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SCIENCE EDUCATION IN NORWAY. COUNTDOWN TO THE NEXT REFORM

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Abstract

Integrated science courses in grade 1-11 in the Norwegian school system include biology, chemistry, physics and earth science. The arguments used for integrated science are of scientific, pedagogical and practical nature. Between 1993 and 1997 primary and lower secondary education went through a comprehensive reform process and a new science curriculum was introduced. Until 1997 science in primary schools was not a separate subject, but part of an integrated subject including social studies. The reform of primary education resulted in re-establishment of science as a separate school subject. Another revision of the curricula of all school subjects will take place within a few years. The revision should pay special attention to the problem of overloaded science courses, not allowing for enough time for practical work, and to the need for a more coherent science curriculum for all stages from grade 1 to 13.
Key words: science education, curriculum, educational policy.

Science education for all

In the Norwegian school system science is a compulsory school subject from grade 1 to grade 11. There are no separate courses in chemistry, physics or biology until in grade 12 and 13. The school science courses in grade 1 to grade 11 include elements from biology, physics, chemistry and earth science. Until in 1994 science had been a compulsory subject for all students in primary and lower secondary school, but only for those grade 11 students following general study programmes in upper secondary school. In 1994 a compulsory course in science was introduced for *all* grade 11 students, both in general study programmes and in vocational training programmes.

Integrated science teaching

Rather than offering science as courses in biology, chemistry and physics, science courses in the Norwegian school system include topics from the physical as well as from the biological sciences. The science courses are frequently characterised as being "integrated" courses, with reference to elements from biology, chemistry, physics and earth science being included.

Integrated science teaching, however, should mean more than just putting different elements together and giving the course a new name. Integrated science teaching should mean that the different elements of the science curriculum are integrated into a coherent programme in such a way that it provides students with knowledge and understanding that could not have been acquired through studying the separated elements. Integrated science should allow students to understand, for example, that energy is a key concept not only in physical sciences, but also in studies of life processes and biological systems. Furthermore, it should show the relationships between phenomena in which energy is transformed and the relevance of energy transformation in a variety of phenomena and situations.

In integrated science students should also meet scientific issues which do not easily fit into either of the traditional science disciplines, such as different environmental issues and issues in biophysics and biochemistry, in relevant contexts. For the same reasons issues such as the nature of science, the role of scientific evidence, probability and risk, and the ways in which scientists justify their claims, should all be important aspects in integrated science.

Although the concept of integrated science teaching is not a new issue in Norwegian school debate, and has been widely accepted, several questions still remain to be discussed and answered. Examples of such questions are: should science be taught integrated even in grade 12 and 13; and, how should school science be defined at different levels? Should for example earth science in upper secondary school be included and should technology be a separate subject or an integrated part of school science?[1] The arguments used may be grouped as follows: scientific arguments, pedagogical arguments and arguments of practical nature (Sjöberg, 1998).

Scientific arguments

On a scientific base, one may argue that the natural sciences have so many features in common, as regards both their content and their methods, which as a whole differ so strongly from other science areas, that it justifies considering them as coherent unity distinct from other academic subjects. This alone, however, is not sufficient as an argument in favour of teaching science integrated in schools. The scientific community has, after all, found good reasons for splitting up science into biology, chemistry, physics and other science areas, although it is widely accepted that these areas have many common features.

On the other hand, it is also accepted that fragmentation of the scientific community may make science appear as a world of discrete ideas and methods, which for many may seem to lack coherence. Therefore, if school science should emphasise coherence and relevance, and give students sufficient knowledge and understanding to follow science and scientific debates with interest, it would probably be better to introduce science as a whole rather than as separate subjects.

Pedagogical arguments

In a pedagogical perspective, one might argue that it is important to work systematically and allow students to understand the basic principles represented in biology, chemistry and physics as separate subjects. Accordingly, relevance, contexts and more overriding perspectives such as different aspects of the nature of science should wait until later.

"First the basics and then the big pictures" is a commonly held opinion by teachers. As some say: " The big issues are too difficult to understand, some are hardly understood even by scientists. How then should students be able to understand those issues, before they have acquired basic understanding of the elements of science in subjects such as biology, chemistry and physics?" As a consequence of such a view, integrated science should not be introduced until at upper school levels.

On the other hand, integrated school science presented in a coherent way which reflects the true nature of phenomena in the natural world, the work done by scientists and the meaning of science in society, rather than being a collection of more or less isolated content fragments, would enhance more meaningful learning. Such contexts would provide essential relevance and meaning for young people. It may enhance their motivation and counteract the tendency of seeing science as something detached and irrelevant to their own concerns and interests. A curriculum for integrated science, based upon current ideas about learning, would perhaps result in less content knowledge, but more easily develop the sense of wonder and curiosity of young people about the natural world. Furthermore, such a curriculum would more easily develop the

[1] Recently a governmental committee proposed the introduction of "Technology and Design" as a separate subject at lower secondary level (Utdannings- og forskningsdepartement 2003).

ability to understand and interpret scientific information, and gradually develop the ability to understand science in a critical way.

Arguments of practical nature

Teachers' professional qualifications are a factor of major importance in education. Most science teachers in secondary schools have a university degree including one and sometimes two of the subjects biology, chemistry or physics. Only a few science teachers are specialised in more than two of the subjects.

At university science is usually separated into distinct subjects, and teachers develop a professional identity greatly based on their university subjects. Many teachers, therefore, may only reluctantly agree to teach integrated science. For science teachers integrated science may mean that parts of the curriculum content may not be dealt with in a satisfactory manner. Despite their acceptance of the advantages integrated science may represent, many science teachers would prefer not to have to teach those parts of science which they feel lie beyond their professional qualifications. As a consequence, in some schools, mostly upper secondary schools, science courses are separated into traditional subjects and taught by two or sometimes even three different science teachers. Some textbooks in science facilitate such a practice through organising the science content as easily distinguishable sections for physics, for chemistry and for biology.

The nineties – when everything changed

The nineties will forever be memorised as the great reform decade in the Norwegian education system. In 1993 a national core curriculum was introduced, which was meant to be an ideological framework for all education from grade 1 to grade 13. In 1994 a comprehensive structural change effected all parts of upper secondary education (grade 11-13), leading to a total reorganisation of all programmes for vocational education. The 1994 changes also included the introduction of new curricula for all subjects. In 1997 primary and lower secondary education went through a comprehensive reform process. An extra school year was introduced by lowering the age at which the youngest pupils entered school (from age 7 to age 6). The new curriculum emphasised the use of new teaching methods and of new models for organising teaching, and new curricula for all school subjects were introduced.
In 1998 and in 2003 teacher education in Norway went through reform processes.

A new science course in primary schools

A new science curriculum was not the only change made in an attempt to improve science education in primary schools. First of all science had to be re-established as a school subject. Until 1997 science in primary schools was not a separate subject, but integrated with social studies into a subject called O-subject (O for orientation). When the O-subject was introduced in the seventies, it was meant to enhance learning with the pupils' own natural and social environment as a starting point and learning context. Working with both science and social issues should emphasise the relationships between science and society. The arguments used were basically the same as the pro-arguments for integrated science as referred to above. Yet, this integration never became a success.

Research showed that the science component of O-subject tended to become weakened. Studies of classroom practice showed that in most cases the social studies component dominated clearly. An analysis of textbooks used in O-subject showed that science topics were clearly underrepresented and that presentations of science topics often were of poor quality. The situation seemed to be most negative for topics in the physical sciences. Some of the textbooks appeared to have been written by author teams in which no persons at all with science

qualifications were represented. Similarly, many of the teachers who taught O-subject were poorly qualified to teach science and amongst those, not surprisingly, many tended to avoid science topics in their teaching.

Therefore, when the reform of primary and lower secondary school replaced O-subject with separate subjects, science and social studies, most teachers welcomed this. It was generally agreed that the integration of science and social science had failed. Science was re-established as a subject in primary school, from grade 1 to 7.

Earth science

The position of earth sciences has generally spoken always been weak in Norwegian school education. This is somewhat surprising because Norway is a nation with long and rich scientific traditions in earth science and the nations wealth can largely be ascribed to exploitation of mineral resources and oil and gas resources. The rich variety of the Norwegian landscape and nature should also justify more attention in the education of young people to the processes that have formed the country.

Earth science in school has normally been a part of geography, which in primary school usually has a rather strong emphasis on social issues. In the new science curriculum, however, an attempt has been made to include earth science topics. Science in grade 1-10 not only integrates biology, chemistry and physics, but earth science is now a part of the integrated whole as well. Earth science finally seems to have landed where it belongs, as a natural part of school science.

Science and environmental studies

The name that was chosen for the new science course in primary and lower secondary school was, somewhat surprisingly, "Science and environmental studies". All the way during preparations for final approval of the curriculum by the Norwegian Parliament, the name of the course had been "Science". However, together with some minor adjustments made just before final approval, a new course name turned up. No significant changes of the curriculum were made; it was only the name of the course that had been changed from “Science” to “Science and environmental studies”. It was undoubtedly done with the best of intentions, but it may have some negative effects.

Ever since environmental education entered the scene in Norwegian education in the early seventies, it has been of great importance that environmental education should be integrated into all education in school and that it should not become associated with a particular school subject. This has been clearly stated by the Ministry of Education in its official policy for implementation of science education. This was simply neglected by the politicians when they decided to change the name of the science course.

If the purpose of the change was to emphasise the close connection between environmental issues and science, then why wasn't the same done for other school subjects, such as geography and economics? By connecting environmental studies and science so closely together, one might create the belief those environmental problems most of all are of a scientific nature. One might argue that today's environmental problems should be considered as an important argument for learning science in school. However, there are many other valid arguments for learning science, which are of equal importance.

What went wrong?

In 1999 the Norwegian education authorities, even before anybody knew anything about how the new curriculum would effect students' learning in science, assumed that there would be a need for a curriculum revision in mathematics and science in grade 11 because the introduction of the new curriculum in grade 8-10 would ”produce” students who had learned ”more”, or the

new students should at least have a different kind of skills and knowledge. Based on this belief the curriculum for mathematics in upper secondary school (grade 11-13) was revised.

The science curriculum was however, after a long discussion, not changed. An important argument which was used against a revision of the 11th grade science curriculum before knowing anything about the ”new” generation leaving grade 10, was that one can never be sure that the changes one aims at through a new curriculum really lead to changes that are reflected in the learners' results. A curriculum is, after all, only one of the factors affecting learning processes and learning outcomes (van Marion & Valdermo, 2000).

Today one may ask why today’s 11th graders do not seem to differ very much from the students in grade 11 in the past. Is it possible after all, that the new 8-10th grade curriculum in science alone did not bring about the intended changes, and that this at least partly may explain why today's 11th graders seem *not* to have significant more interest, better skills and more knowledge in science?

The new science curriculum for grade 1-10 is without doubt an improvement when it comes to structure and progression and the emphasis on practical work and students' own experiences. Many science teachers say they appreciate the ideas expressed through the new curriculum and that the new curriculum has led to positive changes in their classroom practice (Tveita, Almendingen & Klepaker, 2003).

The new science curriculum document never became what it was intended to be. A hearing, based on a draft curriculum, resulted in an immense number of issues that many seemed to ”miss” and many of these issues were later included in the final science curriculum. The result was an overloaded science curriculum. Although the curriculum expresses modern ideas emphasising the meaning of children's curiosity and questions linked to everyday science, there is too little time to work thoroughly with the issues, simply because there are too many issues in the curriculum. This results in superficial learning and leads to fragmentary knowledge. Poor basic understanding of scientific issues is a common problem and an overloaded curriculum does not contribute to solve that problem.

Preparing a platform for change

The comprehensive reforms at all levels of the Norwegian education system in recent years have brought about changes at the system level, school level and classroom level. Some, but not all of these changes were improvements. Recently the Ministry of Education has announced that the development of a new curriculum for science and the other school subjects will start in 2003/2004. This time the mistakes made under the reforms of the nineties should be avoided. First of all it is important to make sure that the new curriculum will be a coherent programme for all science education from grade 1 to 13 in Norwegian schools. Under the reforms in the nineties a new science curriculum for grade 11 was developed initially, followed by new curricula for the biology, chemistry and physics courses in grade 12 and 13. Finally a curriculum for grade 1-10 was developed. Soon after the curriculum for grade 1-10 was introduced, one realised that the recently developed curriculum for grade 11 did not correspond with the curriculum for grade 1-10.

As a starting point for a change of science education in Norway, some principal questions have to be considered thoroughly. In a report presented by a group of British experts in science education, the outcome of a series of seminars was presented (Millar & Osborne, 1998). The aim of the seminars was to consider and review the form of science education required to prepare young people for life in our society in the next century. The seminars considered four principal questions that also seem to be relevant in a Norwegian context:

1. What are the successes and failures of science education to date?
2. What science education does young people need today?

3. What might be the content and structure of a suitable model for a science curriculum for all young people?
4. What problems and issues would be raised by the implementation of such a curriculum, and how might these be addressed?

Conclusions

In 1997 science education in primary and lower secondary education in Norway went through a comprehensive process of change. Only minor changes were made in science education at upper secondary level. New changes of the science curriculum at all stages will be made within a few years. No dramatic changes should be expected, although there is a strong need for a more coherent curriculum from grade 1 to grade 13. There seems to be widespread consensus that science education in grade 1 to 11 should be integrated, i.e. courses that include physics, chemistry and biology, and that earth science should be a part of science in primary and lower secondary school. Furthermore, there are no indications that science and social sciences will be re-established as an integrated course in primary school. As a whole, most science teachers seem to be more or less satisfied with the curriculum changes made in the nineties. However, a major problem in today's science education, mainly in grade 7 to 10, is that the courses are overloaded. A new science curriculum should, therefore, not include as many topics and allow for more time spent on practical work in and outside the classroom.

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Резюме

ЕСТЕСТВЕННОНАУЧНОЕ ОБРАЗОВАНИЕ В НОРВЕГИИ. РЕШАЮЩИЙ МОМЕНТ ДЛЯ СЛЕДУЮЩЕЙ РЕФОРМЫ

Петер ван Марион

В статье представлена система естественнонаучного образования в Норвегии. Естественнонаучное образование /ЕНО/ интегрированное. Нет никаких отдельных курсов по химии, физике или биологии. Интегрированное обучение естествознанию должно означать больше чем только соединение различных элементов и предоставления курсу нового названия. Содержание ЕНО включает знания по биологии, химии, физике, науке о земле. Интегрированный курс обоснован научными, педагогическими и практическими аргументами. Согласно реформе основной школы (1997) в Норвегии с 1 по 10 класс основной школы введен новый предмет "Учение о природе и окружающей среде". Этот курс организован таким образом, что учащиеся регулярно возвращаются к основным темам этого курса, углубляя при этом свои знание, получая новые и расширенные знания.

Интегрированное обучение естествознанию должно означать, что различные элементы учебного плана обьединены в последовательную программу таким способом, что это обеспечивает учеников качественными знаниями, которых не возможно приобрести, изучая отдельные дисциплины.

Интегрированный курс должен помочь ученикам понять, например, что энергия – ключевое понятие не только в физике, но также и в исследованиях процессов жизни и биологических систем. Кроме того, важно показать отношения между разными явлениями. В интегрированном курсе ученики должны также встретить научные проблемы, которые легко не вписываются ни в одну из традиционных дисциплин естествознания, например, различные экологические проблемы и проблемы в биофизике и биохимии.

Всесторонние реформы на всех уровнях норвежской системы образования в последние годы вызвали изменения на уровне системы, школьном уровне и уровне работы в классе. К сожалению, не все эти изменения были усовершенствованиями. На сей раз ошибок, сделанных согласно реформам девяностых нужно избежать. Прежде всего важно удостовериться, что новым учебным планом будет последовательная программа для всего ЕНО от 1 до 13 класса в норвежских школах. Главная задача ЕНО – подготовить молодых людей к жизни в нашем обществе в следующем столетии. В принципе важно рассматривать четыре основных вопроса:

- каковы успехи и отказы ЕНО до настоящего времени?
- В каком ЕНО молодые люди нуждается сегодны?
- Что могло бы быть содержанием и структурой подходящей модели для учебной программы естествознания для всех молодых людей?
- Какие проблемы может возникнуть при выполнении такой учебной программы?

Основной вопрос – как школьное ЕНО должно быть определено на различных уровнях общеобразовательной школы?

Ключевые слова: естественнонаучное образование, программа, политика образования.

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