Can the science subjects get better at teaching bilingual pupils?

Published in Danish in Sprogforum 56, 2013, 13-20.

> 'Denmark is the Western country with the highest share of pupils with an immigrant background that lack competences in the science subjects.' (Egelund 2007: 198)

Equity has not been attained in basic education in Denmark between pupils with an immigrant background and Danish pupils, as their achievement in all subjects is lower than the Danish pupils' (Tosprogstaskforce). This has been pointed out for several years by both national and international research. Science subjects are especially problematic.

According to the Pisa 2006 study's conclusion, "[...] 52 per cent of the immigrants and 48 per cent of immigrant descendants [...] 'were lacking competences in science subjects' and '[...] only Qatar has a greater proportion of students with immigrant background with lacking competences in science subjects.' (Salamon et al 2008: 143).

Far from being surprising, this result has been predicted for many years! Seventeen years ago, Jørgen Gimbel (1995) in this journal wrote his famous article 'Bakker og udale' about bilingual pupils' knowledge of words relating to science subjects. He predicted the consequences of the lack of teaching Danish as a second language:

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> 'However, the [fifth grade Turkish] [...] pupils' knowledge of the chosen subject area's vocabulary must be considered well below average compared with their Danish classmates' knowledge of the same words in fifth grade. This fact cannot avoid causing subject-related problems for bilingual pupils in subsequent years, independently of how teaching of the subject is being practised, if one doesn't work consciously and systematically with their second language (acquisition)" (Gimbel 1995: 33)

Working consciously and systematically with a second language requires both working over a long period and the participation of all teachers. Therefore the view on teaching Danish as a second language as an issue that is over before seventh grade as long as language stimulation has begun early enough, is a problem, as it also is when some teachers don't think about their subject class as also being a language-developing class. A teacher who wishes to offer all students the best possible learning conditions should draw on the necessary methods.

The Danish as a second language syllabus says clearly that Danish as a second language must '(...) be integrated with the school's other subjects." (Ministry of Education 2009: 3) Second language acquisition is a process that cannot be isolated, neither within a given time horizon nor within the Danish language subject. Pupils are constantly confronted with new requirements both in and outside school. Throughout their school career they are introduced to new subjects and new subject areas and hence to new language challenges. Thus, all teachers are involved in the pupils' Danish language acquisition and therefore it is appropriate to prepare classes collaboratively among teachers.' (Ministry of Education 2009, 40).

Could science subjects and Danish as a second language be integrated?

The question is whether it is more difficult to integrate Danish as a second language with science subjects than with language subjects, since pupils with immigrant background achieve less well in these subjects than in the language subjects.

This question became insistent when I began working as a science and maths teacher in the Unge2 program in the town of Ballerup, Denmark. At that time I had good theoretical knowledge

about integrating Danish as a second language with science subjects, and I was inspired by earlier experimental projects (e.g. Laursen 2004, 2008, 2009).

> The Unge2 program[1] helps young newcomers between 15 and 25 years to pass the basic education final exams. In addition, pupils over 18 follow the Danish language courses for adults and take the final exams there, too. On average, it takes pupils three years to complete the programme, which then allows them to continue studying higher secondary education on equal terms with young Danes. Pupils are divided into classes according to their second language competences. Classes in the same subject are, as far as possible, taught parallel in order to enable pupils to switch to a higher or lower level in the subject. Newcomer pupils participate from day one in all subjects[2]. This means that teachers working in the Unge2 program at any time prepare their classes with the Danish as a second language syllabus and the particular subject's syllabus.

Interdisciplinary themes can strengthen language development and save time

An argument which is often used against the integration of Danish as a second language into science subjects is that it takes longer to get through a theme and one therefore cannot fulfil the curriculum requirements for the subject.

In order to meet this problem, a coordinated plan across the subjects for the school year can be made. In my own planning I emphasise finding common themes across the science subjects and, if possible, also combining with Danish or Maths classes.

Thus, the theme 'bricks of life' has been a focal point for an interdisciplinary theme about carbohydrates, proteins and fats in physics/chemistry, the composition of cells and basic genetics in biology and heredity and the environment in Danish.

Combining science subjects seems natural, not only because the subjects of the different syllabuses encourage doing so, but also because the same subject-related vocabulary is repeated in the different subjects. Thus, one may find both the word 'sugar' and the chemical formula $C_6H_{12}O_6$ which basically expresses the same thing in the language of chemistry, in a biology textbook.

In this way, pupils use their subject knowledge and the recently learned vocabulary and expressions simultaneously in several different contexts and thereby increase their chance of remembering the words and their meanings.

Understanding science subject texts

Science subject texts at secondary school level are difficult and pupils can become overwhelmed by the amount of difficult and new words and unknown combinations of letters and numbers, as found in chemical formulae, for example. In most science subject texts pupils also encounter illustrations, graphs and tables with contents that are not necessarily explained in the main text. This means they are not just another way of representing the text's content, but rather supplementary 'text'. Science subject texts are thus 'multimodal' (Daugaard 2008) and require from the pupils a set of reading strategies in order to benefit the most from the content of the text and to use it constructively when building up their own knowledge of a theme.

Science subject book systems are often divided into a textbook and a work book. Characteristic of these systems is that the tasks in the work book are not questions about the text in the textbook but rather a perspectival supplement to it. Thus, in physics/chemistry and biology they are mostly guidelines for experiments, and in geography may be atlas tasks or tasks related to new information written in the work book and not in the text book.

One of the big challenges is therefore to create work sheets which allow pupils to work systematically with textbook texts, so that they do not read randomly but know what they are looking for in the text. Working actively with the text increases their chance of understanding the subject. In the following, I will present some examples of my own work with typical tasks to enhance the understanding of textbook texts.

From text to illustration and vice versa

Ask the pupils to convert a piece of text into graphics. Figure 1 shows a pupil's understanding of a short introductory text on carbohydrates.

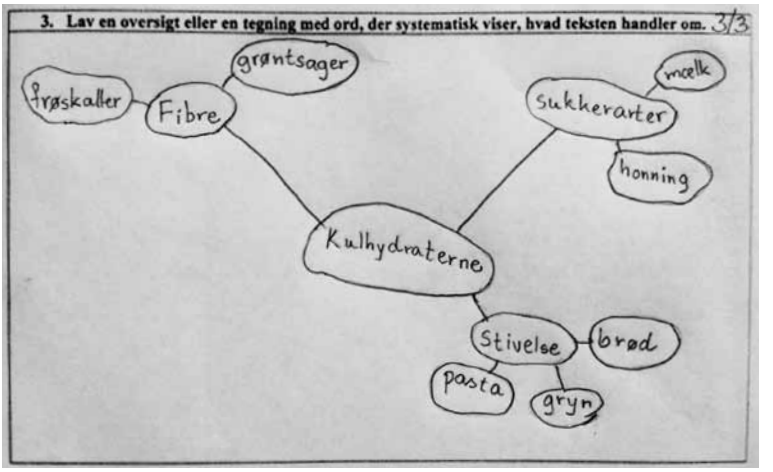

Figure 1. Translations:
3. Draw an overview or an image with words that systematically show the content of the text.
brød: bread; fibre: fibers; frøskaller: husks; gryn: meal; grøntsager: vegetables; honning: honey; kulhydrater: carbohydrates; mælk: milk; pasta: pasta; stivelse: starch; sukkerarter: sugars

Another reading strategy is to set up information from the text in a table, as in the following example:

Read pages 38-39 in 'Chemistry we eat'. Find examples of different proteins and fill in this table.

Name of the protein	Where can it be found in the body?	What function does the protein have?

Furthermore, pupils learn to interpret different kinds of graphs, diagrams and illustrations. An example of this kind of task is the following:

On pages 14-15 in 'Geotopes 1' you can see a circle diagram and three maps. Find a precise headline for each of them and explain the meaning of signs, colours and numbers. Then write a text based on the information which is concealed in the diagram or map.

Circle diagram page 14	
Headline	
Which materials are mentioned and why?	
What do the percentages mean?	
Write a text based on the information in the circle diagram.	

When a pupil is asked to explain every part of a diagram, the teacher has a good chance to evaluate the pupil's reading strategies and qualify them. Furthermore, pupils learn to express themselves more precisely.

Linguistic repetitions

In every subject there are linguistic repetitions, i.e. expressions which appear frequently in relation to that subject. Science subjects are characterised, among other things, by many taxonomies and processes (Sørensen 2008: 19). Taxonomies are categorisations, often consisting of over- and subcategories. Themes about mammals, carbohydrates, the composition of cells or soil types, for instance, contain taxonomies and definitions. Science subjects also describe many processes, as for example the carbon cycle, the water cycle, the digestive system or chemical reactions.

In order to make the pupils aware of these linguistic repetitions, I have made 'reading strategy posters'. These posters explain what to do when finding certain words in the text.

If pupils find the verb 'signifies' in a text or the expression 'there are two kinds of...' they know there will follow a definition of subject-related concepts or a categorisation.

If pupils find the verbs 'consists of' or 'contains', they know the text describes something that is composed. In this way pupils get strategic reading tools which convert the textbook texts into key players when acquiring the subject matter.

Also the different types of diagrams are related to a certain vocabulary. In order to read and talk about a circle diagram an expression like 'the share of... was...%' is typically necessary. Diagrams that show a development over a time period will require the use of words and expressions like 'increase', 'grow' and 'fall' and their derivals, 'from...to', 'in the period', 'the highest', 'the lowest', 'the smallest', 'the biggest'.

Pupils' subject-related linguistic production

Finally, I would like to mention the importance of giving the pupils opportunities to produce both written and oral subject-related language. This is partly done through the above-mentioned work with the textbook. But it is at least as important for the pupils to get opportunities to train their subject-related orality. Especially for the final exam in physics/chemistry, which is an experimental-oral exam, pupils need to be coherent in the subject-related discourse.

To achieve this I have used different pre-conception tasks, as for instance brainstorming session forums about new themes or hypothesis-making before experiments ('What do you think will happen?'). Moreover, during the school year the pupils have to give presentations about themes we have been working on. In physics/chemistry these presentations are furthermore combined with simultaneous laboratory experiments.

During the startup of a theme on weather and climate in geography, pupils began by writing down all the different types of weather they knew, both from Denmark and their home countries. The list became very long and pupils were then given the task, alone or in pairs, of being responsible for one type of weather. Their task was now to find images on the internet which illustrated that weather. Once having chosen the pictures, they were asked to write short captions for every picture. They also had to prepare an oral presentation based on the images in which, among other things, they had to point out what clothing would be suitable to wear in such weather and what would happen if one got 'too much' of such weather. Too much rain, for instance, could lead to flooding, too much sun could lead to drought.

The use of images made the types of weather tangible for all pupils, and their presentations led us into discussions about why seasons around the world were different, about the nuances in different types of weather, e.g. different types of rain and wind and the consequences of different types of weather.

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After having integrated Danish as a second language systematically into science subjects over the last three years, I am convinced that there is both time and space to reprioritise methods used in teaching science subjects without going beyond the practical and experimental work. On the contrary, it is strengthened if pupils can talk

and write in a qualified way about the experiments and if they are encouraged to connect their theoretical knowledge with practical experiments and to explain the relevance for society of such experiments.

A *systematic* integration of Danish as a second language requires preparation. Initially, it may seem hard work to unravel the linguistic aspects regarding different themes, both in the textbook texts and the guidelines to the experiments, and to prepare reading guides or work sheets that support the development of subject-related discourse. Nevertheless, as in every other form of preparation, the recycling value is high; on the one hand generic and theme-independent worksheets will be generated, as for instance sheets for analysing experiment guidelines, tables and diagrams, on the other hand theme-dependent worksheets will be generated which can be used again in subsequent years or shared with colleagues. In this way a school can build up its own collection of learning sequences and materials that integrate Danish as a second language and science subjects within the space of a few years.

Integrating Danish as a second language with all science-subject lessons is in my opinion one of the methods of rectifying the existing bias in academic performance between Danish pupils and pupils with an immigrant background – and thus an important step towards equality in education.

Notes

1 Further information about the Unge2 program is available at www.unge2-projektet.dk

2 Pupils are taught in as many lower secondary subjects as possible, i.e. Danish, maths, English, biology, geography, physics/chemistry, and varying optional subjects (in the school year 2009/10 they were offered: sports, cooking, arts, German, using presentation programmes, and homework help).

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