

Teaching natural science at primary schools - politically not important or educationally too difficult ?

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Abstract : Concerning the possible role of weather at schools, it is stated that perhaps the meteorologists have focused too much on physics and geography in upper secondary education. A more successful and socially useful alternative may be to present weather at primary schools not as a collection of facts, but rather as a touchable inroad for young children to scientific approach. The EMS proposes to coordinate development of teaching material for such education.

1. Meteorology is a touchable introduction to science.

Around the age of fifteen, when compulsory schooling ends, a steadily diminishing percentage of children are moving to scientific studies of physics, mathematics, chemistry, engineering and such. A majority of them consider science to be boring and uninteresting as a career (OECD 2001) -- and scientific subjects are reputed not to be easy, and they do not have the lure of big salaries and high status. Why should you be a scientist when you can be his boss ? Reversing this trend by teaching environmental science, in particular meteorology, at primary schools is not taken seriously because of two false premises.

First, professional meteorologists know from their own work that meteorology is a branch of physics, requiring insight in the modelling of flow and energy. Then to many of them it seems a logical premise that the subject of weather can not really be presented at lower levels than mid-secondary schooling, age level about fifteen, because it ought to be dealt with at schools in the context of physics.

Unfortunately, physics teachers do not agree. Nobel prize winner Richard Feynman, a physicist with a wide-open mind, shied away from meteorology because "even a smooth moving mass of air going over a mountain turns into complex whirlpools and eddies, turbulent flow that we cannot analyze today. Quickly we leave the subject of weather" (Feynman, 1963). In other words, the mix of physics subjects and the degree of statistical uncertainty in meteorology are uncomfortable for deterministic thinkers. Many science teachers rationalize their unease into the premise that "meteorology is just not science and not amenable to practical work" (Fisher, 1996). Condescendingly, physics teachers shift secondary school meteorology to geography teaching, where it may be reduced to an optional factual description of climates (Green and Rees 1984). A well-judged and technically already accepted project proposal to investigate use of weather teaching at primary schools was rejected, because a physicist on the deciding scientific committee declared meteorology useless as an introduction to "real" science. Presumably he meant by this the abstraction into uncertainty-free formulas.

However, both the above premises are wrong. First, only for professional meteorology can be said that it can only be taught to those who have mastered a sizeable amount of formal physics. Second, teaching of non-formalized meteorology in primary schools constitute for young children a very practical introduction to what natural science is dealing with and how it operates. Such an introduction is very desirable for society, because present-day secondary school pupils can hardly be enthusiastic about a way of thinking to which they have not been exposed yet. If a child has not experienced

at the age of ten that it is both interesting and useful to understand, measure and play around with the concrete physical environment, he or she is unlikely to take up non-compulsory school subjects in abstract science at fifteen -- an age when matters of social relations are quite predominant.

When the physicist Bohren started to teach elementary meteorology to so-called "nonscience" students, it did not take him long to realize that he could not reach them by the kind of arguments that appealed to him. The merest hint of an equation would make them run to the dean's office to complain about cruel and unjust punishment. What did move them, he discovered, were things they could see, and hear, and touch (Bohren, 1987). In this respect, meteorology has very big advantages over chemistry and many branches of physics because it is an easily touchable science. Weather has the property that its phenomena are visible, familiar, accessible, and practically worthwhile to understand even a little bit. Many meteorological subjects can be introduced without much abstraction in a semi-qualitative way and give kids some understanding of their own environment, about which they are still quite curious at the age of ten. Then these kids may consider at the age of fifteen that it might be a satisfactory career choice to become a physicist, or an engineer, maybe even a meteorologist.

2. Feasibility of teaching natural science to primary-school children.

Discussing the possibility to teach natural science in primary schools, three major questions arise. First, what matter do you want to teach them which they are not getting already ? Second, can this matter be made interesting for average school classes of kids, or does it only interest a few genius types ? Third, can average schoolchildren learn it at that age, are they capable, and what is the result ?

The primary task of a primary school is teaching essential skills, namely reading, writing and arithmetic, maybe a second language. Moreover factual knowledge is presented, such as history, maybe cultural or religious subjects, and description of the environment by way of geography and some facts of nature. In most countries the children are tested at the end of the primary school to provide arguments for a choice of secondary education. Such tests generally investigate skill proficiency and the amount of learned facts, not structural insights.

Such a program provides no systematic introduction to the skill of inquiry into causal relations of facts. Maybe some relations are presented, but not how they are discovered, or that most relations have a degree of uncertainty. In primary teaching, "what" is generally stressed much more than "why". But science deals with finding out and getting to understand matters from appropriate observations and their critical evaluation -- it is more than a skill, it is an approach. Such an approach certainly can be introduced to primary school children. It is just not true that it can only be taught when causality can be summarized in algebraic formulas.

Investigations into the attitude of 8000 schoolchildren towards scientific matters showed first, that their interest and achievement can be best understood by classifying them in three groups (Häussler and Hoffmann 1998). The largest group, about three-fifths, with as many girls as boys, are mostly interested in applications of science and its power to explain phenomena. One-fifth of the children, mainly boys, are very interested in scientific processes as such, and one-fifth, mainly girls, are most interested about social implications of science. So there is a gender difference, as expected, but it is not sharp, and only when the teaching is process-oriented then most girls are turned off. A classification according to age shows that generally at the age of 15 years the interest in most of the exact science subjects is about half of what it was at 10 years (Hoffmann et al. 1998) -- which is a clear argument in favor of the introduction of science already at primary schools.

When interests are classified according to science subject, only process-oriented children are approximately equally interested in all subjects. Application-oriented children, and certainly the socially-oriented ones, have significantly less interest for "hard-core" quantitative and technical theories. The application-oriented ones also have little interest in science-related socially controversial matters. Natural phenomena is the only subject in which all children are equally and highly interested, which shows that meteorology is a obvious subject for introduction of science at primary schools (Häussler and Hoffmann 1998). Biology (particularly for girls) and technical subjects (for boys) might be also useful for this purpose.

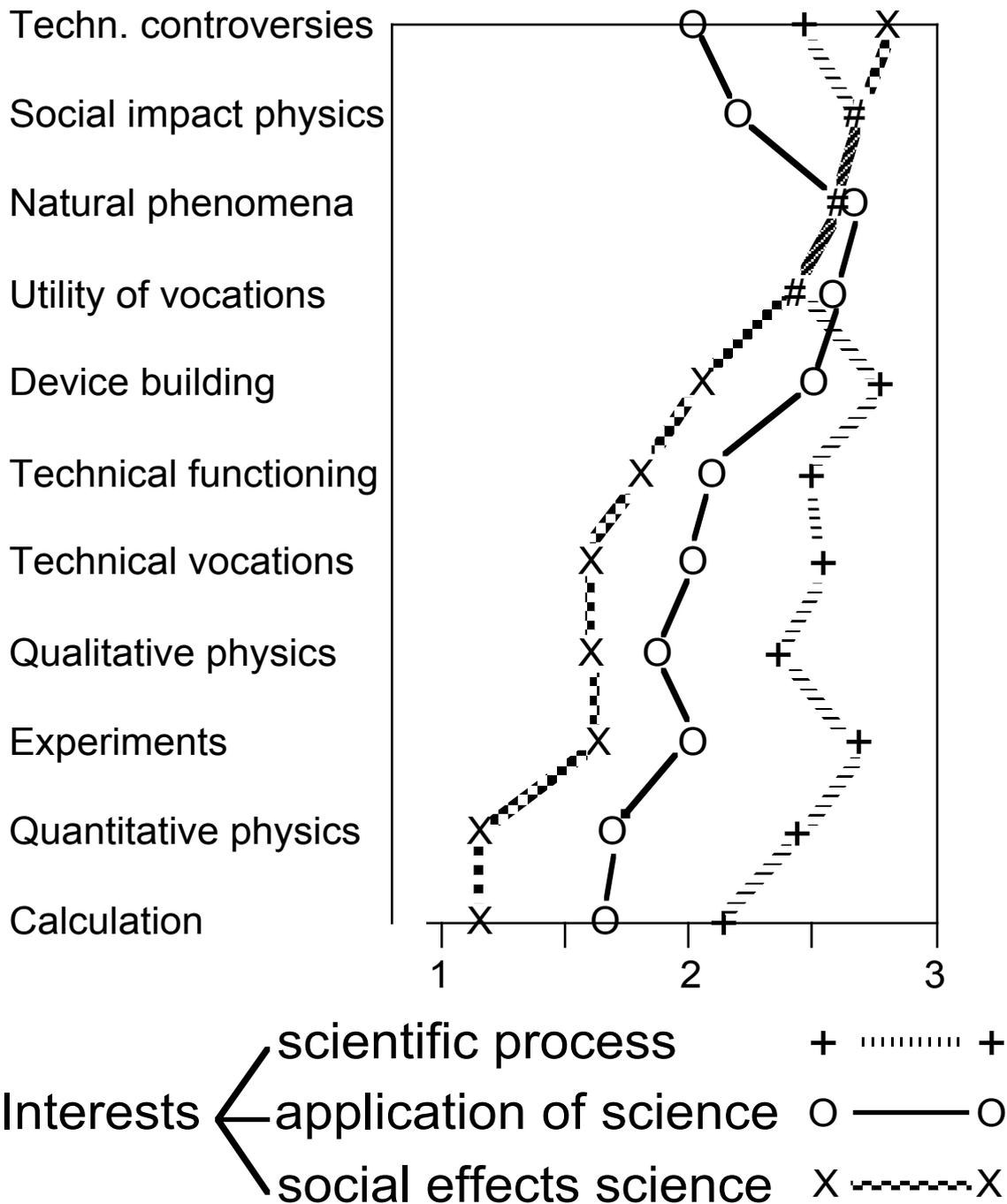


Figure: Average reaction of the three interest types (process-oriented, application-oriented and socially-oriented) to 11 context-activity configurations. (Redrawn from Häussler and Hoffmann, 1998)

Interest in a topic is a necessary but insufficient condition for learning. Successful education depends also on the context in which the topic is presented, and also on the activity by means of which the topic is dealt with. In primary schools, activity should be taken literally because it is a most effective way to involve ten-year olds. Published studies on weather education for primary schools (Rowley and Spencer 1970, Floor 1983, Ilsley 1985, Kennard 1993) and lower-secondary schools (Spiropoulou et al. 1997, Benito-Capa 2001) show that then some scientific literacy is achieved, misconceptions are eliminated, enthusiasm generated. Apart from classroom experiments, an obvious activity is to observe weather outdoors and then to discuss, compare and maybe analyze the observations.

Contextual links to application of scientific insight in everyday life can be various. For example, Kirkeby Hansen (1996) discusses ways to teach water physics at primary schools as a basis for explaining weather processes. He notes that evaporation is more familiar than condensation, and uses dew on bathroom mirrors as a classroom example. Bohren (1987) expands the bathroom example by invoking surface tension, teaching children that their eyeglasses can be defogged with a drop of detergent. The context of such examples must be familiar to children, not too technical or too abstract.

Conclusion: meteorology at primary schools is not educationally too difficult. Its results are useful to society in general by making science attractive, and also to meteorology by generating an environment-conscious public.

3. Accessibility of primary schools for meteorology and similar subjects.

When stating that teaching natural science at primary schools seems politically not important, I am not talking about government politics. It is kicking down a wide-open door to state that the political establishment, while publicly expressing concern about the decrease of interest in science among their nation's youngsters, is doing little to improve matters. One of the worst political measures of the eighties in many European countries was the financing changeover from one based on numbers of students and teachers to one based on the number of awarded degrees or diplomas. The half-baked justification was that schools should behave like industry and business, getting income according to output, but since usually government defined output mainly quantitatively, this led inevitably to decreasing quality of the degrees. Simultaneous fast-output constraints on student activities then chased many of them away from "hard" subjects such as science. You can name many other adverse governmental policies, such as increasing the size of management while lowering the number of teachers per student -- but particularly here in the country of Don Quichote one should be aware that it is not always wise and practicable to tilt against governmental windmills.

Rather, our own politics deserve attention. At present, the role of meteorology at primary schools is not really supported by the weather and climate community. In the last five annual AMS education conferences hardly any papers were presented dealing with primary schools, and those on secondary schools nearly all were on the pre-college level K-12 (see Table below). In this EWOC conference, half a dozen papers out of 130 deal mainly with children less than 15 years of age. To improve our input of good young meteorologists and the weatherwisdom of our public, it is short-sighted to bet only on the high-school and university horses. In the present political climate they are not winning, and even losing regularly. For example, in the Netherlands the Minister of Education has proposed to parliament to lighten study loads at secondary schools by decreasing teaching hours in mathematics and science by a third, keeping humanities at the previous level. In her early career the Minister was a teacher of English, and C.P. Snow's model of literary intellectuals looking down on scientists may be appropriate. So

in upper-secondary education, physics teachers often have to fight hard to keep their own house in order and will have little sympathy for adding the subject environment.

Table **Five Education Symposia of the American Meteorological Society (symp.nrs. 7 - 11, 1998 - 2002)**

Percentage of 328 papers chiefly dealing with following subjects :

8 %	Weather Service training
27 %	College and university
17 %	High school ("K-12")
8 %	Middle school
3 %	Elementary school
22 %	Datastreme, and other schemes of information distribution
15 %	Outreach, and general AMS

Above has been shown that environmental subjects can play a positive role in primary education and lower-secondary education. If we as meteorologists want to play to our strengths, we might like to make that role important, but we are few in number. In the United Kingdom, for instance, the number of schools is about a factor ten larger than the number of Royal Meteorological Society members. The RMS does a magnificent job in the MetLinkInternational project (Walker et al.2000), enlisting a few percent of those schools and stimulating the weather and science interest of their children, but there is little more we can do alone. We have to enlist teachers, and must just hope that no structural shortages of teaching staff prevent teachers to prepare presentations of child-accessible practical natural science.

Floor (1983) concluded from experience that schoolteachers can be made interested to teach meteorology if they had some basic scientific training and if they can obtain a minimum of material such as textbooks. Presence of the subject in the official curriculum (like in Norway) would help, but primary teachers appear to have more leeway to fit in extras than their colleagues at secondary schools. Schoolbooks on e.g. nature education exist, but too often their sections on weather are written by a biologist or a geologist because "everybody knows about weather anyway" and just give facts without the causes and structures behind them. So meteorologists and oceanographers would do well to develop more good teaching material than presently available (e.g. Harrison and Havard 1991), either as background for the teachers or for the children at school. This is a challenge !

One more point : the chance of success in encroaching at primary schools are much larger if we team up with other touchable sciences (biology, ecology, technics) into a joint subject of environmental science. However, presentation of these matters as systems with experiments and with causal relations to investigate, not just as a set of descriptive facts, may well require revised teaching material for all combined subjects -- not only for meteorology but also for biology. Some member societies of the European Meteorological Society (EMS), for example the German, French and Croatian societies, have summerschool activities for primary school teachers. Such action is needed because the majority of primary schoolteachers had little exposure to scientific approach in their earlier training.

Challenge : Teaching of environmental science -- I say science, not just environment ! -- at primary schools should get as much attention from meteorologists and oceanographers as its teaching at universities. At least, a necessary action is that

some of us try to produce good material to help teachers in introducing primary school children to scientific ways of thinking. The EMS stands available to coordinate such textbook and material development action internationally. National meteorological societies can organize interested members into writing teams, and nowadays results of such action can be distributed to interested primary teachers by internet. In the long run our university departments will profit from such work, and we may even get grudging agreement from physicists. The only change which you really can make is a change in your own attitude and actions.

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