing such texts are not explicitly included in the curriculum. Neither is the analysis and training in different types of scientific discourse. For a curriculum using students' future democratic participation as a justification for the subject, this creates a big problem/tension. This deficiency/tension is all the more important as the science teachers' competence in linguistic aspects of science is probably weak; as a consequence, linguistic aspects of science will not be emphasised enough if not explicitly spelled out in the curriculum.

In the traditional view, from a cognitive perspective on learning, the *students' understanding* is in focus. Linguistic formulations of insights and new knowledge are thought to be unproblematic, following automatically, once comprehension has been reached. This false idea is still present between the lines in the new Norwegian science curriculum. Thus the implicit view of language and learning is that linguistic competence in science is not identified as a competence per se, it does not need to be taught like scientific concepts need to be taught, and therefore does not need to be made an object for learning nor for assessment. At the same time, however, the curriculum signals that the students' scientific comprehension becomes valuable only when it can be communicated. The science teachers' interpretation might be that it is sufficient that the teacher prepares for ways of working that help the students understand the science well, and that this automatically will enable them to communicate their understanding among one another and with the outside world.

One possible exception to this are the learning objectives explicitly stating that the students shall be able to *keep records*, *present reports* and *choose the publication method* when doing practical work. However, here it is neither signalled that the students shall learn to read or write reports or understand their typical structure in order to increase their competence in comprehending or producing such text types. In the curriculum, the justification for writing reports is simply that reports are important in science. The specific conventions and expectations of different genres are not made transparent, they are not topicalised.

Probably the uses of new verbs (operators) in formulations of competences will lead many teachers to include ways of working where the students have to participate more actively with descriptions, explanations, demonstrations etc. This will be done mainly as the teachers want to prepare their students for examinations and tests where the new competencies will be in focus. Reading, although clearly/definitely an integral part of scientific literacy and a highly relevant base for future participation, will probably not be emphasised, because it is not demanded by the curriculum explicitly.

In sum, the new Norwegian curriculum for general science is interesting in the context of Language Across the Curriculum (LAC) due to its focus on basic communicative skills and science for citizenship. The curriculum puts emphasis on reading, writing and talking, together with mathematical thinking and the use of digital tools, as basic competences in science. This emphasis on competences and citizenship also implies some specification as to what the anticipated/foreseen situations are in which students should to be able to participate as future citizens. Thus, the different part of the curriculum include a focus on communication and participation in different contexts like further studies, the workplace and democratic decision-making processes involving socio-scientific issues (see Kolstø, 2007). Although the curriculum explicitly talks about different types of scientific texts and the importance of language for learning science, linguistic competences in the narrow sense of the term are not explicitly spelled out beyond the descriptors already mentioned: they seem to be highly underdeveloped in light of the ambitious goal of preparing all students for future democratic participation.

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Language and Communication in Subject-Specific Contexts: A Case Study on Germany

Helmut Johannes Vollmer

Examples from the National Education Standards (NES) for Science Education (grade 10, end of compulsory education with a qualifying certificate) ed. by the Conference of the Education Ministers (*Kultusministerkonferenz, KMK*)

After the PISA shock of 2001, the Education authorities of the 16 German provinces (*Länder*) started to develop National Standards of Education for a number of subjects including Biology, Chemistry and Physics, which would be binding for all schools throughout the country. The definition of standards to be reached by the end of compulsory education (grade 10) is based on an overall model of subject-specific competence, sub-divided into four competence areas or components, namely:

Subject-Specific Knowledge (*Fachwissen*)	The basic facts, concepts and principles vary according to the subject: they include notions such as system, structure, function, dynamics/development
Procedural competence (*Erkenntnisgewinnung*)	The formulations vary per subject, e.g. for Biology: to observe, compare, experiment, use models and apply other working techniques
Communication (*Kommunikation*)	To obtain/infer information in relevant subject-specific ways and discuss it
Evaluation (*Bewertung*)	To identify/recognise biological/chemical/physical facts/issues in different contexts and evaluate them

As we can see, *Communication* is considered to be one of four basic competence areas in science education. It is defined identically on an abstract level (see above) in all three subjects of the natural sciences; each document also includes a passage which points to an integrated concept of *scientific literacy* (*Naturwissenschaftliche Grundbildung*, cf. KMK 2005a, b, c). On a more concrete level, however, the *competence area of communication* is spelled out somewhat differently; also, the formulation of the actual communication standards varies in number and quality. Finally, the tasks added to each of the curricular documents, illustrating the competence area(s) in question, indicate different understandings of what is actually meant by subject-specific communication.

1. Chemistry (translated from KMK 2005b)

"In the area of communication, descriptions are given of the competences which are necessary for a subject-related information exchange based on an appropriate linking of everyday language and subject-specific language/terminology.

In their environment, pupils meet phenomena which they can explain to themselves and to others with the help of chemical knowledge, using subject-specific language. In the attempt to analyse and come to terms with these, they discover relationships, search for pieces of information and evaluate them. In order to do this, it is necessary to understand the subject-specific language of chemistry on a basic level and apply it correctly. Results or partial solutions found by the pupils will be shared with others. This exchange of information with different partners requires pupils to constantly translate from everyday into subject-specific language and vice versa. In so doing, the pupils check how far the statements made are valid and chemically correct. They can present their positions in subject-specific terms and reflect on them, find arguments or revise their interpretations/views/opinions if necessary because of counter-arguments/objections presented.

Communication is a necessary tool for the learners in order to develop explanations for observed phenomena, to present these in appropriate forms (verbal, symbolic, mathematical) and share them with others. Thus communication is an instrument for as much as an object of learning.

In addition, it is an essential condition/prerequisite for successful work in a team. Criteria for team competence include a structured, coordinated planning of work, reflection of the work processes as well as evaluation and presentation of the findings/results obtained". (KMK 2005b, 9-10).

Based on this description the following national standards were defined (*italics* added by HJV):

"Pupils can

K1 *search/make searches* on a chemical issue in diverse sources

K2 *choose* topic-related and relevant/convincing pieces of information

K3 *examine* presentations in the media in terms of their subject-specific correctness

K4 *describe*, *illustrate* and *explain* chemical facts using subject-specific language and/or models or other non-verbal forms of representation

K5 *relate* chemical facts to everyday phenomena and *translate consciously* between subject-specific and everyday language and vice versa

K6 *record* the process and the results of experiments and of discussions in appropriate forms

K7 *document* and *present* the process and the results of their own work according to situation and addressees

K8 *argue* correctly and logically in subject-specific terms

K9 *support/defend* their positions/viewpoints relating to chemical issues/facts and *reflect objections* self-critically

K10 *plan, structure, reflect on* and *present* their work as a team" (KMK 2005b, 12-13)"

In first attempts to study empirically which types of text (or genres) are to be mastered productively by students of chemistry (end of grade 10), the following list came up:

Descriptions, Explanations, Protocols, Reports, Presentations, and Argumentations.

All of these include subject-specific language use, the transformation of everyday concepts/language into scientific notions/language, the mastery of graphs, numbers and other symbolic means of representing meaning, working individually and in groups (cf. Ralle 2006).

2. Biology (translated from KMK 2005a)

"Communication means to construct information in a focused, subject-related way and to exchange about it with others".

Communicative competence is seen as the basis for human interaction and togetherness, in the private sphere as much as in work life: "Communication enables us to interact with the reality of life and thus to understand and mediate biological facts and conditions. Forms of communication are a direct learning object on the one hand, and a tool in the learning process on the other hand. Gaining knowledge and acquiring language both influence and constitute one another" (KMK 2005a, 11). This explicit positioning is expanded further in the following passages:

"The basis for understanding this world is verbal language. The subject of biology also contributes to the development and extension of the language and reading competence of the learners. The learners translate subject-specific language into everyday language and vice versa. Through this, the students reach a discourse competence about biology topics, including those which are of specific relevance (and importance) for society and for everyday life.

Communicating in biology involves the use of different texts and "images/non-verbal signs" as informational sources (codes): diagrams, tables, subject-based symbols, formulas, equations and graphs. Learners understand and interpret these codes, relate them to one another and process them. These abilities are a basic, fundamental part of reading comprehension. The ability to present something linguistically in a concise and structured way is of particular importance in this context.

The processing of biological information supposes prior knowledge on the part of the learners. In many cases, the learners bring along everyday conceptions, ideas and perceptions which are meaningful for the development of an adequate subject-specific understanding, but which need to be modified at times. The students reflect on their stored knowledge as much as on their acquired levels of knowledge and competence and their learning processes. In addition, the learners use the practical methods and procedures of epistemology (*Erkenntnisgewinnung*) as sources of information, plus media such as books, journals, film, the Internet and data-processing programmes, animation, simulation and games, as well as questionnaires for experts. If students use these sources of information in a goal-oriented way, they acquire a structured and distinct competence in communication.

Communicative ability is developed in a number of social forms/formats and is supported through critical reflection on the processes involved. Therefore, the communicative competence acquired in school is also a basis for communication outside school" (KMK 2005a, 11-12).

Communication Standards for Biology

Based on the above description of communication in subject-specific terms, 10 different communication standards were developed for biology in a consensus-building procedure (with representatives from all the 16 Länder involved and with the consent of the relevant lobby groups as well as the wider public (italics added by HJV).

"Pupils can

C1 *communicate* and *argue* in different social forms

C2 *describe* and *explain* originals or authentic representations with the help of drawings and idealised diagrams/pictures

C3 *illustrate data* of measurable units (related to systems, structure and function as well as to developments) with linguistic, mathematical or visual means of representation in appropriate ways

C4 *analyse and evaluate* deliberately pieces of information related to biological issues from different sources and *process these* also with the help of diverse techniques and methods in ways adequate for specific audiences and situations

C5 *present (demonstrate)* biological systems (e.g. organisms) appropriate to conceptual/subject base, situation and audience

C6 *present the results and procedures* of biological investigation and experimentation and *build their arguments* on that

C7 *relate* to socially relevant biological themes/topics and those important in everyday life

C8 *explain* biological phenomena and *relate* everyday ideas to them

C9 *describe* and *explain* the meaning of subject-specific as well as everyday texts and pictures *in a structured linguistic presentation*

C10 *apply* idealised representations, schemata, diagrams and symbolic language to complex biological issues" (KMK 2005a, 14-15)."

The selection of these particular aspects of subject-specific communication (and *not* of others) and their definition as standards is arbitrary, of course, as are the choices made in chemistry or physics. They indicate some insecurity as to the exact nature of communication in terms of theoretical structure and subject relevance. On the other hand, we encounter a relatively wide understanding of what communication in biology (or chemistry or physics) means with a clear orientation of relating it to the discourse and to decision-making processes outside school. It seems as if the perspectives for structuring this competence area are handed over to research on a larger scale. Accordingly, comprehensive research projects which focus on spelling out the four different competence areas in more detail, based on empirical data, are still continuing. One of the results (as in my own research; Vollmer 2006, 2007) is that communicative competence is closely linked to subject-specific knowledge and the processes of meaning construction themselves.

Therefore, it is not surprising that we also find formulations in other competence areas, especially in that of *procedural competence* and *evaluation competence* (see above), which clearly point to communicative activities and which either imply language comprehension or production directly as evidence for a certain (level of) competence. Here are some examples taken from other competence areas in biology:

"Learners can

E11 *Describe* storage and transmission of genetic information…

E10 *Analyse interactions* with the help of models

B5 *Describe and evaluate* the effects of human interference into an ecological system

B7 *Discuss options* of behaviour for participation in an environmental and nature-preserving way in terms of sustainability" (KMK 2005a, 14, 15)."

What these examples clearly show is that there are more language requirements involved in subject learning and assessment than is acknowledged for the time being.

3. Physics (translated from Lower Saxony, 2006)

For physics, let us look at the formulations *not* on the national level, *but* on one of the *provincial* levels (namely that of Lower Saxony). Here we can see how the NES are implemented through a so-called *core curriculum* (of the province) before the schools adopt the standards in their own way as part of their school-based curriculum.

3.1 Communication in Physics in Lower Saxony (grade 5-10)

The core curriculum in physics in Lower Saxony is organised in such a way that the basic competences are to be achieved by everyone by the end of grades 6, 8 and 10 (in three different columns): Competences for grade 8 and 10 are *additions* to the ones acquired before. In other words, the expectations for the end of compulsory education *include all the competences developed earlier, over the whole time span within lower secondary education*. By implication, it is understood that competences acquired earlier will then be developed on a higher level of performance when tested or assessed at the end of grade 10. It is remarkable that there is no mention whatsoever of any minimum level or reference point (definition of the actual "standard" to be reached) for any of the competence components. Although there is clearly a developmental thinking underlying this core curriculum, there is no reflexion on stages or levels of development within one and the same competence.[2]

[2] From the point of view of "measuring" or evaluating the competence profile of an individual student (e.g. for diagnostic purposes and the development of necessary steps to support the learning of that student or of a whole class), however, it is not enough to acknowledge the "existence" of a certain competency, but rather find out how

3.2 Competence Areas in Physics

A distinction is introduced between process-oriented and content-oriented competences. Whereas the *content-based competences* are subdivided into topic or knowledge areas (e.g. energy, thermodynamics, magnetism and electricity, mechanics, optics, atomic physics), the *process-based competences* comprise aspects from the procedural, the communicative and the evaluation competence areas, namely:

To argue physically

To solve problems

To plan, experiment and analyse

To mathematise

To work with models

To communicate and document

To evaluate.

In the following, I will present (in more or less free translation) some of the sub-components stated for the different "process competencies" starting with "*Communicate and Document*" (*italics* are added, HJV).

3.2.1 Communicate and Document

"The students have to understand/comprehend the utterances of others and texts with a physics content; they have to appropriate the meaning and examine it. In this context they pick up information, structure it and document their mental work, their learning paths and the results of it. In doing so, they use different forms of representation and media. The learners increasingly attend to addressee-specific presentations and the selection of appropriate elements of language. Of particular importance is the documentation of how a task was solved if electronic computational aids were used.

3.2.1.1 Communicating

End of year 6	*Additional* at the end of year 8	*Additional* at the end of the school year 10
The pupils *share/exchange* understandably about physical relations in their everyday language	The pupils *use* increasingly *subject-specific terms* for presenting physics issues, relationships etc.	The pupils *use learned elements of subject-specific terminology* and *chose the language levels* according to addressee
Paraphrase subject-specific texts and insights in their own words	Structure and interpret subject-specific accounts/constructions	
Take / extract date from age adequate representations		Choose information from a collection of formulas and other appropriate sources properly / *sachgerecht*
Write reports under guidance	Write reports autonomously	Present results in a written form through a longer autonomous piece of work in appropriate terms
Present work results in age-	Report about work results	

far and to which point or level it is (already) developed or not.

adequate forms, also with the help of given media Utter critical comments and accept them Work on tasks in groups	and use elementary media in doing so Take on roles in groups	Present self-made experi-ments in an appropriate and addressee-specific way choosing adequate media Continue to develop work in groups

3.2.1.2 Documenting

An essential criterion for acknowledging scientific results is their reproductivity. This requires an adequate form of documentation. In the classroom the learners develop forms of representation which are increasingly done autonomously and situation- and addressee-adequate, without falling back on ritualised form of writing reports or minutes. Part of this documentary competence lies in the increased use of precise measurement symbols, units and circuit symbols. The capacity to present results and knowledge in a transparent form is to be practised specifically in order to prepare the base for future learning."

At end of school year 6	*Additional* at end of school year 8	*Additional* at end of school year 10
The pupils	The pupils	The pupils
Document their results under guidance in forms offered in advance	Take their notes increasingly independently	Write their notes completely independently
Produce simple sketches/outline plan and circuit diagrams	Document experimental design, observations and procedures increasingly independently	Document their working steps also in self-planned experiments and analyses in appropriate written forms
	Use graphical representations agreed upon for visualisation	
	Produce measurement tables on their own and indicate symbols and units accordingly	
	Use diagrams for the presentation of linear relationships with saying / on their own	Use graphical representations for ad-hoc relationships including GTR/CAS
	Present their knowledge in a conceptual network	

A second area, in which communicative competences are explicitly stated and required, is identified as "argumentation in physics". But even in competence areas, where no language requirements are anticipated, communication comes in as a necessary component without which the competences in question could neither be acquired nor demonstrated. This will be shown through the example of "working with models" and "evaluating".

3.2.2 To argue in physics

"Argumentation in physics goes far beyond the exchange of mere opinions by developing and including subject-specific vocabulary. Questions posed and assumptions made are ventilated by the application of other means of representation, especially of graphs, of linguistic formulations for relationships and finally of equations as well as the planning and execution of hypothesis-based experiments leading to provisional, but rational answers. Special attention should be paid to the gradual transition from everyday language to subject-specific language use. In addition, the transition from non-verbal representations to linguistic forms of representation has to be developed. This development has to be relearned with each new topic or subject area; the reconstruction of steps and processes for reaching and defining new insights or outcomes is thus also necessary for advanced learners.

At end of school year 6	*Additional* at end of school year 8	*Additional* at end of school year 10
The pupils *Reproduce* their acquired knowledge and *use newly learned vocabulary*	The pupils	The pupils
Describe subject-specific relationships in everyday language	Use increasingly subject-specific elements in their communication	Use the acquired subject terminology with increasing certainty and choose the linguistic level consciously
Identify aspects which are possibly relevant for a certain context	Distinguish important from less important aspects	Distinguish physical aspects from extra physical ones on their own
Formulate problem-oriented questions	Formulate and support assumptions on the basis of experimental findings and theoretical considerations	Scrutinise assumptions by checking them critically
Argue in the form of the more the more	Argue with the help of diagrams, especially in view of proportional relationships	Argue with the help of diagrams of linear functions, of simple potencies and exponential functions
Apply simple circuit diagrams	Support their argumentation by self-made diagrams	Apply non-verbal forms of representation adequately.

3.2.3 *Working with models*

"Issues in physics are made accessible through modelling and idealising. Models can be concrete, iconic, graphic, mathematical or they can use analogies.

At end of school year 6	*Additional* at end of school year 8	*Additional* at end of school year 10
The pupils	The pupils	The pupils
Translate between simple *Schaltungen* and symbolic representations	Give reasons for relationships based on presented circuit diagrams	
	Present relationships in the form of graphical representations	
Utter assumptions about connections and causes	Formulate testable assumptions and develop approaches for testing them	Test hypotheses with selected examples by self-designed experiments
Use the model of elementary magnets for interpreting observations	Use model-based conceptualisations for solving problems under guidance	Use model-based conceptualisations as a tool for solving problems and formulating hypotheses. Distinguish between conceptualisations and models, through iconic representation and reality

3.2.4 *Evaluating*

According to the authors of the Lower Saxony core curriculum for physics, evaluation competence comprises the ability to position one's acquired knowledge critically and to be able to answer the question of where physics can contribute (substantially) in socio-scientific contexts and where not. Consequently, it is considered indispensable that the students learn to distinguish between scientific, social and political components of an evaluation. In connection with issues of sustainability, with the application and effects of technology and with issues of health, the learners are to develop approaches and criteria for assessment and evaluation. The opportunities to develop such evaluation competence within the physics classroom are seen as limited (because it is rarely possible within the school context to go through all the necessary steps for developing this competence fully), yet very complex at the same time requiring distinct communicative skills and competences (without being named as such).

At end of school year 6	*Additional* at end of school year 8	*Additional* at end of school year 10
The pupils	The pupils	The pupils
Check the validity of their results by *comparing* them with those of other groups	*Calculate* the influence/effects of sources of error on the validity of their results	*Calculate* the measurement errors based on the experimental design
	Decide with reason on the permission of lines of best fit (*Ausgleichsgeraden*)	*Choose* out of many possibilities those curves of best fit (*Ausgleichskurven*) which are adequate/fitting for a certain situation
	Evaluate the space/reach of validity of the phenomena under investigation	*Evaluate* the generalisation of empirical findings
Demonstrate the relevance of simple technical systems for everyday life	*Assess* the need of energy at home and its distribution in a realistic way	
Give reasons/justify security rules in connection with magnetism and electricity	*Use* their knowledge for the *assessment* of strategies for saving energy	*Use* their knowledge about circular processes for the *assessment* of economic and ecological aspects of energy provision
	Use their knowledge about electric units/plants/ for the *assessment* of everyday economic and ecological aspects/issues, particularly in relation to loss of warmth	*Name* the consequences of discovering nuclear fission (*Kernspaltung*) in social and political terms; *demonstrate* the limits of views/argumentation in physics
	Justify rules of traffic security	*Justify* security rules in dealing with ionising radiation

3.3 Summary

In the competence areas for physics (grade 5-10), as outlined in the core curriculum of Lower Saxony in Germany, *language use* is explicitly defined and particularly focused upon under the heading of "Communicate and Document". But subject-specific language *requirements* are by no means limited to this area: they are also implicitly demanded in many other instances (without having been identified as such). In the tables above, 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 it*; these competences can only be acquired and developed by using language adequately and efficiently. This is even true for the competence area called "*mathematisation*" 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.

Language competences are built up more or less systematically from grade 5 to grade 10. The (provincial) curriculum can only indicate certain stages in this developmental process by identifying and naming what should have been learned by the end of grade 6, 8 and 10. In sum, we can say that subject-specific language competence is spelled out in part as communicative competence (through *linguistic indicators*). But way beyond that we have observed that communication in a wider sense seems to be a necessary constituent or tool pervading most of the competencies in a subject like physics, their learning and their teaching as well as their necessary assessment.

4. Conclusion

The German Educational Standards in the three science subjects for the end of compulsory schooling are extremely progressive in that they explicitly acknowledge and identify "Communication" as one out of four indispensable competence areas, equally important as "Subject-Specific Knowledge" or "Epistemological/Procedural Competence". Based on this almost "revolutionary" perception, communicative aspects of subject-specific learning are beginning to gain more attention in teaching, assessment and also in teacher training – provided they are broadly accepted and implemented by the teachers themselves. In the long run, the individual subjects will feel responsible for supporting language learning as part of subject learning and thus for contributing their share in the development of an overall language/communication education across the curriculum for each and every learner. In Germany we speak of "*gesamtsprachliche Bildung*" as a goal, enabling all students to live and participate successfully in school, in the workplace, in society and thus in shaping our national and European future.

At the end of grade 10, all the communicative competencies mentioned and the specific sub-components developed in subject-specific contexts are expected to be present and accessible for assessment. However, issues of which level of performance (reference level) should be reached by that time for a particular component are not addressed. These considerations which would imply some kind of developmental thinking and scaling along the lines of transparent criteria are still missing, although they are indispensable for the operation and application of the whole approach. The expectations that these reference levels can be described empirically one day, is only partly satisfactory - it neglects the need to lay open our pre-existing theoretical assumptions or implicit criteria by which we (as teachers or researchers) assess the acceptability level of a specific communicative performance anyhow.

What we need in the future are clear descriptions of levels of competence (based on transparent criteria) for each single communicative competence and competence component. This is at the heart of the ongoing curriculum reform. Only then are new ways of competence-based teaching and of fair assessment (internal as well as external) possible. Only then are we in a position to define a particular level of performance as a *standard*, either as an ideal standard or as norm standard or, as it should be, as a minimum standard for all that can be reached by each and everyone, including migrant learners and those underprivileged native learners who are at risk because of their disadvantageous socio-economic background. For them especially, subject-specific language learning across the curriculum is a way of empowerment and participation in the important issues of the subject and their socio-cultural relevance outside school. To make these learners communicatively "safe" for participation is a huge responsibility and challenge for teachers and the educational system as a whole. *In terms of educational policy*, the identification of subject-specific communication as such as a competence area of its own is an important step in the acknowledgement of language across the curriculum. We will now have to go beyond this level and substantiate how exactly communication shapes efficient subject learning, what the communicative dimensions and elements to be learned are, how they can be taught in an integrative way within the subjects and how they can be assessed appropriately.

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The new Education Framework and the Science Module in the Czech Republic

Taťána Holasová

In the Czech Republic a new curriculum framework entitled *Framework Education Programme for Primary Schools* (age 6 – 15) has been developed. The corresponding Framework for Secondary Schools is in its final phase of development before being approved by the Czech Ministry of Education. This framework is built on parallel principles as the one partly documented here.

There are two extremely important features in the current Czech education reform:

1. The development of *key competences* (especially *communication competences*)

2. The setting out of *educational strategies*. The literacy and oral skills in (all) subjects, including science, are taught on the basis of these strategies.

You will find below extracts from the opening chapters of the new Czech curriculum framework for primary schools (for lack of availability of the one for secondary schools). Extracts from the module "Man and Nature", in which chemistry, physics, natural history and geography co-operate, are also included. The example is taken from the natural history (biology and geology) part. The focus remains strongly on disciplinary goals.

1. Extract from the Framework Education *Programme for Primary Schools*

"In line with the new curricular policy principles outlined in the National Education Development Programme for the Czech Republic ("White Book") and enshrined in the Education Act (on Pre-school, Primary, Secondary, Higher Vocational and Other Education), a new curricular documents system for pupils and students from 3 to 19 years age is being introduced into the Czech education system. Curricular documents are developed at two levels: the national level and the school level (see Diagram 1).

The national level in the curricular documents system comprises the National Education Programme and education frameworks. The National Education Programme defines initial education as a whole. The education frameworks define binding scopes of education for the various stages: pre-school education, primary education and secondary education. The school level consists of school education programmes, forming the basis of education at the individual schools[3].

Education frameworks:

- are based on a new education strategy, stressing the key competences, their interlinking with the educational contents and application of acquired knowledge and skills in practical life; this new strategy also encompasses the concept of life-long learning
- formulate the expected level of education that should have been attained by all students who have completed the educational stage in question
- promote educational autonomy of schools as well as teachers' professional responsibility for the outcome of the educational process".

"Principles of the Education Framework for Basic (Primary) Education

The Education Framework for Basic (Primary) Education:

- conceptually follows up the Education Framework for Pre-school Education and forms a basis for the concept of education frameworks for secondary education

[3] The School Education Programmes are developed by the school itself, based on principles set out in the applicable Education Framework. As a tool, the schools can use the *Manual for Developing School Education Programmes ("the Manual")*, which exists for each Education Framework. The Manual contains instructions for the preparation of the School Education Programmes as a whole, procedures for developing the various components of the School Education Programme, and examples.

- defines everything that is common to and necessary within the compulsory primary education system (including the lower grades of extended secondary schools)
- specifies the level of key competences that the pupils should have attained when finishing their primary education
- specifies the education content – expected outputs and subject matter[4]
- specifies cross-sectional subjects with pronounced formative functions that should be included as a mandatory component of basic education
- promotes a comprehensive approach to the implementation of the educational content, including the possibility of its interlinking as appropriate, and presumes the choice of a variety of teaching procedures, different methods and formats of teaching suiting the individual pupils' needs
- enables the educational content to be modified so as to suit the needs of pupils with special educational needs
- is binding for all secondary schools specifying their requirements for entrance procedures
- is an open document to be upgraded periodically taking into account the changing needs of the society as well as teachers' experiences and changing pupils' needs and interest.

"Key competences

Key competences consist of knowledge, skills, abilities, attitudes and values that are important to the individual's personal development and to the individual's role in society. The selection and concept of key competences are based on values that are generally accepted by society and on generally shared ideas as to which competences of the individual contribute to his or her education, welfare and success in life and to the strengthening of functions of a civil society.

The reason for and aim of education is to provide all pupils with a set of key competences at a level they are able to attain, and in this manner to prepare them for their further education and their role in society. Acquiring key competences is a long-lasting and complex process which starts during pre-school education, continues during primary and secondary education and takes its final shape during the individual's subsequent life. While the level of key competences that the pupils have attained when finishing their basic education should not be regarded as the final level, the key competences acquired form an important basis for the pupil's life-long learning, his or her start of practical life and the working process.

Key competences are not isolated phenomena, they are mutually linked and intertwined, multifunctional; they have a cross-subject nature and can only be acquired as a result of a comprehensive education process. Therefore, forming, shaping and developing them must be the ultimate aim of the complete educational content and of all of the activities taking place at school.

The content of the education framework for basic education understands the subject matter of teaching as a means to master activity-oriented expected outputs which are gradually combined and create preconditions for an efficient and comprehensive use of acquired knowledge and skills at the level of key competences.

The following competences are regarded as key competences at the basic education stage: learning competences; problem-solving competences; communication competences; social and personal competences; civic competences; working competences.

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[4] The education of mentally handicapped pupils is based on an adapted version of the Education Framework for Basic Education, which will be a separate annex to the Education Framework for Basic Education.

“Communication competences

At the time he or she is completing his or her basic education, the pupil:

- formulates and expresses his or her ideas and opinions in a logical sequence; his or her oral or written expression is apt, coherent and cultivated;
- listens to what other people are saying; understands and responds adequately; takes efficient part in debates; defends his or her opinion and uses appropriate arguments;
- comprehends various types of text, record, visual material, commonly used gestures, sounds and other information and communication means, considers them, responds to them and makes creative use of them for his or her own development and engagement in social contacts;
- uses information and communication means and technologies for high-quality efficient communication with the outer world;
- uses his or her acquired communication skills to create relations that are needed when living together with other people and for a high-level cooperation with other people”.

“Educational areas

The content of basic education within the education framework is crudely divided into nine educational areas. Each educational area comprises one or more interlinked *educational fields*:

Language and communication through language *(Czech language and literature, Foreign language)*

Mathematics and its applications *(Mathematics and its applications)*

Information and communication technologies *(Information and communication technologies)*

Man and his world *(Man and his world)*

Man and society *(History, Civic education)*

Man and Nature *(Physics, Chemistry, Natural History, Geography)see Extract 2*

Arts and culture *(Music, Fine art)*

Man and health *(Health education, Physical education)*

Man and his work *(Man and the world of labour)*

Each educational area is defined by the introductory Characterisation of the educational area, which describes the position and relevance of the educational area within the basic education system and describes the content of each of the educational subjects included in the educational area. Furthermore, the links between the educational contents of basic education at Stage 1 and Stage 2 are highlighted.

The Characterisation is followed by the Goal orientation of the educational area. This section describes what the pupils are guided to by the educational content so as to gradually acquire the key competences.

Practical interlinking between the educational content and the key competences is provided by the fact that on the basis of the goal orientation of the educational area, the school defines (within the school education programme) its educational strategy for the subjects taught, i.e. it identifies educational opportunities and activities resulting in the expected outputs (see Diagram 2).

The educational content of the educational fields (including the complementary educational subjects[5]) comprises the expected outputs and the subject matter[6]. Within

Stage 1, the educational content is additionally divided into Time Period 1 (grades 1 to 3) and Time Period 2 (grades 4 and 5). This division is meant to help schools distribute the educational content among the grades.

Expected outputs are activity-driven, practically aimed, usable in common life and verifiable. They define the expected competency in applying acquired knowledge in practical situations and in common life. The education framework of basic education identifies the expected outputs at the end of *grade 3* (Period 1) as tentative (i.e., not binding), and at the end of *grade 5* (Period 2) *and grade 9* as binding.

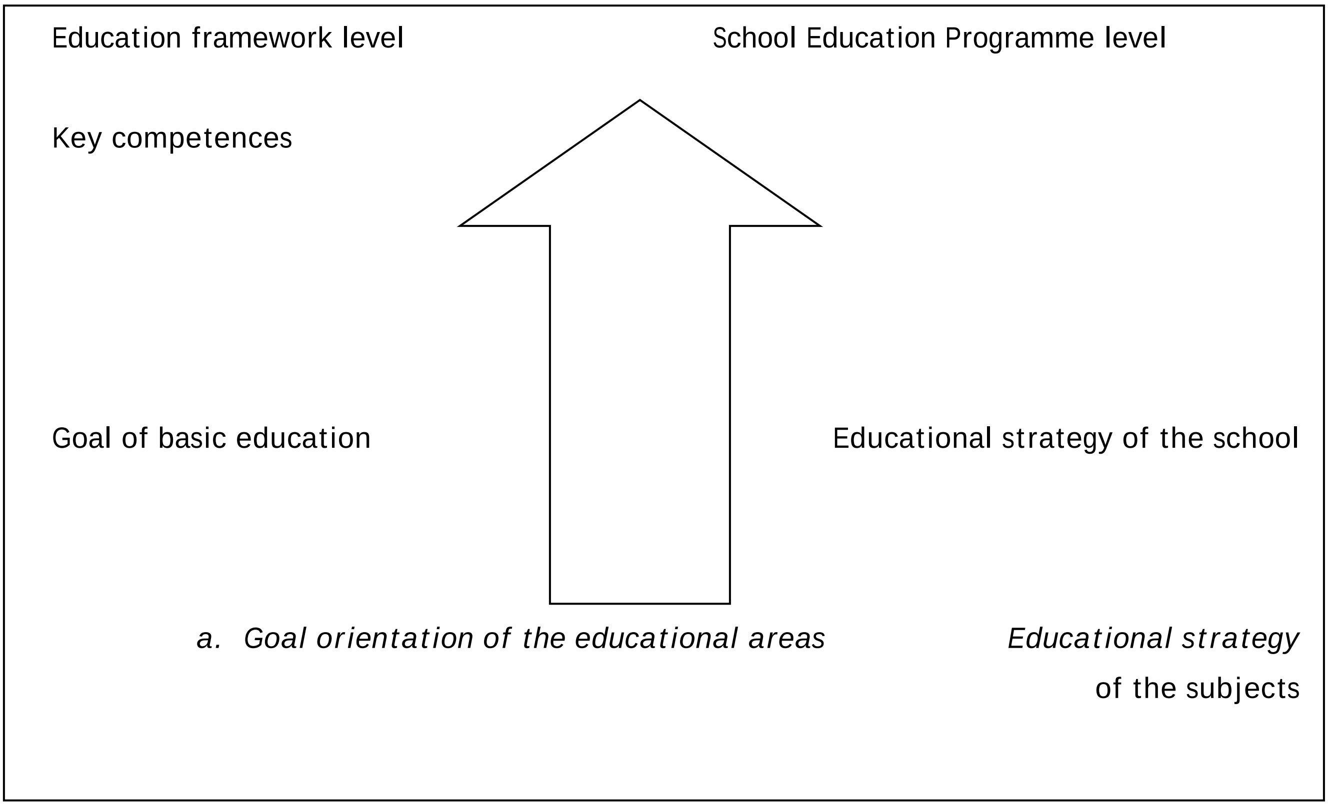
The *teaching matter* is structured within the education framework of basic education into topics and is supposed to be a *means to achieve the expected outputs.* Due to its informative and formative function it is an integral part of the educational content. Curriculum defined within the education framework of basic education is recommended to schools for distribution and further detailing for the individual grades or longer time segments. At the level of the school education programme the curriculum is binding.

The school will divide the education content of each of the educational areas into *teaching subjects* and will detail it and, where appropriate, complete it within the *curriculum* in accordance with the pupils' needs, interests, inclination and talents so that *the development of the key competences can be ultimately pursued*.

An educational field can comprise either one subject or more than one subject; also, a subject can integrate the education contents of more than one educational fields. The education framework of basic education allows *interlinking (integration*) of the educational content at the level of themes, thematic areas, or educational fields. Integration of the educational content must respect the logic of the structure of the educational fields involved. A qualified and skilled teacher is a basic precondition for a functional integration.

The system is conceived so as to achieve a situation where the teachers would *co-operate* when setting up the school education programmes, *interlink* suitable themes which are common to the individual educational fields and *strengthen the trans-subject approach to education.*

[5] Complementary educational subjects are subjects complementing and widening the education content of basic education.
[6] The education content for mentally handicapped pupils is defined in a separate Annex to the Education Framework for Basic Education.



Education content | Curriculum

Expected outputs | Detailed outputs

Subject matter | Subject matter

Diagram 1: Direction followed to form, shape and develop pupils' key competences

2. Extract from MAN AND NATURE (Integrated Science Module, translated)

"Characterisation of the educational domain

The educational domain Man and Nature covers issues connected with the investigation of nature. It gives pupils the means of and methods for gaining a deeper understanding of natural facts and their laws. It also gives them a basis on which to better comprehend contemporary technologies and helps them to orient themselves in modern life.

In this educational domain, pupils are given the opportunity to see nature as a system with interacting and interconnected components. An understanding of the importance of maintaining a natural balance for the existence of all living things, including Man, is based on such knowledge. This educational domain also intensively supports the development of open and critical thinking (open to alternative views), and of logical reasoning.

The subjects covered by the educational domain Man and Nature are Physics, Chemistry, Natural History and Geography. Through investigative and active teaching, they enable pupils to better understand the laws of natural processes and thereby realise the usefulness of scientific knowledge and its practical applications in everyday life. It is especially notable that by studying nature by specific cognitive methods, pupils also acquire important skills. First of all, they learn to observe, experiment and measure objectively and reliably, to create and verify hypotheses on the basis of observed natural phenomena, to analyse the results of this verification and to draw conclusions. The pupils learn to investigate the causes of natural processes, the connections or relationships between them, to pose questions (How? Why? What? and What will happen if?) and to look for answers, explain the phenomena observed, identify and solve cognitive and or practical problems, and use the laws of natural processes and their own knowledge to forecast these processes and/or the effects of tampering with them.

In the aforementioned educational fields, pupils are getting gradually to know the complexity and multiformity of the real world, and essential connections between nature state and human activities, and then acquire knowledge of human dependence on natural sources and of influences of human activity over the state of the environment and over human health. Pupils learn to explore changes running in nature, to uncover the causes and consequences of human impact on important local and global ecosystems, and consciously utilize their science knowledge to favour of environment protection and principles of sustainable development. A complex view of relations between Man and Nature, an important part of which is as well the awareness of the positive influence of nature on the development of human emotional life. is –shaped too – together with physical, chemical and natural history education – via geographical education, that enables pupils gradually to uncover the connections between natural conditions and human life, resp. the human community in the nearby surroundings, in the regions, in the whole territory of the Czech Republic, in Europe and in the whole world.

The educational content of the educational field "Geography", which has both scientific and social character, is placed in this educational area as a whole in order to maintain its integrity.

The educational area Man and Nature follows on from the educational domain Man and His/Her World, which brings knowledge of nature to pupils at the 1st stage of basic education at elementary level and interacts primarily (but not exclusively) with the educational fields Mathematics and its Application, Man and Society, Man and Health and Man and Work and of course with other educational areas too.

1. The goal orientation of each educational area

Education in a given educational area aims to form and develop the key competences by leading the pupil to:

- investigating natural facts and their relations using various empiric cognitive methods (observation, measuring and experiment) as well as methods of rational thinking;
- needing to pose questions about the course and causes of various natural processes, to formulate them correctly and search for adequate answers;
- mode of thinking that requires the verification of hypotheses about natural facts by several independent ways;
- evaluating whether the scientific data obtained are important, reliable and correct enough to enable the pupil to confirm or refute the hypotheses and/or conclusions made;
- participating in activities encouraging care and respect for natural systems, one's own health and the health of other people;
- understanding the relations between human activities and the state of the environment;
- reflecting on how to use energy sources most effectively, particularly renewable sources such as solar radiation, wind, water and the biomass;
- behaving appropriately when brought into contact with objects potentially or actually threatening to human lives, health, property or the environment."

"Natural History"

Educational content of the educational field

2nd stage

GENERAL BIOLOGY AND GENETICS

Expected outputs

A pupil

- *distinguishes the fundamental manifestations and conditions of life and is well informed of organism evolution;*
- *describes the main differences between the cells of plants, animals and bacteria and clarifies the function of basic organelles;*
- *recognises, compares and clarifies the function of the basic organs (organ systems) of plants and animals;*
- *classifies organisms and place selected examples into kingdoms and lower taxonomic units;*
- *explains the nature of sexual and non-sexual reproduction and their importance from the point of view of heredity;*
- *gives examples of heredity in everyday life and of the impact of the environment on the formation of organisms;*
- *exemplifies from everyday life of the importance of viruses and bacteria in nature and for man.*

Subject matter

- the origin, development, diversity and manifestation of life and its importance: – nutrition, respiration, growth, reproduction, development, reactivity to stimulations, opinions regarding the origin of life;
- basic life structure: cells, meshes, tissues, organs, organ systems, unicellular and multicellular organisms;
- the importance of organisms and the principles of classification;
- heredity and the mutability of organisms: the nature of heredity and the transmission of hereditary information; genes, crossbreeding;
- viruses and bacteria: occurrence, importance, practical use;

BIOLOGY OF MUSHROOMS

Expected outputs

A pupil

- *recognises our most common edible and poisonous mushrooms with fruit bodies and compare their characteristic features;*
- *explains different ways of the nutrition of mushrooms and their importance in the ecosystems as well as their place in food chains;*
- *clarifies the function of two organisms in a thallus of the lichens;*

Subject matter

- mushrooms without fruit bodies: basic characterisation, positive and negative impact on man and living things;
- mushrooms with fruit bodies: structure, occurrence, importance, principles of gathering, consuming and first aid in case of mushroom poisoning;
- lichens: structure, symbiosis, occurrence and importance;

PLANT BIOLOGY

Expected outputs

A pupil

- *derives on the basis of observation the organisation of a plant body starting with cells and meshes and ending with individual plant organs;*
- *compares the interior and exterior structures of individual plant organs and exemplifies their functions and relations to the plant as a whole;*
- *explains the principles of basic plant physiological processes and their utilisation in plantation;*
- *distinguishes between the basic systematic groups of plants and identify their important representatives with the help of atlases and keys;*
- *derives on the basis of observation the dependence and adaptation of some plants to environmental conditions.*

Subject matter

- the anatomy and morphology of plants: components and structure and the importance of individual parts of the plant body (root, stalk, leaf, flower, seed, fruit);
- the physiology of plants: the main principles of photosynthesis, respiration, growth and reproduction;
- plant systems: recognition and classification of given representatives of typical sorts of algae, bryophytes, pteridophyte ferns (club-mosses, horsetails and ferns), gymnosperms and angiosperms (monocotyledonous and dicotyledonous), their development and the utilisation of economically important representatives;
- the importance and protection of plants.

ANIMAL BIOLOGY

Expected outputs

A pupil

- *compares the basic interior and exterior structure of selected animals and explains the functions of their individual organs;*
- *distinguishes between and compare particular groups of animals, determines selected animals and classifies them in taxonomic groups;*
- *derives on the basis of observation the basic manifestations of animal behaviour in nature, clarifies using examples their way of life and adaptation to a given environment;*
- *evaluates the importance of animals in nature as well as for man and applies principles of safe behaviour in the contact with animals.*

Subject matter

- body structure, structure and function of individual body parts: animal cells, mesh, organs, organ systems, unicellular and multicellular organisms, reproduction;
- the development, growth and system of animals: main representatives of particular animal groups – protozoa, invertebrates (ctenophora, nemerthea, helminths, molluscs, annelids, arthropods), chordates (selachians, fishes, amphibians, snakes, birds and mammals);
- the distribution, importance and protection of animals: economically and epidemiologically important species, care for selected domestic animals, breeding domesticated animals, animal communities;
- manifestations of animal behaviour.

HUMAN BIOLOGY

Expected outputs

A pupil

- *determines the position and clarifies the structure and function of organs and organ systems in the human body and explain their interrelationships;*
- *gets oriented in the main stages in the development of the human phylogenesis;*
- *clarifies the origin and growth of a new individual from conception to old age;*
- *distinguishes the causes and symptoms of common illness and describes how to prevent and treat them;*
- *applies premedical first aid when people are wounded or injured.*

Subject matter

- human phylogenesis and ontogenesis: human reproduction;
- anatomy and physiology: structure and function of individual parts of the human body, organs, organ systems (supporting, locomotory, circulatory, respiratory, digestive, excretory, reproductive and regulative), higher nervous activity, hygiene of mental work;
- diseases, injuries and prevention: causes, symptoms, practical rules and procedures for treating common diseases, serious injuries and life-threatening states;
- life style: positive and negative impacts on human life.

INORGANIC NATURE

Expected outputs

A pupil

- *clarifies the effects of the Earth's formation on the origin of life and its duration;*
- *recognises the characteristic properties of selected minerals and rocks using determining tools;*
- *distinguishes the consequences of interior and exterior geological processes including the geological circulation of minerals and water;*
- *compares the importance of pedogenetic factors for soil origin, distinguish the main soil types and soil species in nature;*
- *distinguishes the particular geological periods according to characteristic features;*
- *gives on the basis of observation the importance of the impact of the climate and the weather on the development and sustainability of life on Earth.*

Subject matter

- Earth: origin and structure;
- minerals and rocks: origins, properties, qualitative classification, practical importance and determination of representative samples, principles of crystallography;
- interior and exterior geological processes: causes and consequences;
- soils: composition, properties, importance of soil for the nutrition of plants, its economical importance for society, the danger and examples of its devastation , possibilities and examples of re-cultivation;
- evolution of the Earth's crust and organisms on the Earth: geological changes, origin of life, occurrence of typical organisms and their adaptation to the environment;
- geological evolution and structure of the territory of the Czech Republic– Czech massif, Carpathians;
- the climate and weather in relation to life.

ESSENTIALS OF ECOLOGY

Expected outputs

A pupil

- *gives examples of organism occurrence in specific and related environments;*
- *distinguishes and gives examples of organism systems, populations, communities and ecosystems and clarifies and gives examples the basic principles of the existence of living and non-living components of an ecosystem;*
- *explains the nature of simple food chains in different ecosystems and evaluates their importance;*
- *gives examples of positive and negative impacts of man on the environment and of disturbance to ecosystem balance*

Subject matter

- organisms and the environment: mutual relationships among organisms and between organisms and the environment; populations, communities, natural and artificial ecosystems, food chains, balance within an ecosystem;
- nature and environment protection: global problems and their solution, protected areas.

EMPIRICAL EXPLORATION OF NATURE

Expected outputs

A pupil

- *applies empirical methods of exploring nature;*
- *observes the basic rules of safety and behaviour in exploring living and non-living nature*

Subject matter

- empirical procedures of exploring nature: observation with a magnifying glass, microscope (possibly also telescope), simplified determining keys and atlases, starting a herbarium and collections, example of how to catch certain animals, simple classification of plants and animals;
- prominent biologists and their discoveries. ”

Language for learning science: a social constructivist perspective

Jenny Lewis

Traditional approaches to teaching frequently use a transmission approach in which the teacher talks and the students listen and record. In this approach the teacher is seen as the main source of knowledge and the usual assumption is that students have no relevant prior knowledge. In this situation students are expected to learn what they have been told, in the way that they have been told it. They are not expected to question or interpret or engage with that knowledge, even to put it in their own words.

Constructivist approaches to teaching and learning start from a different perspective.

The assumption is that children, far from being empty vessels or blank sheets waiting to be filled, come to their schooling with a wealth of everyday experiences which they have already started to organise. During this process of organisation the child will develop their own explanations and theories which link different experiences together in ways that make sense to them. When presented with a new idea or experience in the classroom a child will try to make sense of it in terms of their existing ideas. Through this process their developing knowledge is personally constructed in ways which are meaningful to them. It is commonly assumed that this process requires the development of language skills and a vocabulary relevant to the context – that we need language in order to develop our thinking. In this approach the role of the teacher is to provide experiences that support the student's construction of knowledge

In teaching and learning science there is a *problem with personally constructed knowledge*. While school science is often presented as a body of uncontested facts the knowledge base from which these 'facts' are drawn is *socially* constructed. Through observation, experimentation, a good understanding of previous work and some imaginative thinking an individual (or more often a group) may develop a new hypothesis or theory *but* this will not be accepted by the science community until it has been exhaustively examined, critiqued and tested. In the process a number of competing explanations or hypotheses may be developed and considered and the original theory may be refined or even discarded. Eventually, a robust theory or explanation – one which is consistent with our existing knowledge and can be used to explain or predict across a range of contexts – may emerge and be accepted into the body of established scientific knowledge. This knowledge, initially based on conjecture but supported by an accumulation of rigorously assessed evidence, is rarely obvious and the key ideas are often counter-intuitive ('*Gas has mass?! Your telling me that's what wood is made from - gas? Wood is solid!*'). It is highly unlikely that an individual could develop complex scientific ideas through experiential learning and the personal construction of knowledge. *At some point, in some way, the science explanation must be explicitly presented to the student.*

Where the *gap between the scientific idea and a student's existing ideas* is small (speed, for example, or the skeleton), the teaching is relatively straightforward – 'transmission' may be the most effective approach – but the bigger the gap between the science explanation and a student's existing ideas, the more difficult it is for the student to assimilate the science concepts. Where the science explanation appears too implausible a student may resist or reject it altogether. Alternatively they may learn a series of 'facts' but be unable to assimilate these into a coherent conceptual framework which they can apply across contexts or they may adapt the science explanation to fit with their existing ideas, leading to misconceptions about the science. In either case the result is a limited and flawed framework on which to build further science learning. Assessment tasks which test factual recall may indicate a good knowledge of science, particularly for those students who understand the assessment 'game'; assessment tasks which test understanding may reveal a very different picture. If students are to develop some understanding of the more difficult concepts then science teachers need to help their students to bridge the gap between their existing ideas and the science explanations to be learnt and to support or scaffold their students' construction of a scientific understanding.

The important point when considering social constructivism is to recognise that there are two parts - *one* relating to the social origin of scientific knowledge, the *second* relating to the social context of the learning. A social constructivist approach to teaching and learning science is underpinned by a Vygotskian perspective on the use of language to scaffold learning, it begins with the students' existing ideas and considers the conceptual gap between these and the science ideas that are to be taught. In analysing the gap the nature of the difficulties become more apparent. Teaching approaches and strategies can then be designed to address these difficulties, so helping students to bridge the gap and develop a better understanding of the science explanation - a process which can be described as 'talking the science into existence' (Ogdon, 1996). Typical activities include:

- The use of diagnostic tasks or questions to assess the students' existing ideas; these can take a variety of forms – oral, visual or paper based; using words or pictures or practical demonstrations - but they all encourage students to express their own ideas, in their own way or words;
- Focussed small group work which encourages students to articulate and justify their ideas; in the process they become more aware of the range of ideas within the classroom and are encouraged to justify their own ideas, question the ideas of others and re-evaluate their own thinking;
- Whole class discussion which might typically draw together the different ideas arising from the small group work and consider them systematically, with the aim of achieving some consensus about the science explanation;
- Activities which set up cognitive conflict; exposing the flaws in the students' existing ideas, so making them more receptive to the scientific explanation;
- Providing students with opportunities to use or apply the science idea so they can see the advantages;
- Breaking big ideas down into smaller and more accessible ideas and presenting these in ways that help students to build up the bigger picture.

In these ways the students are supported in constructing a scientific explanation which they can understand. All of the activities require some use of language – to articulate and share ideas; to support students in moving from the use of everyday to scientific forms of discourse. The approach as a whole is supportive of students from disadvantaged backgrounds, including those working in another language, since it uses students' existing ideas (however acquired) and preferred vocabulary as the starting point, but moving it towards more rational, explicit, academic language use.

Relevant literature

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23*(7), 5-12.

Leach, J. and Scott, P. (2002). *Designing and Evaluating Science Teaching Sequences: An Approach Drawing On the Concept of Learning Demand And A Social Constructivist Perspective. Studies in Science Education 38*,115-142.

Mortimer, E. F. and Scott, P. H. (2003). *Meaning Making in Secondary Science Classrooms* Maidenhead: Open University Press.

Ogborn, J., Kress, G., Martins, I. and McGillicuddy, K. (1996). *Explaining science in the classroom* Buckingham: Open University Press.

Science education for citizenship – through language competence

Stein Dankert Kolstø

Science in the public domain

Many decisions in society involve science-based arguments. In the public and political sphere, there are global issues at stake like climate change and biodiversity as much as local issues ranging from energy supply to food additives. Although such issues call for political decisions, they do have a scientific and particularly a *science dimension* that needs to be considered. In democracies it is important that citizens engage in political debate and that schools prepare future citizens for such participation. Societal issues with a science dimension have some characteristics which it is important to be aware of when discussion how school science can contribute to the general goal of democratic citizenship/participation.

First of all, most issues are related to risks on the individual/personal level, for example to risks for human health (e.g. smoking, lead in petrol, irradiation of food) or to the natural environment (e.g. wildlife preservation, dioxins, oil spill etc.). Secondly, in addition to consensual science, the science dimension often involves disputed non-consensual science from the frontier of research. Examples are questions/problems and discussions about the nutritional consequences of irradiation of food and the environmental consequences of gene-modified crops. A decision-maker's opinion on such uncertain science issues might have a decisive impact on one's view on these issues. The presence of scientific uncertainty also blurs the traditional division of labour between science and politics - where science is supposed to contribute the "facts" while democratic processes shall develop and justify the value-based options and decisions. This scientific uncertainty implies that engaged citizens as well as politicians might need to study the scientific dimension in the issues at hand in greater/more depth in order to make a thoughtful and responsible decisions.

A third characteristic, which further complicates the challenge, is the frequent existence of expert disagreement. This dimension is of course linked to the aspect of scientific uncertainty, which makes it possible for different experts to judge the present evidence differently. Moreover, as Funtowicz and Ravetz (1993) have claimed, the science involved in societal issues is often characterised by high systems uncertainties, making it especially hard to attain reliable or consensual scientific results. BSE and the climate issue are cases in point.

The scientific uncertainty also makes it legitimate, in principle, to ask whether vested interests might influence an expert's or an organisation's view or position on a concrete issue. More specifically, scientific research can be initiated by any industry, organisation or directorate with sufficient resources, e.g. through contract research, in order to produce insights that might support their view on an issue (Ziman 2000). Consequently, it has become harder for the engaged citizens and for politicians alike to judge the validity and the reliability of scientific claims.

We also need to be aware, that issues with the above mentioned characteristics are also present at workplaces and in citizens' private life as consumers, e.g. in decisions on what technologies to use, goods to buy and health and safety measures to take in specific contexts.

Science education for citizenship

The presence of social/societal issues with a science dimension (denoted socio-scientific issues within science education) have triggered several educational initiatives and research projects focusing on preparing students for positive engagement with such issues. To some extent, this is an interdisciplinary area as it partly overlaps with citizenship education, character education and science studies as established fields of research (Zeidler 2003).

However, the science dimension of many issues has their own challenges for citizens, and this has led to a necessary focus on socio-scientific issues in science education.

A focus on societal issues with a science dimension is also included in the concept of scientific literacy as defined in the OECD-initiated PISA project:

> 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 2003).

This definition, which focuses on decision-making, includes important aspects of citizenship. More broadly, science education for citizenship can be defined as science education focusing on preparing students for active, informed, critical and responsible participation in issues and situations where insights into different aspects of science might improve the quality of this participation (Kolstø 2001). Thus, the general purpose of science education for citizenship is to empower students to engage in/with socio-scientific issues. This empowerment includes the ability to read and listen to scientific information and arguments with understanding, examining and evaluating this information and these arguments critically, and to contribute to discussions and even decisions in a competent, informed manner from their own subject-specific knowledge background and from their own points of view.

Democratic participation

The decisions on socio-scientific issues in the political or collective sphere should ideally be based on democratic processes. However, the quality of these processes is dependent not only on citizens' involvement, but also on their insight into the issues, their understanding and their thoughtful examination of views and arguments involved. This point is strengthened by the fact that many socio-scientific issues are of great importance for human health, wealth and development, and for our natural sustainable environment.

This situation triggers the general question of what competencies need to be developed and emphasised in school science in order to prepare future citizens for this engagement, for their capacity of examining and of participating in thoughtful decision-making on socio-scientific issues. This question is thoroughly discussed in the science education literature, e.g. in Ryder (2001) and Kolstø (2001) as well as in Kolstø et al. (2006). The general answer is threefold, and corresponds to the product, process and institutional aspects of science:

Students need

- a thorough understanding of the main explanatory stories in science (e.g. particle model of matter and 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.

In addition to this broad knowledge base, students need to be able to 1) read and interpret scientific information, 2) examine and discuss information critically, and 3) make thoughtful decisions and communicate/negotiate their own points of view. These three competence areas all involve communication, and thus basic language competencies. This takes us to the more specific question of what language competencies are needed for citizens to engage positively in socio-scientific issues in the ways described. To answer this question one also needs to consider what channels are available for citizens who want to participate in democratic processes on socioscientific issues, including information gathering, examination of information and arguments, participation in decision-making processes and dissemination of viewpoints.

1. Retrieve and interpret information

Information and viewpoints on socio-scientific issues might be found in the media, like newspapers, TV, radio, the Internet or libraries. In/On the Internet and in libraries citizen can get access to texts written in scientific genres, like explanations, science textbooks, expositions, experimental reports, reports made for the management or position papers. The tendency of citizens to look up authentic scientific experimental reports when engaged in a specific issue, e.g. children's illness, seems to be increasing. In addition. citizens 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/in subject-specific contexts.

2. Examination of information and arguments

Examination of information and arguments is based on critical thinking and involves at least three aspects. First, the lines of reasoning might need to be examined, 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 need to be examined, e.g. through comparing views of different experts, inspecting evidence and references provided, and comparing them with consensual science. Examples of how university science students do this kind of examination might be found in Kolstø (2006). These kinds of examinations might be done individually/in private or collaboratively, together with friends and colleagues.

3. Decision-making and dissemination of viewpoints

Based on the processes of acquiring information and examining views and arguments critically, citizens might want to contribute actively to a debate through posing questions, giving observations, sharing and exchanging arguments and viewpoints with others. In modern society a range of platforms and channels are available for this, as much as a range of areas for debate exists. Entering into discourse with friends and colleagues is an obvious opportunity, but the agendas of NGOs are also an important area for this type of (oral) discourse. The engaged citizen might also communicate his or her views in a written form, e.g. through letters to the editor, blogg or private websites. In addition, citizens can contribute to texts produced by NGOs in which they are engaged (e.g. through brochures, web-articles, press releases, flyers, newpaper reports, letters to the editor etc.).

Language competence and science for citizenship

In recent years, there has been an increasing awareness of the role of language in learning science, and of language competencies as a prerequisite for participating in situations with a science dimension (Keys 1999, Phillips & Norris 1999, Sutton 1992, Wallace, Hand & Prain 2004, Wellington & Osborne 2001). Learning a subject, science included, does not only involve new concepts, explanations and arguments, but also new ways of making and communicating concepts, explanations and arguments. Learning science involves learning a new way of thinking. Furthermore, new ways of thinking imply new ways of talking. Consequently, learning science is (almost) like learning a new language. As an example, science has developed/invented new types of texts (genres or versions of genres) suited for specific purposes of importance in science. In addition to the science textbook which reports on the content and structure of a topic, scientists makes experimental reports, expositions and prescriptions (Martin 1993). While textbooks contains consensual science and aims to provide an overview on a topic, the experimental report presents a new claim backed by empirical evidence. In general, scientific texts might include facts, hypotheses, claims, evidence, arguments and 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. (Norris & Philips 1994). This interpretation is guided by awareness of the author and purpose of the text, of the audience it is written for and the conventions at work, observed by a particular discourse community. All of these influence the type of text under consideration.

However, to what extent is lacking linguistic insight and knowledge about the features and structure of scientific texts really a problem for engagement in/with scientific matters? Obviously, the identification of non-consensual claims in a text as scientific facts will confuse a debate and leave the citizen disempowered. Several studies have shown that students, confronted with scientific texts, frequently confuse the epistemic status of claims (as opposed to rules or laws). Rather, they need to learn to identify what are claims and what is evidence and what is the conclusion (Phillips & Norris 1999, OECD 2001). Moreover, science teachers often observe how students find it very demanding/challenging even to read in their science textbook, and how students need much guidance in order to learn how to write a lab report. Other types of scientific texts are seldom emphasised in school science, even though the students will encounter them as citizens.

Concerning oral discourse in science, scientists make use for instance of inquiry type of dialogue (Walton, 1998), aiming at identifying the knowledge foundation for further work, and critical inquiry, aiming at identifying weak points in a line of reasoning. In the public sphere, citizens meet scientific discourse in the media and through professional consultancy. Scientists might explain a phenomenon, report on the structure of a topic, argue for a point of view or report on the different arguments and possibilities related to an issue. Again, different types of discourse are used for different purposes, and awareness of these purposes and different epistemic connotations of different claims is important for adequate understanding and criticism.

Today, citizens are not afford to listen only to experts' advice and act accordingly. Typically we want our future citizens to be active in relation to science, and this involves reading and listening, discussing meaning and arguments, and contribute with personal knowledge and views on science matters. In short, we want citizens to be able to participate in communication on science-related matters. To participate in communication, through reading and listening, by examining "facts", by making written and oral contributions, and above all by argumentation, demands basic insights into science, but also skills in understanding and producing different types of scientific texts and discourse. Thus science for citizenship, although not typically emphasised in science teaching at present, needs to include a large variety of linguistic competences in science. Obviously, some students are able to learn the "codes" (conventions and lexico-grammatical as well as discoursal features) needed for reading and producing different sorts of scientific texts by observing examples and learning from them/these. However, for educators it is important to notice that more students (if not all of them) could develop increased competence in interpreting scientific texts and discourse, and examining other's positions and contributing with own points of view, if the linguistic basis of science and of science participation were explicitly included and taught in school science.

Linguistic competences for science students

Linguistic competence in science, as an integral part of scientific literacy, needs to be identified as explicit competences for inclusion in competence based science curricula. A full discussion of this challenge is outside the scope of this text. However, we will indicate some possible competence areas. Above we discussed possible situations, channels and levels for future participation, and the presence of different kinds of texts and discourse on a scientific content/topic both in science, in the media, and in private communication. Accordingly, we will sort /distinguish possible competence areas on the three suggested levels of participation, and suggest relevant linguistic competences for each level.

1. *Retrieve and interpret information through reading and listening*

To be able to acquire science-related information, students should be aware of different types of texts and discourse, their main purposes and structuring, and the use of different representations of information in multimodal forms/texts. They should be able to identify and differentiate scientific claims, evidence and conclusions in an utterance, and interpret the epistemic status of statements correctly (as presented in the text or discourse itself). They should also be able to make summaries of scientific texts which includes references to visual information and representations in the text. In order to check and develop one's own understanding further, students should be able to "talk science" using inquiry types of discourse with peers (e.g. Lemke 1990). In more linguistic terms, this would involve questioning, arguing, supporting, relativising …..etc. (list to follow).

2. *Examination of information and arguments through discussing*

To be able to engage critically with science-related texts and discourse, students should be aware of a range of criteria used to judge the trustworthiness and quality of scientific information and arguments and their sources. They should be able to identify instances of hedging and qualifiers and the consequences for interpretation of the claims made in expository and experimental report types of texts. Furthermore, they should be able to participate in critical inquiry types of dialogue through asking epistemic questions in order to check/examine the reliability of science-based claims and arguments.

3. *Decision-making and dissemination of viewpoints through discussing and writing*

To be able to contribute with own views, students need to become aware of the intersubjectivity of knowledge and how this constitutes important conditions for the framing of public and scientific debate. They should be able to write exposure kind of texts, making an argument for a point of view related to the science dimension of a socioscientific issue. They should also be able to give written and oral explanations of scientific concepts and phenomena and participate in enquiry types of debates aiming at comparing arguments and develop a personal view on a scientific issue.

When identifying appropriate linguistic competences related to critical thinking and participation in democratic debate, it is important to be aware of the existence of *different levels of expertise*. It is not possible, nor desirable, to try to make *all* students into scientific experts, on all levels, for all issues. However, it is possible to recognise quality at one level of expertise in a specific area, although not being able to produce quality oneself. At another level of expertise it is possible to understand information in an area, although not being able to judge the quality of this information oneself. If we want all of our students to be able to participate (at least to some extent) in the relevant soci-scientific discourses of today, we have to teach them on these two levels at least.

Concerning the level of scientific literacy in general among science students, it is important to be aware that activating science learners in "talking science" is not only relevant for future participation in socio-scientific issues, but also highly relevant for effective science learning. However, in the past/traditionally school science has primarily engaged students in explanatory talk, and tested students' ability to produce written scientific explanations and lab-reports. When narrowing students' exposure to these few kinds of texts and discourse types, students' access to scientific ways of thinking and communicating becomes very restricted accordingly. Moreover, without training in focussed reading exercises and without guidance in the production of more diverse kinds of scientific texts, and without training the diverse types of oral discourse (including negotiaton of meaning) involved in science-related issues, students will be less prepared to participate in democratic processes where all of these diverse kinds of texts and discourses mentioned are used.

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