DOCUMENT RESUME

ED 327 419 SE 051 866

AUTHOR Krabbendam, Hans, Ed.; de Vries, Marc, Ed.
TITLE Goals and Methods in Science, Mathematics and Technology Education in the Netherlands. Report of a Conference in the Framework of the OECD Project, 'Science, Mathematics, and Technology Education.'
INSTITUTION National Inst. for Curriculum Development (SLO), Enschede (Netherlands).
PUB DATE 90
NOTE 88p.
PUB TYPE Collected Works - Conference Proceedings (021)

EDRS PRICE MF01/PC04 Plus Postage.
DESCRIPTORS Educational Assessment; *Elementary School Mathematics; Elementary Secondary Education; Environmental Education; Experiential Learning; Foreign Countries; Interdisciplinary Approach; *Mathematics Education; Physics; *Policy Formation; Problem Solving; *Program Descriptions; Science and Society; *Science Education; *Secondary School Science; Teaching Methods; Technology
IDENTIFIERS *Netherlands; *Organisation for Economic Cooperation Development

ABSTRACT

The aim of the Organization for Economic Cooperation and Development (OECD) project "Science, Mathematics, and Technology" is to formulate recommendations for educational policy. Preparations for the project were made in each of the various member countries. Reported here are the results of the Netherlands meeting. The conference and this report should be seen in the context of Dutch education, in which several political factors play a role. This report contains the papers that were presented, as well as the impressions of the discussions that followed and suggestions for questions to be studied in the project. Two themes discussed included: "Goals and Content" and "Methods and Settings." Papers include: (1) "Towards providing the basis for sustainable development? The reality or fiction of environmental education in schools"; (2) "Goals and contents, how can they assessed?"; (3) "Introduction to the teaching of technology in Dutch secondary schools. A survey of the development of Goals and Content for technology education"; (4) "In search of contexts in mathematics for 12-16 year-olds"; (5) "Teaching physics and context in the Netherlands"; and (6) "Settings and methods in education in technology in the Netherlands." Also included are opinions about the Dutch participation in the OECD project "SMT Education." (KR)

Goals and methods in science, mathematics and technology education in the Netherlands

Report of a conference in the framework of the OECD project 'Science, Mathematics and Technology Education'

Editors:
Hans Krabbendam
Marc de Vries

National Institute
for Curriculum Development
the Netherlands

Contents

1. Introduction

Seen from a historical perspective, the relationship between science, mathematics and technology is very close. One can find many examples of developments that were caused by a common effort in which each discipline had it's own contribution.

A nice example of this can be found in: 'Mathematizing and Society, or: What is the end of a success story?', an article which tells, among other things, about Tartaglia, a 16th century mathematician[1]. Tartaglia developed a theory on the trajectory of bullets, and in particular the angle that was needed to get the furthest range. He did not dare to publish his theory, because he realized that he was what he called himself: 'perfecting an art that hurts other people and is aimed at the destruction of humankind'. He even burnt his papers. The moment however, the Turks attacked Italy, he thought it was time to 'defend himself against the fierce wolf that threatened his flock' and he revealed his ideas. Thus Tartaglia was initiating the theory of ballistics. Later on Galileo found out that in vacuum projectiles follow a parabola. In practice, one also had to take into account the air resistance, which was very problematic in that time.
Besides Tartaglia and Galileo, many other, among them Huygens, Newton, Bernoulli and Euler, worked on this theory. Until the 19th century it was a pure mathematical theory, in which factors of resistance were numerically estimated. That numerical calculations, however, were not effective, because the real resistance functions were yet unknown and there were many complications in the artillery of that time, because the guns did not shoot regularly and the speed of the bullets when leaving the gun was inconstant.
But technology standardized the artillery and the projectiles and resistance functions could be found experimentally. This worked out well for many years, until technology demanded more and resistance functions had to be determined more accurately, because of the development of long-range artillery. So many kinds of artillery were developed that enormous numerical tables had to be made. This was one of the main causes for the development of computers in the period between the two World Wars. Of the 13 known computers, that were developed in the years 1937–48, at least 9 were primarily developed for ballistical calculations. Further automatization was reached by connecting the computers directly with the artillery.

This story shows clearly at various moments the contribution of the various subjects to this, doubtful, progression.

1) an article of H.J.M. Bos, publiced in 1976 in Euclides, the Dutch journal of the Society of Mathematics teachers.

In Dutch education, and in particular in secondary education, these historical relationship seems to have disappeared. Education is marked by a division in subjects, that causes developments that are specific for the various/subjects. A continuing divergence is the result of this.

Therefore it is welcomed that the Organization for Economic Cooperation and Development (OECD) planned to initiate a project in which the three subjects Science, Mathematics and Technology are brought together.

The aim of the OECD project 'Science, Mathematics and Technology Education', that is part of a broader project 'The Curriculum Redefined', is to formulate recommendations for educational policy for these three subjects, on:

- the nature of the various subjects,
- their mutual relationships,
- the relationship between these subjects and the rest of the curriculum.

The project will deal with the following themes:

- goals and content of the curriculum,
- the students' perspective,
- methods and settings,
- the teachers' perspective,
- evaluation and assessment.

The first issue is to find out what aspects are worth studying in the project.

Preparations for the project are made in each of the various member countries. The official start will be in Paris, March 1990.
In the Netherlands, a mini conference has been held in order to prepare for the project. The report of this conference is what you find in this book.
We have selected two themes to be discussed: 'Goals and content' and 'Methods and settings'. The latter theme was focused on the use of contexts in education. A selection had to be made while it is not possible to iscuss all five themes properly in a two day conference. Another reason is, that we think our country can contribute in particular to these two themes.

The three aims of the Dutch mini conference were:

- survey the state of affairs with respect to the two themes,
- study the coherence between various trends in the Netherlands and see to what extent differences and relationships between the subjects account for this,
- determining questions for the OECD project to be studied in the planned national surveys, of which we think that they can be answered internationally.

This report contains the papers that were presented, as well as impressions of the discussions that followed and suggestions for questions to be studied in the project. It is evident that a two day conference is not enough to study the themes exhaustively.
It is also evident that the conference and this report should be seen in the context of Dutch education, in which several political factors play a role. For a good understanding it is necessary to describe this briefly.

After a long process of integrating pre-primary ('Kindergarten') and primary education we now have one type of primary education for children of ages 4-12. The integration also affected the curriculum of this school type.
The discussion on the structure of the lower part of secondary education (ages 12-16) now seems to come to an end. It seems that this structure will be a common collection of subjects for the various types of lower secondary education (both for the general and for the vocational part of secondary education). These 14 subjects are called the 'Basic Education' ('Basisvorming' in Dutch) and for each of the subjects 'End terms' (goals) are stated and legitimized. The higher part of secondary education will still be divided into a general part (preparing for a higher vocational education or for university) and a vocational part.
The discussions on the Basic Education were a great stimulus for rethinking the curriculum for the lower part of secondary education. That goes both for science and for mathematics and for technology, the last mentioned being a new subject that will be introduced as a part of the Basic Education of pupils.
Other political trends deal with adult education, the introduction of computer technology, the curricula of teacher training institutes, modularization and the quality and effectiveness of education, leading to more attention for central evaluation and assessment.
Constitutionally there is a freedom for education in a sense that various ideological types of schools are all paid by the government. Partly as a result of this it often takes a long time for educational changes to be implemented. The conviction and approach of curriculum developers plays a vital role here.

Although the situation in Dutch education seems to be rather restless, this could be a suitable situation for joining the OECD project 'SMT Education' because of the possibilities to use results in our discussions and learn from what is going on abroad.

In this report you will find impulses from the Netherlands for the project.

Chapter 2 contains the papers that have been presented in the first theme, 'Goals and content', as well a a brief report of the discussions that were h ld. Chapter 3 contains the same for the second theme, 'Methods and settings'. Discussions here were focused on the use of contexts in education, an issue that plays an important role in to-day's Dutch deliberations.
For each subject we have stated a number of questions of which participants thought it would be useful to have them answered in the international project.

We hope that this report can be a valuable contribution for the conference in Paris, March 1990, during which the actual start of the OECD project 'SMT Education' will take place.

2. The theme 'Goals and content'

2.1 K. Boersma: 'Towards providing the basis for sustainable development? The reality or fiction of environmental education in schools'

2.2 J. van Dormolen: 'Goals and contents, how can they be assessed?'

2.3 J. van der Velde: 'Introduction to the teaching of technology in Dutch secondary schools. A survey of the development of Goals and Content for technology education'

2.4 Discussion report

2.1 Towards providing the basis for sustainable development? The reality or fiction of environmental education in schools

Kerst Boersma,
National Institute for Curriculum Development (SLO), Enschede

Introduction

During recent years, a situation seems to have occurred in which the want of appreciation of the relevance of our education has come to an end. Those involved in education are invited to make a contribution to great social problems such as health, over-population, war and peace, hunger in the Third World and the environment. Part of these social problems is, among other things, translated in educational issues which try to settle into regular education, also into the so meticulous science education. The waves of education in healthcare, sex, peace, development work and environment have subsequently caught up with us. And the height of those waves is, to a large extent, determined by the political swell which occurs.

Several months ago, I obtained from the Netherlands Ministry of Education and Science a 'request' to compile a brochure for members of parliament so that they could be informed about the activities which had been organized in education for 1990 for Environmental Education. The brochure was entitled 'Towards providing the basis for sustainable development'. For the Ministry of Education and Science the brochure was a logical result of the fact that, as a result of a parliamentary motion, they were forced to make additional funds available for the purpose of Environmental Education. The Ministry of Education and Science wanted to show that they had done their homework properly. Rather striking is the fact that, in doing so, this not only provided the recognition that Environmental Education deserves its own place in education, but also that Environmental Education are also considered as being an instrument for the implementation of environmental policies. In other words, that Environmental Education also contributes to the realization of objectives already defined for policies with regard to nature and the environment. This situation evokes several contradictory considerations or questions. Of course, on the one hand, it is without any doubt that an effective policy must be implemented with regard to nature and the environment, and if Environmental Education can make an important contribution to this, then they should.
However, on the other hand, the question arises whether it is appropriate in our present cultural society for the Ministry of Education and Science to assign such instrumental roles to education, because those roles are not directly or in the first instance related to the development of the individual or the way in which the individual functions in social systems, but to the solution of socially determined problems. Of course, in its proposed Bill for Environmental Education, the government has been sensible

enough to acknowledge the fact that Environmental Education also fulfills a pedagogical function (Agriculture, Nature Management and Fisheries/Public Housing, Planning & Devel pment and Environment Control), 1988) and some people have attempted to illustrate that both the instrumental and pedagogical approach are not necessarily mutually exclusive (Boersma & Schouw, 1988). However, this does not imply that preference is not given to the instrumental function, certainly in the view of environmental lobbyists.

Another problem which is certainly not unique in the case of Environmental Education, is that the rhetoric is extremely impressive, but that it is in the least clear as to what exactly can be achieved by this. In other words, whether or not the objectives formulated for Environmental Education can actually be achieved. The problems with regard to the instrumental role of Environmental Education and the extent of reality of the formulated objectives are interrelated, as soon as one accepts the fact that Environmental Education may also play a significant instrumental role. I accept this. The question then arises to what extent one will be in a position to meet the high expectations one has. This issue is especially cogent since it seems very likely that in coming years an extensive national innovation will be programmed for Environmental Education which will be socially legitimized with the aid of that instrumental role. The required funds can only be acquired as a result of such verification. This means that the following questions have to be answered:

1. Which objectives must Environmental Education reach in education and to which objectives should the subject contribute?
2. To what extent can these objectives be achieved in education?
3. To what extent can the objectives that can be achieved accommodate the instrumental role of Environmental Education?

The first question, i.e. which objectives must Environmental Education reach in education, has already been answered in the Netherlands in several different ways. Considerable agreement in opinion has gradually become apparent in this connection. The objectives as formulated by the project group for Environmental Education for advanced secondary education (NME-VO, 1989) are now considered as being a useful start to further implementation and discussions.
The second question, i.e. the tension between the required objectives and the objectives that are actually attainable, is only seldom posed (however, refer to Boersma, 1989). An answer to this question, on the one hand, can have unintentional consequences in the sense that the interests of bodies providing subsidies could be restrained by this.
On the other hand, however, it seems rather useless from the point of view of the developers and the researchers to leave the subsidizing bodies with expectations that are much too high. As yet, the third question, i.e. to what extent the objectives that can be achieved can accommodate the instrumental role of Environmental Education, has not been posed. in other words: the instrumental role of Environmental Education has only been mentioned, but as yet there are no signs indicating that the proposition will be assessed within the near future. In this present contribution, provisional answers will be given to these questions.

The answers to these questions can be no more than provisional since (more) conclusive answers can only be given after much development and research work has been carried out.

The desired objectives for Environmental Education in Schools

Various answers can be given to the question as to what the desired objectives for Environmental Education should be. In the first instance, it can be concluded that, certainly within the last years in the Netherlands and in other countries (e.g. NME-VO, 1989; Maas Geesteranus, 1988; Boersma & Schouw, 1988; Breiting, 1988), Environmental Education has been expressly placed in the perspective of sustainable development.

Secondly, it can be concluded that Environmental Education should contribute to what is called 'the enlargement of the social fundament for the policy with regard to nature and the environment'. If these two objectives are combined for Environmental Education, in the first instance, several questions arise:

- What is sustainable development? Sustainable development is certainly not easily defined. It's meaning can vary from sustainable economical development to development based upon renewable resources. The policy with regard to the environment as it presently stands can certainly not be defined as being 'sustainable' in an ecological sense: the boundaries of the environment are still, to a large extent, determined by the economy and not the other way around.

- Enlargement of the fundament for an effective environmental policy can only mean that the government is being increasingly forced to realize an environmental policy that extends considerably further than is presently the case. In all, this will inevitably lead to disapproval of the current environmental policy and it doesn't seem realistic to assume that the present cabinet, or future cabinets will invest very much in their downfall. So, what does 'enlargement of the fundament ..' imply? Approval of the current environmental policy? Filling in the red square in time? Being prepared to make material or immaterial sacrifices?

As a consequence, it seems inevitable that Environmental Education is directed to the enhancement of 'environmentally justified' behaviour. We must all use energy more efficiently and separate different kinds of waste. Many have already contended this and the argumentation in support of this is evident: if we all act in an environmentally justified manner, environmental problems will, as it were, be automatically solved.

Environmental Education should focus upon environmentally justified behaviour: in other words, that people will need to make choices (from behavioural alternatives) which contribute best of all to sustainable development. In doing so, however, another problem occurs: problems related to the environment often have the structure of the 'prisoner's dilemma (Van Asperen, 1986): environmentally justified behaviour is only in the interests of the individual if everyone behaves in the same way. The chances that individuals will act on their on account, i.e. without such behaviour being imposed on them by the authorities, is therefore only very small. Moreover, in the long term, nobody benefits only from environmentally justified behaviour on an occasional basis. At present, the conclusion seems to be that promoting environmentally justified behaviour can only be effective in combination with a simultaneous government policy. Without that government policy, pupils are more or less deceived and environmentally justified behaviour would then lead to no more than just peace of mind. Extension of the fundaments just means that we must accept the environmental policy as it has been determined, together with all the possible effects it may have on our personal lives.

Of course, it could then be easily said that this does not necessarily contribute to sustainable development and that, from an ethical point of view, this would not be the right thing to do. Of course, on the other hand, this is the only way for changes to be effectively implemented. This is not possible without first establishing a sound fundament. Naturally, it is understandable that those who are concerned with Environmental Education from a pedagogical point of view are less inclined to stimulate such a passive form of support. They are more concerned with fine educational categories of objectives by developing values, or forming attitudes, decision making, or problem solving. These are the kind of educational objectives which have been frequently discussed during the last 20 years or more and the rhetoric of science education is full of it. We now see the same sort of rhetoric in Environmental Education. This is evident, for example, from pleas for 'environmentally literate persons', as the equivalent of 'scientifically literate persons'. The environmentally literate person is described as follows:
'... a citizen able and willing to make environmental decisions which are consistent with both substantial quality of human life and equally substantial quality of the environment. Furthermore, this individual is motivated to act on these decisions either individually or collectively' (Hungerfort & Payton, in: Breiting, 1988, p. 41).
A beautiful summarization. Account is taken of both the fundament and the pedagogical verification; in essence, it means that you make the right choices (and have the will to do so) and that those choices determine the way you act.

The reality content of the objectives of Environmental Education

When we are concerned with determining the content of reality of the objectives of Environmental Education, two courses can be taken: following the course of applying common sense and conducting empirical research. Both can result in a tempering of the rhetoric and that more realistic (and desirable) objectives can be formulated for Environmental Education.
Let us first address the level-headed question of common sense. Let us apply this to the objective of Hungerfort & Payton. What strikes us most of all here is that the objective is based upon a number assumptions. These assumptions can be expressed more explicitly and assessed accordingly. These assumptions are as follows:-

1. It is known which choices must be made when we are concerned with sustainable development;
2. A choice can be made between different ways of dealing with the environment;

3. Behaviour (as defined here) is determined by the cnoices one makes;
4. It is significant for behaviour to be acquired in school.

Let us attempt to assess the objectives.

1. <u>It is known which choices must be made when we are concerned with sustainable development</u>
   In the introduction, it was already pointed out that there is a great deal of confusion with regard to the concept 'sustainable development'. Moreover, it is often emphasized (e.g. by Soeteman, 1988) that the parameters of the concept are by no means clear or consistent. At this particular stage, we will probably come no further than defining a number of golden rules derived from various environmental reports, e.q. non-renewable resources cannot be called upon without the availability of alternatives or without compensating them in some other way.
2. <u>A choice can be made between different ways of dealing with the environment</u>
   Unquestionably, there are more ways of dealing with the environment. Some ways, however, are quite objectionable since they do not comply with the criteria for sustainable development. The problem here is the fact that choices for alternatives - or perhaps in particular those which are objectionable - are related to all kinds of people's interests and/or groups of people. Making certain choices therefore, does not only mean taking up a certain position, but also choosing 'sides' against your own interests or against the interests of the social systems of which we partake. The so-called 'prisoner's dilemma' already shows that this is difficult. In many cases, the 'side' one chooses is probably determined by the parents, the school, the work one does, the council and/or the government. Choices can sometimes not only be against your own interests, but more often than not, those choices can probably not really be made.
3. <u>Behaviour (as referred to here) is determined by the choices one makes</u>
   In all kinds of models for decision making and problem solving, procedures are described which must be followed in order to come to a decision and to implement that decision Such models assess the advantages and disadvantages of different alternatives, after which they are implemented. Such models are probably useful for solutions or approaches to certain technical problems, or as a procedure to be followed by process-sensitive leaders of discussions with sufficient authority. In many cases (at least), behaviour is not based upon rational considerations or argumentations (Margolis, 1987), but upon an 'acquired' meaning, strongly influenced or determined by that which is desirable in a specific context (refer also to (2)). The assumption in its general sense, therefore, doesn't appear to be tenable and rational models for decision making probably only have pragmatic significance within specific contexts. This is the reason why it is repeatedly suggested that an appropriate justification or argumentation is applied only after the choice (for behaviour) is made (Veen & Wilke, 1986).
4. <u>It is significant for behaviour to be acquired in school</u>
   Much of so-called environmentally justified behaviour only has significance within a specific context, e.g. in the home. Whatever the case, environmentally justified behaviour can only have partial significance within situations in school. Therefore, in schools, most efforts will be aimed at encouraging

environmentally justified behaviour in relation to contexts and it will only be partly possible to learn within contexts. Only fieldwork in the broadest sense offers this opportunity. Due to the fact that behaviour is certainly, in part, determined by the specific context in which it has significance, it seems doubtful what the significance of learning behaviour in the classroom is. From research conducted by Langeheine & Lehman (1986), among other things, it has become evident that education has no influence on environmentally justified behaviour in one's own surroundings. For the time being, the conclusion is that the learning of behaviour, i.e. acquiring skills, is only of significance only if it is related to the acquisition of instrumental skills like the care of animals. For the rest, it seems sensible to fall back on the argumentations of A.D. de Groot (1978) when he states that education should be aimed at developing a consciously applied repertoire of behaviour.

The conclusion must therefore be:
- that it is only known in broad terms which choices have to be made;
- that pupils can make choices (now and later) only to a limited extent;
- that the 'choices in relation to behaviour' are based on rational considerations only to a limited extent;
- that it is significant, only to a limited extent, to learn behaviour within a school-context;

Within the framework of objectives such as those defined by Hungerfort & Payton, 'decision making' often holds a very important position (for example, refer to Zoller, 1987). Research conducted within the framework of the development of the course module entitled "Fuel" for pupils in grade 3 at higher and advanced secondary level by the project group for Environmental Education at higher secondary level (de Jager & Van der Loo, 1990) may serve to illustrate how difficult it is for such objectives to be achieved. Decision making is explicitly implemented in this course module as an educational objective. In this project, a distinction is drawn between 3 different levels of decision making, namely:

1. pupils include arguments relating to environmental issues in the decisions they take (criterion: completeness of the analysis of the problem);
2. pupils can assess environmental measures to be taken correctly from an environmental point of view (criterion: completeness of alternatives);
3. after careful consideration, pupils take an environmentally justified decision (criterion: choice of the best possible solution);

The information collected was derived from interviews and discussion sheets which could be completed at home. Among other things, the research carried out visualized the following problems:
- pupils mention few measures to be taken to save energy which have consequences for their own behaviour;
- pupils mention fewer measures to be taken in relation to air pollution which require an adjustment of their behaviour than before;
- consideration on the basis of one criterion (fuel consumption) of simple measures like cooking on gas or by using electricity is a complex assignment;

- the consideration of issues not relating to the environment in choosing either the use of gas or electricity;
- an important consideration for reducing the maximum speed to 100 km/hour is road safety;
- pupils hardly seem willing to save energy if this concerns measures which affect their own comfort or when this affects their own pocket money.

On the grounds of these problems, it can be concluded that, as yet, the topic 'Fuel' does not result in pupils forming a complete or correct picture of environmental problems which result from the consumption of energy. Furthermore, most striking is the fact that pupils mention a lot of technical solutions and it appears that the pupils, when mentioning measures, have already made a pre-selection in the sense that they consider measures which they themselves must find acceptable. They are not very willing to mention measures which require an adjustment of their own behaviour. A good inventory of possible solutions hardly seems possible.

Despite the directness of the topic relating to aspects of the environment, when choices have to be made, other arguments than those relating to the environment determine the decisions taken and if no specific reference is made to environmental aspects, they are readily considered when decisions are taken. On the grounds of the above, the significance of decision making as an educational objective is questionable if, on the one hand, it is not self-evident that attainment level 1 is achieved and that attainment level 3 is really unsuitable as an educational objective on the other. Common sense and empirical research point strongly in the same direction: making proper choices and basing one's behaviour on those choices is an educational objective with a very doubtful reality content.

If this objective cannot be achieved with Environmental Education, the question remains how Environmental Education in schools could then contribute to such an objective. Let me (again) give several provisional answers and let me do this on the basis of the assumptions made.

1. Sustainable development
   - 1.1. Attention can be paid to the content (or contents) of the concept 'sustainable development';
   - 1.2. Attention can be paid to the necessity and possible consequences (for the personal world of the pupil, society) of sustainable development;
   - 1.3. Attention can be paid to the necessity to assess the effects of choices on their implementation once they have been made and, possibly, to adjust or to revise them.
2. Making choices
   - 2.1. Attention can be paid to the different ways in which to deal with the environment (and environmental issues);
   - 2.2. Attention can be paid to the context-dependency of choices and the importance attached to those choices;
3. Decision making/problem solving
   - 3.1. Attention can be paid to the way in which decision making actually takes place in relation to nature and the environment, both at an individual level and collectively;
   - 3.2. Attention can be paid to (a) decision making model(s) or model(s) for problem solving as models to guide decision making processes or problem solving processes, or to assess the way in which solutions are given and decisions are taken;

4. Own behaviour
   4.1. Attention can be paid to the influence of one's own behaviour (or collective behaviour) towards nature and the environment and, in particular, to the prisoner's dilemma.
   4.2. Attention can be paid to practicing instrumental skills in relation to the care of plants, animals and people;
   4.3. Attention can be paid to the context definiteness of environmental behaviour.

In order not to make too confident judgements at this stage in the development of Environmental Education, the formulation 'attention can be paid to ....' has been purposely chosen and is a formulation in terms of teaching and not teaching effects.

The content of reality of objectives in Environmental Education (…

With the adjustment of the position taken with regard to the desired objectives of Environmental Education, the question must now be answered to what extent these (or: this type of) objectives can be achieved. This question can be divided into 2 parts:

a. are educational strategies available which can result in the achievement of the objectives?

b. can the educational strategies be sufficiently implemented?

These questions cannot be discussed and answered in detail, since the required specific research and development work has hardly been carried out. I will suffice with broad answers:

a. The availability of educational strategies

In the Netherlands and abroad, not much research has been carried out with regard to educational strategies specific to Environmental Education. Certainly in the Netherlands, most of the relevant research in this field is related to concept development in physics and chemistry in which emphasis is laid upon the fact that effective educational strategies must be largely concept-specific, due to the role of preconcepts with regard to learning specific concepts of teachers and pupils. Up until the present, concept-specific research for Environmental Education has hardly been undertaken. Until such research is undertaken we will have to suffice with models of a more general nature like that of Licht (1988).

The research and development of educational strategies in other psychological dimensions or fields, such as the development of values (refer to Delhaas et al, 1990) has only been undertaken to a very limited extent. And very little attention has been paid to the development of educational strategies in which the various psychological dimensions and fields have been correlated after the development of the concept 'confluent education' (Brown, 1975), certainly at higher secondary education level. As far as the availability of effective educational strategies is concerned, as yet, it must be concluded that there is hardly any reason for an optimistic view.

There are very few strategies available for Environmental Education which are specific to nature and the environment and most realistic therefore would be to collect and use strategies which are used in adjacent subject-related didactical research or which have resulted from that research. As yet, it seems that no more can be guaranteed than 'knowledge and insight'.

Pupils can acquire knowledge and insight with the use of educational strategies such as those which have already been used and criticized by many for a number of decennia.

b. The implementability of educational strategies
As yet, there seems to be hardly any reason to assume that educational strategies in which teachers are required to act in a considerably different didactical manner than they are accustomed to can be easily introduced. At present, it looks like this can probably only be done if, when it is introduced, use is made of written (lesson) material in which the teacher is given more precise and clearer instructions on didactics by way of procedural specifications (Van den Akker, 1988).

As yet, the conclusion must therefore be:
- that there are hardly any effective educational strategies available;
- that there is hardly any reason to assume that if they were visible they would also be easily implemented.

An important choice (also politically) must be made in this respect. If the effectiveness of Environmental Education is to be increased, this means that a lot will need to be invested in the development of implementable educational strategies and their actual implementation.

The instrumental role of Environmental Education

On the grounds of the previous paragraphs, it can be easily argued that high expectations with regard to the instrumental role of Environmental Education are not very realistic. That conclusion is also justified and therefore must be drawn.
Nevertheless, on the other hand, it is an illusion to assume that the instrumental role of Environmental Education in schools is easily demonstrated. Environmental Education in schools will never be the sole instrument for an effective policy with regard to nature and the environment. It only has significance in combination with other instruments (such as information, legislation, subsidies, etc.,) and events (such as environmental calamities/disasters and the press reports on such events) and as soon as there is a sufficient basis for nature and environmental policy, it can be stated that that is partly due to the teaching of Environmental Education in schools. Besides, Environmental Education in schools is the only policy instrument with which issues relating to nature and the environment can be addressed structurally and over a longer period of time.
Environmental Education in schools is the only instrument with which a minimum line can be set for all present and future citizens. This is a way to ensure that all citizens in the Netherlands can be held responsible for contributing to future policies concerning nature and the environment. From a political point of view, one is not primarily concerned with the resultant effects of Environmental Education in schools, but with the insurance of a minimum teaching content in school curricula. In our present society it is customary to consider the successful attainment of examinations as a guarantee for quality, partly on the grounds of their civil effect. The actual question with regard to the resultant effect is not posed, i.e. what the significance is of what the pupils have learnt, both for their own benefit and for the benefit of society. If Environmental

Education is incorporated into the school's curriculum and school examinations, the instrumental role of Environmental Education is then sufficiently guaranteed.

Didactical experts, curriculum developers and researchers find this an extremely dissatisfying state of affairs. This is why they are always the first people who contend repeatedly that more relevant aims must be formulated and that a lot of development work and didactical research has to be carried out. Most tragic of all is the fact that, although they might be right, nothing is being done about it. Moreover (and they seldom realize this), the extensive development of Environmental Education in schools benefits from upholding the line of distinction between the actual and the required situation. Rhetoric is necessary. So. let us remain convinced of the assertion that it is necessary that Environmental Education in schools will contribute to forming a sound fundament for sustainable development. We haven't got that far yet, but we must, or rather: we could at least do considerably better than at present. This cannot be disputed and if our rhetoric is both clear and loud enough, we can be assured of the fact that we could do better. Environmental Education in schools will have to remain fiction, at least for a part.

Literature

Akker, J.J.H. van den en W.A.J.M. Kuipers (1987), Natuur- en Milieu-educatie in het onderwijs. Selecta Reeks, SVO, 's-Gravenhage.

Asperen, T. van (1986), Milieu en overheid. In: W. Achterberg en W. Zweers (red.). Milieufilosofie tussen theorie en praktijk. Van Arkel, Utrecht. 175-193.

Boersma, K.Th. (1989), Dream and reality in environmental education. Paper on behalf of the 5th. International Symposium on World Trends in Science and Technology Education, 11-20 December 1989, Manilla, Philippines. SLO, Enschede.

Boersma, K.Th. en J.C. Schouw (1988), Tussen natuur en milieu. Uitgangspunten voor een didactiek van natuur- en milieu-educatie. SLO, Enschede.

Breiting, S. (1988), Sustainable Development and the Ideological Foundation of Environmental Education.
In: IUCN (1988). Sustainable Development - Learning for Tomorrow's world. International Conference on Environmental Education, Telemark (Norway), June 8-10, 1988.
Institue for Environmental Analysis/Telemark College.

Brown, G.I. (1975), The Live Classroom. Viking Press. Ned. vertaling (1975): Leven in de klas. Boom, Meppel.

Delhaas, R., H. Koekkoek en T. Akkerman (1990), Kijk, de caleidoscoop beweegt. Keuzemogelijkheden voor waardenvormende natuur- en milieu-educatie. SLO, Enschede.

Groot, A.D. de (1978), Wat neemt de leerling mee van onderwijs? Gedragsrepertoires, programma's kennis-en-vaardigheden.
In: Handboek voor de onderwijspraktijk, 2.3., Groningen, B1-B18.

Jager, H. de & F.A. van der Loo (1990), Besluitvorming als onderwijsdoelstelling. Onderzoek rond het NME-VO lespakket Brandstof (in preparation).

Langeheine, R. en J. Lehman (1986), Die Bedeutung der Erziehung für das Umweltbewustsein. IPN, Kiel.

Licht, P. (1988), De beproeving van een onderwijsstrategie voor de ontwikkeling van natuurkundige begrippen. Paper ORD 1988 te Leuven.

Maas Geesteranus, Chr. (1988), Sustainable Development - a Challenge to Education: The Brundtland Report - a new Challenge for Education. In IUCN (1988), Sustainable Development - Learning for Tomorrow's world. International conference on Environmental Education. Telemark (Norway), June 8-10, 1988, Institute for Environmental Analyses/Telemark College.

Margolis, H. (1987), Patterns, Thinking and Cognition. A Theory of Judgement. University of Chicago Press, Chicago.

Ministeries van Landbouw en Visserij, Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer (1988), Nota Natuur- en Milieu-Educatie. Een meerjarenvisie. Staatsuitgeveruit, Den Haag.

NME-VO (1988), Deelleerplan NME-VO. Deelleerplan natuur- en milieu-educatie voor de vakken aardrijkskunde, biologie, natuurkunde en scheikunde in de leerjaren 1-3 van het voortgezet onderwijs. Rijksuniversiteit Utrecht.

Soeteman, F.J. (1988), Ecologische duurzaamheid en economische ontwikkeling. Council for Environmental and Nature Research, Amsterdam.

Veen, P. en H.A.M. Wilke (1986), De kern van de sociale psychologie. Van Loghumn Slaterus, Deventer.

Zoller, U. (1987), Problem-Solving and Decision-Making in Science Technology-Environment-Society (STES) Education.
In: K. Riquarts (ed.) Science and Technology Education and the Quality of Life. Vol. 2, 562-570.

2.2 Goals and contents - How can they be assessed?

Joop van Dormolen

Introduction

This paper is intended as a posterior consideration of the ways and means by which a group of authors (Werkgroep Zestien Min/Zestien Plus) have come to define objectives and contents for a new series of student textbooks for mathematics for grades 7 to 12 (Wiskunde Exact, vol. 1mhv, 2mhv, 3m, 3hv, 4m, Meulenhoff Educatief, Amsterdam 1986-1990). It is not a historical description of the way the group worked, but rather a reflection on the result of its work and, thus, an attempt to generalize certain experiences while defining objectives and contents. The group consisted of teachers of mathematics and teacher trainers.
This paper does not contain a description of the development from a heterogeneous set of persons with different and often opposing ideas about mathematics to a group in which different skills and knowledge could be taken and used as an advantage. Although, what is written in this paper about objectives and contents might seem the result of a smooth decision process, much of what was produced was the result of long and difficult discussions and attempts on the part of the group of authors. It is our contention that any new group of writers of a mathematics course should spend ample time on the development of adequate group processes.
Initially, the position of the group, like most groups of authors in the Netherlands, differed from other groups of curriculum developers because they were required to adhere to the current curriculum. In one sense this was an advantage because the group had no difficulty in deciding upon the minimum mathematical content of the course. In plain terms, the requirements for the final examination should include this minimum curricular content which the students in question should meet on completion of their schooling.
On the other hand, the current curriculum was also felt as a restraint, because the group denied the importance of certain subject matter that is part of the curriculum and felt this could hamper the development of the course. In the long run, however, this fact forced the group into intensive searches for useful material, both mathematical and non-mathematical, in which the challenged subject matter could play a significant role.

Objectives versus values

For several reasons, the group decided not to commence with the development of the course by defining goals and objectives. Firstly. this was because of a tendency to consider goals and objectives as 'absolute' once they have been chosen. This resulted in a paralyzing effect, comparable to the well-known centipede metaphor: Ask a centipede in which order it moves its legs and it cannot walk any further. Much in the same way, the group seemed to be unable to produce drafts for students' texts, because it was feared that they would not satisfy the standards required by the objectives. Another reason was that defining objectives seemed to suggest that the development of educational material is a deductive process, which is not the case. One cannot deduce the content from the objectives. The defining of objectives makes one aware of how and where one would like to finish. One cannot deduce from them the roads through which one should travel to attain that finish. The next section will show an example to clarify this view. However, these reasons seem to be more or less of a technical nature. In fact, objectives are more profoundly built upon a set of values. Values are chosen subjectively, but not always consciously. It was discovered, for example, that drafts of student texts were not felt satisfactory for some reason, although they tended to be aimed at the required objectives. Facts like these led to the conclusion that it was more important to state explicit values as starting points, rather than goals and objectives as final attainment targets. In plain words: "What we find important" seemed to be more essential to the growth of the group than "What is the final aim?'. A set of objectives appeared to be one of several other aspects of "What we find important".

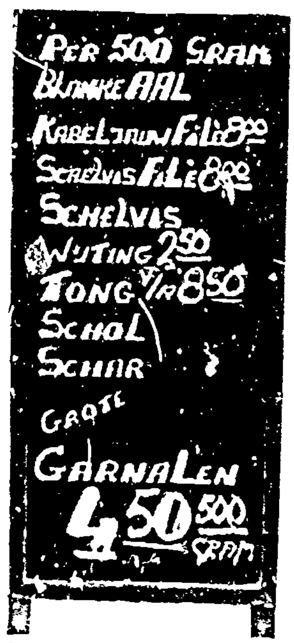
Values: an example

The choice of content and objectives depends on many different values. Not in the least on the value of feeling responsible to instruct students well enough to put them through examinations. In this way, almost every step we take in teaching seems to depend on values. Most of these are hidden values, and more often than not, one is unaware of their presence and their use in one's own decision-making. However, it is necessary that some of the values become explicit in order to make decisions on what, how, why, when and whom to teach. Only then is one able to choose content and objectives, and if one does not know from where to choose, one must have a strong indication as to where to search for it, in corners other than those of the official curricula and in existing textbooks. Here is an example (all examples are taken from Wiskunde Exact).

fig. 1

a

b



c

You often can calculate with numbers. but not always. The numbers on photograph a are not used for calculations.

- How are these numbers used?
- What about the numbers on photographs b and c.

The intention of these pictures (and the accompanying text in the book) is to make students aware of the difference between numerals and numbers. In the English language, the word 'number' is used in many cases where 'numeral' would probably be more appropriate. In the Dutch language, we have something similar. The authors wanted to start from situations outside of the mathematics environment. In this case, it was not difficult. Many instances can be found and it was hard to restrict the choice to these three examples. With which values were we concerned in this particular case? There are several, all of them given here in random order.

- We find it important to help young people to develop in life so that they have power over their own abilities and can cope with the situations they meet with. One of many possibilities is to learn to perceive the world 'with knowing eyes', instead of allowing the world envelop you in a flood of intuitive experiences.
- In order to have this power and to develop these 'knowing eyes', one must acquire certain skills. In this case, the skills involve communicating mathematical notions and evaluating phenomena that appear to be mathematical. We call them values of general mathematical objectives.
- In order to write texts and to teach, we should be more precise than in the generalizations mentioned above. In particular, we must say something more about the mathematics involved. Mathematics has several aspects. For example, we might stress the aspect of algorithmic skills and understanding, or we might at a certain moment want to focus more upon the conventional aspect, such as how to write things down. In the case of numbers and numerals, we find it most important that the reader understands the difference between the two. This is a theoretical or structural aspect. Presently, more will be written about other aspects.

Principles as a junction of values

What was described in the last section certainly relates to values. What is difficult in appreciating them, however, is their seemingly accidental occurrence. It seems as if they occur by looking around and if one discovers something that might involve mathematics, one derives values from it. Instead of applying principles which occur incidentally, a group of developers needs to have a set of principles that act both as starting points, as well as the ultimate assay of the product. In this sense, this would be a guide for the authors during the group's work. The group has chosen the following principles.

1. The material has to be presented within a realistic context of situations recognizable by students and, in addition, problem solving and an active participation of the students should take up a more central position.
2. Mathematics is useful.
3. Students must be able to acquire a good idea of their individual capacities for learning and applying mathematics.
4. The material must comply with examination requirements.

Some remarks about the principles selected

All principles have both idealistic and practical components. The idealistic components follow from a general belief that school education should be focused upon helping students to prepare themselves for their life as adult citizens in society. The practical component is based on the expectation that the principles promote the production of learning material that can motivate students, and that motivated students learn better. This expectation also supports the idealistic component in the sense that it is felt to be important that students, as normal human beings, should be able to do things that are significant to themselves.

The word 'realistic' in the first principle, requires further clarification. We contend that the word is neither synonymous with 'from daily life', nor with 'authentic'. In our view, a realistic situation is a situation which somebody can recognize on the basis of his or her own personal experience and can identify with. In that sense, fantasy, like fairy tales, as part of ones own personal experience, can be realistic for that person, whereas large parts of daily life may not be experienced as realistic at all. Moreover, in most cases, a situation must be made realistic by means of a well-chosen description of the problem in question.

The second principle does not imply that all mathematical content must be considered as a technological instrument for the solution of non-mathematical problems. The principle expresses the opinion that subject matter, however interesting and problematic it may be in itself, must also be useful and usable to solve new problems, either mathematically or not mathematically.

Teaching mathematics as being useful has very much the same underlying ideal as the first principle: students should be exposed to subject matter which they feel has some use for some reason or another. In this sense, mathematics that gives a person pleasure is also useful to that person. Moreover, it is also useful in the sense that it gets people acquainted with a subject that plays such an important role in our society.

The third principle concerns the same idealistic and practical component as the first. In order to be able to live more or less independently in a democratic society, one ought to be aware of one's own aptitudes, abilities and restrictions. We believe that many students drop out of mathematics because they are convinced of their mathematical deficiency, whereas in many cases, the true cause of their inability to understand mathematics has much more to do with the sequencing of the content and the fact that they are often forced to work at too high a level of abstraction.

This means that students must be given the opportunity to reflect on their own learning process.

Criteria for teaching material as a consequence of values

Principles like the four above are fundamental, but they appeared not to be practical enough for the benefit of the consistent assessment of the quality of learning material. A more detailed list of criteria was required in order to achieve this. This list consisted of five categories, each divided into further subcategories.

1. Objectives
   - Subject matter
   - General objectives
   - Mathematical objectives
2. Mathematics content
   - Correctness
   - Aspects of mathematics
   - Authenticity

3. Sequencing of content and objectives
   - learning content
   - personal development
4. Adaptation of the content to students' abilities and knowledge
   - Instructional activities
   - Short term sequencing
   - [nguage
   - Text management by students
5. Drawing up a framework of conditions
   - Teachability
   - Implementation

Objectives

In the first example, something has already been said of the first category. Here is another example which involves criteria relating to both general and mathematical objectives.

fig. 2

25 Park van motorvoertuigen, bromfietsen en fietsen

	1975	1980	1981	1982	1983
	x 1 000				
Motorvoertuigen (1 aug.) totaal	3 809	4 993	5 095	5 140	5 243
w.v. personenauto's	3 399	4 515	4 594	4 630	4 728
bedrijfsauto's totaal	342	375	387	388	390
w.v. vracht- en bestelauto's	301	311	316	317	322
trekkers (voor opleggers)	18	23	22	24	24
speciale voertuigen	13	31	37	33	33
autobussen	10	11	11	11	12
motortweewielers	66	103	114	122	125
Bromfietsen	1 650	814	724	674	634
Fietsen	8 600	10 580	10 784	11 115	11 443

- How many motor vehicles were in The Netherlands on August 1, 1983?
- How many of them were passenger cars?
- Could there have been 4 728 173? Or 4 727 941? Or 4 728 658?
- What other kinds of motor vehicles were there according to the table? If you add the numbers of the different kinds, do you get the number of the first question?

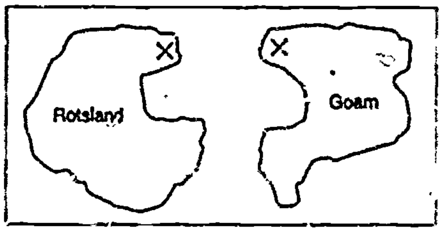
This is one of the many exercises in which one can see an attempt toaim at the general objectives of emancipation. Reading complex tables like this one, and realizing what all these numbers mean, is one way, among many others, of helping students to become independent and critical members of society. In addition, they also learn to appreciate mathematics as a means to become such a person.

Now a remark on subject matter: the relevant criterion is not subject matter as such, but the importance one attaches to it and the choices one makes. This is also true for the two kinds of objectives.

Mathematical content

In mathematics, we have chosen three kinds of content. Correctness is less trivial than it seems. Correctness does not relate to typing errors and mistakes. In actual fact, we often decide that we cannot be as precise as we might like to be from a mathematical point of view because we expect that students will not understand us if we are. So do we compromise, or do we have a genuine didactical means of teaching a certain concept? Look at the drawing of the two islands.

fig. 3



Hans is living on Rockisland; Mieke on Goam. They like to see each other every day for a short while. They stand at the crosses. There they can't see each other.

● Would you stand there too? Draw the place where you would stand.

This problem is one of the first of a sequence leading up to the concept of distance. We assume that the students understand (intuitively) what the distance between two points means. We want the students to learn about the distance between two figures and then, as a special case, about the distance from a point to a straight line. Is it correct to talk about the distance between two figures without explaining what a figure is and without defining what the distance between two points is? We think it is, and will come back to this point later in this discussion when we describe 'sequencing'.

We recognize five aspects of mathematics. The theory has already been mentioned (we prefer to call it structure). Next, there is the necessity to have good algorithmic skills, so algorithms are yet another aspect to be considered. In a sense, the counterpart of structure is logic. Stating definitions and theorems and understanding them is a theoretical aspect, while using them to prove a theorem is an aspect of logic. Authors and teachers have to decide how and to what extent they must teach students to understand and to apply logical rules. The next exercise is concerned with several mathematical aspects.

fig. 4

● What differences and what similarities do you see in these two pictures?

There is a logical aspect, because we want students to learn to make a distinction between relevant and irrelevant arguments. There is also the aspect of methods. In this case, there is no algorithmic way in which to find an acceptable answer to the problem. But students can learn to deal with the subject in a more or less rational way. For example, they could realize that there are several different ways in which they could talk about differences and similarities: form, color, environment, dimension, life form, etc.

Finally, this problem was incorporated in the textbook because we want students to realize that mathematics, just lik all other subjects, has a strong conventional aspect.
When one reflects upon and discusses several answers to the problems, one discovers that some differences are not considered important to others. The only way to solve this is to reach a conventional agreement.

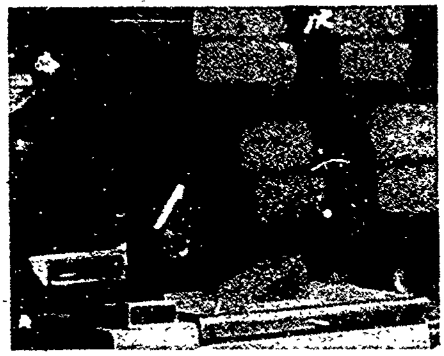
So much for the aspects of mathematics. Authenticity of mathematics has a special meaning in our group. We consider mathematics as a dynamic activity in which kernels and problem situations complement each other. Kernels are statements from bare mathematics, like definitions, theorems, algorithmic rules, conventions, etc. Problem situations give us good reasons to make such statements. In t' exercise involving the two islands, a problem occurs. We want the students to realize that there is a reason to talk about the distance between two figures. We did not just want to explain to them what is meant by distance, either by definition or by giving an example.
There are two other reasons why we bel..eve it is important to take problem situations both as starting points to learn new kernels and as applications afterwards. Both reasons relate to motivation.
The first reason is a tactical one. Psychologically, one is more motivated to learn and to make an effort to learn when one recognizes the problem as such. So this might make a teacher's job easier.
The second reason is an ethical and idealistic one. When interrelating with people respectfully, one is obliged to make them aware of why you want to teach them something instead of just telling them to do just what you say.

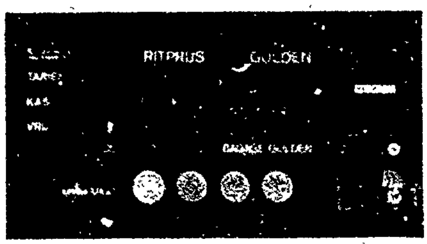
Sequencing of content and objectives

Sequencing has to do with long term planning. This planning can be viewed in two ways. One way is to look at the course learning content takes. It is simply the planning of which topic should be learnt prior to another. For example, we want students to understand the concept of variables before they learn about the use of algorithms for solving equations. One of the many difficulties in planning the sequence of subject content is that it is not unique. This has already been illustrated in the example used to describe distance. Another example is the concept of variables and the ability to solve equations. We want students to understand the concept of variables before they learn to use algorithms for solving equations. However, some types of equations can be solved without understanding the concept of variables. To a certain extent, this is even possible without losing oneself in senseless rote learning.

Another way to look at sequencing is to consider ways of personal development. This has to do with the way people learn concepts. Theories of learning by Piaget, Ausubel, Van Hiele, Vigotskii, Skemp and others, and not in the least experiences of teachers in the classroom, make us aware that, generally speaking, we cannot teach explicit kernels (definitions, rules, theorems and the like) unless our students are ready for it.
In collecting material for our textbooks, we rely very much on Vigotskii's idea of zones of proximate development. The next example explains how.

fig. 5





a. weight $\longrightarrow \boxed{} \longrightarrow$ price

b. distance $\longrightarrow \boxed{16\text{-}(\text{distance-}4)2} \longrightarrow$ height

c. distance $\xrightarrow{\text{minus 4}}$ .... $\xrightarrow{\text{square}}$ ... $\xrightarrow{\text{deduct from 16}}$ height

The temperature can be calculated with the function:

height $\longrightarrow$ 16 - 6 x height

This diagram shows the way we discuss variables and functions. The examples are taken from different places in the course. Whenever possible, we want students to learn concepts through gradual development. This idea has been developed in particular with the concept of variables and function. Why do we believe this is important? Because we are convinced that the most important reason for not understanding mathematics is the bad preparation with regard to the concept of variables. By slowly and gradually allowing the students to get acquainted with the phenomenon of variability, closely related to phenomena that they know in reality, we put as it were, the idea into their heads. Not before having worked with variables in many problem situations, do we help them to realize this and to make it more explicit. In this particular case, students begin to work on page 9, vol. 1, with variables. However, variables are not made explicit until page 165. We call this way of using the theory about the zones of proximate development implicit gradual development.

Here is another example of implicit gradual development of the concept of variables. The picture shows two apartment buildings, one behind the other, facing the south.

fig. 6

In summer each floor of these apartment buildings get sun at noon.
The distance between these buildings is computed as follows:
distance = 2 x height
● Do people on each floor get sun in winter.

It is also an example of the criteria of general and mathematical objectives as we saw in the example of the table of motor vehicles.

The same principle of gradual implicit development applies to the concept and the symbolic form of functions. Here, we have a complication. The traditional symbolic form, as in the example in the diagram above, is an unfortunate one. There is no clear distinction between the output and the prescription of the function. We deplore this because this must also be one of the reasons why so many students have no understanding of the concept. In the beginning of our text (see example a in the diagram) functions are called 'calculator boxes', because of the way in which they are closely related to calculators, automatic weighing machines, petrol pumps, etc. with which students are well-acquainted. In the symbolic form, one sees a clear distinction made between input, output and prescription. At first, the box is black, like in a. In b, one knows what the box does. In c, there is a transition to a more abstract symbolic form. Unfortunately, teachers have to teach a still more abstract form too.

One last example of the use of implicit gradual development - in the example of the two trees, the students implicitly learn to realize that it is important to agree on how two things differ and in which way they are similar.
This applies to many things, such as congruence and similarity in geometry, but also to equivalence of fractions, the equivalence of equations, the way we draw two dimensional pictures of three dimensional bodies, the "equality" of expressions like
$\underline{a} * \underline{a} * \underline{a} * \underline{a} * \underline{a} * \underline{a} + 1$ and $\underline{a}^6 + 1$ on the one hand and
$\underline{a} * \underline{a} * \underline{a} * \underline{a} * \underline{a} * \underline{a} + 1$ and $\underline{a}^5$ on the other, etc., etc.
Consideration of differences and similarities is an important methodological aspect of mathematics.

Adaptation of the content of the students' abilities and knowledge

It means that a decision has to be taken on how and when we want to adapt our teaching to the students' abilities and interests. In the category of sequencing, this is done through long term planning. Here, we consider the short term planning of the subject matter. One way to do this is to decide on the kind of instructional activities we want the students to do.
Another item in this category is short term sequencing. The example of Hans and Mieke was taken from of a series of exercises in which the students learn about distance. When starting to get acquainted with a problem situation, the students have to select different ways to talk about distance and finally to arrive at an explicit description of the distance from a point to a straight line.

Similar remarks can be made about the example of numerals and numbers.
Here is another example. We wanted the students to learn about determining places in a grid by way of polar coordinates. We ask them to imagine that they are at the position marked on the map with a star and that there is a thunderstorm.

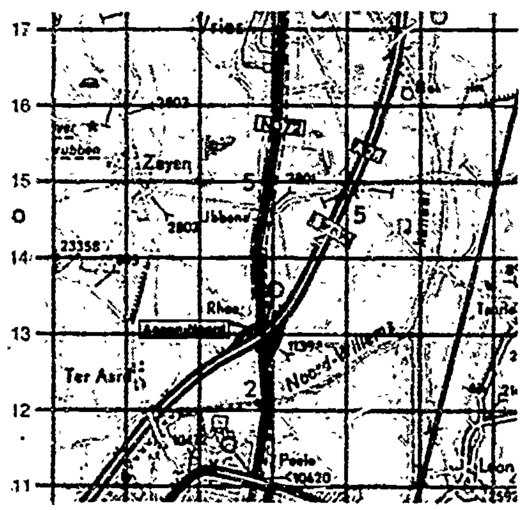
fig. 7

- Draw the three lines.
- Can you decide something from these data about the direction of the thunderstorm?

time	direction
4.17 p.m.	163°
4.19 p.m.	233°
4.22 p.m.	264°

The actual lightning is some kilometers away and the problem situation is to determine where. The students are given the table:

fig. 8



After this, the text goes on to the situation in which one can determine a place on a grid when one knows the direction and distance. This example, like all others, also has to do with decisions about the instructional activities of the students, like examining, representing, transforming, proving, applying, measuring, etc. Another important issue is the way authors and teachers use language. Here we have to answer questions like:

- Do we use complex sentences and, if so, in which situations?
- How much information and how much superfluity should we put into our texts? Do we use verbs that imply an activity, or verbs that describe existence? For example, instead of saying: "Draw the shortest possible line from this point to that line and measure it. Now you have measured the distance from the point to the line", one could write: "The length of the shortest possible line segment from this point to that line is the distance from the point to the line".
- Another problem in texts is when and where to use metaphors. The calculator box is clearly a metaphor for function. In which situations do people learn something from metaphors?
- The last item on this list is text management by students. This has to do with the implicit or explicit didactical agreement the author (or the teacher) reaches with the student. Very often, such agreements are implicit. Do we expect students to answer the second question just with a "yes" or a "no" in the example of the thunderstorm, or do we want an explanation from them? If we make such a choice, shouldn't we tell the students about it? Or do we want them to decide for themselves? And if so, how do they know that we want them to decide for themselves? This kind of question should be answered before sending text manuscripts to the publisher.

Drawing up a framework of conditions

The last category is concerned with the framework of secondary conditions, such as the ability to teach and to implement. These values have to do with the necessity that teachers understand and accept the underlying principles, objectives, values, didactical methods, mathematical content, etc., with the possibility of finishing the book in time, with being acquainted with the existence of the book, with the price, etc. etc.

Remarks

A person's set of personal experiences is a good starting point for learning. It must be understood that this set does not just result from experiences in the outer world, which is usually referred to as 'daily life'. One's personal world also consists of imaginary experiences, or experiences that can easily be imagined. In other words, subjective reality is not congruent with authenticity. This was a great help for our author group, because it took away the necessity of spasmodically trying to find things that really occurred. In the above examples, I have given examples of fictional situations, like in the example of Mieke and Hans on their respective islands and like the thunderstorm and apartment buildings. For students, fictional situations like these are real. The social environment of students is a great source for teaching mathematics, not only for practical reasons. since one can expect the students to understand better and become more interested in learning the subject matter involved, but also for ethical and idealistic reasons. It depends both on the teacher's and the author's set of values and when and in which way each of these reasons are significant to their students.

literature

On can find more about the issues raised in this paper in:

Dormolen, J. van (1986), Textual analysis, in: Christiansen, B. et al, Perspectives on Mathematics Education, Reidel Publishing Company, Dordrecht. And also in other chapters of the same book, together with extensive bibliographies.

2.3 Introduction to the teaching of technology in Dutch secondary schools

A survey of the development of Goals and Content for technology education

Jenne van der Velde,
National Institute for Curriculum Development (SLO), Enschede

Introduction

It is highly probable that Technology will be introduced as a subject in secondary education in the Netherlands within the next few years. The new government intends to introduce a package of fourteen subjects starting on August 1, 1991. The objectives or attainment targets for the subject will be described centrally. Technology is one of the fourteen subjects. Although there was a possibility for schools to include technology in the curriculum before, a legal framework has now been devised to introduce the subject in schools.
This introduction was preceded by a long period of problems, hope and frustration. The start of this period is hard to identify. In 1973, schools for vocational education were given the opportunity to address technology in a different way than just as a preparation for a technical profession. The name of this subject was General Techniques. In 1980, the Institute for Curriculum Development was given the assignment to develop a curriculum proposal for Technology in secondary education. This appears to be the prelude to the overall introduction of technology in the curriculum.

Phases in the introduction of Technology

Looking back on the development and introduction of the subject Technology in secondary education, two successive periods can be distinguished: firstly, the introduction of Technology as a generally formative subject in the vocational part of secondary education and secondly, the introduction of Technology in various types of secondary education. Schüssler divides the first phase into two phases: the prologue and the pioneering phase. The first period ran up until 1980. In total, seven phases can be distinguished in past and future developments.

- the prologue (up until 1973)
  A period of deliberation led to the introduction of General Techniques in the vocational part of secondary education;
- the pioneering phase (1974-1979)
  Vocational schools started to introduce General Techniques under unfavourable circumstances, having no curriculum examples and no textbooks. In many cases, General Techniques seemed to be a preparation for other subjects in vocational training. Some schools developed a more integrated approach;
- project phase (1980-1983)
  In 1980, the Institute for Curriculum Development started the General Techniques project which resulted in a curriculum proposal in 1982. This proposal was based on the concept that education in Technology should prepare pupils for living in a

society in which technology plays an essential role. The proposal can be considered as the first broad legitimation of the introduction of Technology as a generally formative subject in secondary education. A special Working Group submitted proposals to the government to split up the subject Technology into Technology and Care. This proposal was accepted;

- policy phase (1984-1987)
  In this same period, some important decisions were made. Technology will be introduced in all types of general education. Elements of "Care" (the subject house economics/health care) will be incorporated into a separate subject. A number of important publications accompany this process:
  - "Techniek in het onderwijs" (Technology in education") by the NKSR (1984),
  - "Proeve van een Concept-Ontwerp Ontwikkelingswet Voortgezet Onderwijs" ("Trial of a Concept Development Law Secondary Education") (May 1984),
  - "Techniek en Verzorging" ("Technology and Care") by APVO (January 1985),
  - "Wat zouden ze krijgen in het voortgezet basisonderwijs" ("What would children be offered in further basic education"), a proposal for elements by the SLO (November 1985),
  - Working Documents Basisvorming (Basic Education) by the WRR (December 1985),
  - "Techniek binnen de Basisvorming" ("Technique in Basic Education") by a Working Group chaired by inspector M. Visser (December 1985),
  - "Leerplanvoorstel Techniek deel 1 en 2" (Curriculum Proposal for Technology parts 1 and 2") by the SLO (1986-1987),
  - The WRR report "Basic Education" (1986).

  A stream of government notices shows that the introduction of Technology has now become an irreversible process;
- broadening phase (1987-1990)
  Objectives for Technology are being developed. The introduction of Technology has been delayed because of a change of government. Its introduction is now planned for 1991. Many schools start orientating on Technology. A part-time teacher training course in education in Technology was started. Some publishers hesitantly take steps to start developing textbooks.
  At the end of this period, approximately 20% of all schools will have introduced Technology in the curriculum.
- introductory phase (1991-1995)
  It is expected that Technology will be introduced in 1991. About one third of all schools already have a Technology classroom. The introduction is guided by experienced institutes. Educational publishers will provide textbooks. The objectives for technology will be transposed into annual programmes.
  However, a number of problems still remain, like the problem of girls in technology education, differentiation of levels, the introduction of new technologies, classroom organization, minority groups and pupils who do not accomplish the general level. The need for the extension of the number of hours allocated to lessons in Technology will be recognized, mainly by the growing role of computers in industry and because problem solving is considered as an important pillar for programme development. The development of assessment methods will also remain a problem;

- completion phase (1996-2000)
  Technology will be generally accepted as a school subject. The function of Technology as a subject preparing pupils for further education will become increasingly important. There will be a small improvement in the position of girls. New technologies will be introduced in Technology education. Educational software will also be developed. There is still an increasing need for the extension of hours allocated to lessons in order to realize problem solving as an objective.

Features of the subject Technology

A remarkable stability can be seen in the description of features of Technology. Of course, there are differences in concrete elaborations. The most striking differences can be seen in the absence of "care" related topics in Technology education. Didactical differences also exist. However, we will not pay further attention to these differences.

We will now mention some of the features of the subject Technology according to the centrally developed objectives (= attainment targets) for Technology.

Description of Technology within the framework of basic education at secondary level.
The advancement of technology is a pluriform phenomenon which greatly affects society. On the one hand, it affects a person's immediate environment, and on the other hand society as a whole. This advancement is brought about my man himself. Both society and the individual are, to a certain extent, capable of directing the development of technology, i.e. technology and society affect each other and vice versa. Following in the footsteps of its neighbours, the Netherlands feel the need to prepare its citizens for functioning in a rapidly developing technical culture and society. The education system can contribute to this.

Technology in relation to the starting points of basic education at secondary level.
The WRR report (WRR = Scientific Council on Governemental Policy) entitled "Basisvorming", i.e. "Basic Education at Secondary level", distinguishes three types of basic skills and knowledge which apply to all subjects:

a. knowledge of the cultural heritage with which each individual should be acquainted;
b. knowledge and skills necessary in order to function properly in our present society;
c. knowledge and skills necessary for advanced studies or further vocational training.

All elementary teaching subjects should deal with the three categories of basic skills and knowledge mentioned above.

a. Cultural heritage.
   Technology as part of our cultural heritage implies that the pupils gain access to the communality of knowledge which forms an essential part of our culture. Such access can be gained by processing materials and examining the design and operation of tools and utensils. Specific attention to the historical

development of Technology can broaden the individual's understanding of the position of Technology and technical developments in our present society. It can also widen the insight into how and why the sophistication and innovation of technical products are achieved. Technology is a product of human activity which has both a past and a future. Existing knowledge and available means and methods form the basis for a continuing process of elaboration.

b. Social Functioning.

Education in Technology focuses upon the pupil's social skills which are useful and of value in everyday life. Pupils are increasingly confronted with Technology in all possible forms. It is therefore of great importance to create order and to acquire practical knowledge and skills so that pupils will be able to cope with everyday life, both in the present and in the near future, also by means of increasing their capacity of judgement. The world of the pupil, with the differences which exist in that world for boys and girls, will form the principal point of departure from which a selection can be made from the wide variety of technical products. Because we are basically concerned with the education of 12-15 year-olds, the curricula will be based on context-orientated education in which the choice of context is such, that pupils will be able to recognize and experience the relevance. The following contexts were chosen for these proposed attainment targets:

- the environment in which we live;
- work and profession (including medical technology);
- leisure;
- transport and communication.

c. Further education and professional career.

Because education in Technology contributes to the discovery and development of the pupil's personal capabilities and field(s) of interest, it can also contribute to the right choice of further education and professional career in the technical sector. This is particularly important to pupils who follow general and advanced secondary education and for girls. If one considers technical vocational education, it appears, in this particular field, that various disciplines and subdisciplines can be distinguished.

Within the context of education in Technology in the basic education of pupils at secondary level, it is not realistic to address technical training and professions in which technical knowledge and skills are of great importance. However, it is possible to develop the manner in which pupils relate to this and these possibilities should be used. Besides this, exemplary education could be provided which has a specific bearing on technology in various professions.

Description of the subject

Based on the characteristics of technology previously mentioned and in consideration of the points of departure for the provision of basic education at secondary level, the Development Group arrived at the following description of Technology. Technology focuses upon the aspects of Technology which are of importance for a sound understanding of culture, for functioning in society and for further technical development. To achieve this, pupils gain knowledge of and insight into the three cornerstones of technology (matter, energy and information) and into the close relationship between technology and the sciences. They gain insight into the relationship between technology and society and learn to form their own opinion about applications of technology in our society. They learn to produce technology and "to become technologically involved". Pupils learn how to deal with a number of technical products and are provided the opportunity to discover personal capabilities and interests in relation to Technology.

Summary of the subject components

The general description of the attainment targets is divided into three principal components. These three subject components are further elaborated in the attainment targets. Here, we will confine ourselves to mentioning the three subject components of Technology and a summary of the various topics. We should like to remark that the sequence in which the descriptions are given does not necessarily indicate their precedence.

The subject components are:

A. Technology and society
B. Working with products of technology
C. Producing technology

A. Technology and Society

The topics are drawn as much as possible from the real-life situations of pupils and are interrelated with the components of B and C.

The topics are:

- the cornerstones matter, energy and information,
- the relationship between technological progress and economical and social conditions;
- the consequences of technological progress in everyday life.

Production process:

- characteristics of the manufacturing industry,
- phases in the production,
- the concepts automation, mass production, systems, mechanization, quality control & assurance, logistics, economy of scale, standardization,
- working conditions and distribution of tasks between men and women,
- recent developments in the field of machine and tool operation,
- visits to industrial firms.

Technology in professions:

- the nature of technical activities,
- technical aids and equipment,
- working conditions and personal satisfaction.

Chemical technology:

- the effects of technical developments on changes in the environment,
- technical solutions for environmental problems and their limitations,
- relation between offer and demand of technical provisions and environmental effects.

B. Working with technology

The topics derived from the everyday world of pupils are covered in the form of practical work in which the central focus is put on practical involvement and investigational activities.

The topics are:

Principles of operation:

- motion and transmission,
- transformation of energy.

Technical systems:
- shaping material,
- principles of design and construction.

Automation:
- system elements,
- connecting models and making them operational,
- solving control problems.

Use:
- proper nomenclature and expressions,
- selecting and using the right tools,
- product assessment,
- the use of assembly and operating instructions,
- relationship between maintenance and the environment.

C. Producing technology

The topics are covered within the framework of producing functional (= operational) products (work projects).
Topics are:

Preparation of work:
- the use of technical documentation and instructions,
- problem analysis,
- working according to a planned schedule.

Design, drawing, interpretation of drawings:
- solving construction problems,
- simple sketches and technical drawings,
- reading technical drawings,
- conditions of material,
- (precision) measuring,
- transferring data to materials.

Working and processing materials:
- the production of work-pieces according to DTMC-models (i.e. a strategy for design and production) from wood, plastic, textiles and metal,
- working on a production line.

Assessment:
- process assessment,
- product assessment based on prescribed criteria.

After the first advice for attainment targets had been discussed by educators a second advice was developed that did not differ much from the first. Some formulations had been changed, the total amount had been reduced.
The Development Group characterizes the subject as practice-orientated (75% practical work and 25% theory). Each pupil should be given the opportunity to experience practical work and to gain insight by self-activity.

A brief analysis

Related to the various types of contents as described in the attainment targets, we can see that the same characteristics of the subject reappear time and again. We have selected some citations from various publications and have related them to the classification in three types of basic skills and knowledge.

Dealing with products of technology

In publications of pedagogical centres, published before 1980, acquiring skills in developing and executing a strategy for acting took an important position. Problem solving activities also appear time and again, as well as "the ability to cope with technology". Pupils should not just learn various partial skills, but also learn to shape a desired technical situation.

Learning the social significance of technology
Citations that can be found, contain terms like "critical review of technology and its significance to humans", "learning to assess technical application", "responsible adaptation of the environment". From almost all publications, it becomes evident that Technology always concerns the relationship between humans and technology. Reflecting on technology is also a part of education. Another aspect is "vocational orientation".

Producing technology
"Technology as a practical subject" is often found in publications on technology education. "Acting in a technical way", "learning basic skills", "dealing with the pillars of technology: matter, energy and information" can be found frequently.

Problem solving

So far, we have presented a survey of the attainment targets and given a brief comparison of the characteristics of the content of technology as can be found in various publications. From 1980, a growing convergence of objectives and contents for technology can be recognized. Whether or not this convergence will remain in its further concretion is yet uncertain. Internationally, some new developments can be identified.
In American publications, two concepts become increasingly important: "technological literacy" and "problem solving". These two can also be important for the developments in the Netherlands. Here, we propose a development of technology education directed towards a problem solving process.

Many schools will select, adopt and adapt the SLO proposals for annual programmes. Adaptations are often minor and include: making the material look nicer, attempting to present a clear concept of technology.
The presenting of a clear concept of technology to pupils can be achieved by introducing a central theme in the programme. Problem solving could be such a theme.
In my opinion, developing an annual programme based on problem solving activities is the right course to be followed when the theoretical concept is clear. Whether or not it will act as a remedy to assist pupils in solving real problems will depend on the recognition of the need for problem solving activities and the choice of subject matter.
Problem solving can also contribute to the effectiveness of education in technology. Instead of precious equipment that is perhaps only used for ten minutes each year, problem solving activities could take place using cheaper materials. In my opinion, problem solving should include: helping pupils effectively solving technical problems in such a way that they can then solve other technical problems independently.
According to Lowell D. Anderson (in The Technology Teacher, an American Journal for Technology Education), learning to solve technical problems is learnt best of all by practicing the problem solving process. Everyday reality is then simulated in the school.

Problems should be selected in such a way that they appeal to and stimulate pupils and constantly demand the application of new elements of knowledge and skills.
Solving technical problems requires three kinds of skills:
- process skills
- basic skills
- skills related to decision making

Process skills are required in order to distinguish between the various phases occurring in the problem solving process.
Basic skills are required in order to solve the problem in question. An example of this kind of skill is: the right use of materials and tools and the skill of decision making, such as the collection of the right data and information in order for the correct decision to be made.
A problem must be chosen in such a way that it allows for practicing these three kinds of skills.

It is possible to develop an annual programme based on the problem solving process as a central theme. There should also be periods in which the information required for problem solving is presented. These periods should also be interesting and important in themselves.

The materials that have already been published by the SLO so far can be used to devise such a programme. A critical remark will have to be made here. Although it is highly desirable to devise an annual programme in terms of problem solving activities, the number of lessons (180 hours) will probably not be sufficient to realize this programme. Time will also need to be allocated to both exercising skills and for the realization of the problem solving process. Experiments in education will have to show whether this is feasible or not. It can be calculated that about half of the time allocated to teaching will have to be focussed upon exercising skills.

Literature

APVO (1985), Techniek en Verzorging.

NKSR, (1984), Techniek in het onderwijs.

Proeve van een Concept-Ontwerp Ontwikkelingswet Voortgezet Onderwijs, (1984).

SLO (1985), Wat zouden ze krijgen in het voortgezet basisonderwijs?

SLO (1986-198⁻ , Leerplanvoorstel Techniek deel 1 en 2.

Visser M. e.a. (1985), Techniek binnen de Basisvorming.

WRR (1985), Working Documents Basisvorming (Basic Education).

WRR (1986), Rapport Basiseducatie.

2.4 Discussion report

The first theme, 'Goals and content', has been discussed in three groups. Results of these discussions are reported here.

The discussion has focussed on five issues:
1. the way in which goals and contents are selected,
2. the process of teaching pupils to reflect on the knowledge they gain,
3. the question of whether or nor it is allowed to use education as a means for changing behaviour,
4. the relationships in goals and contents between science, mathematics and technology,
5. strategies for innovating goals and contents,
6. the role of teachers in innovating goals and contents.

The way in which innovations in goals and contents have taken place in the past seems to vary considerably between the subjects in the Netherlands. In science and mathematics education innovations are often initiated by educationalists with the results of research studies as a basis. In chemistry education, however, initiatives for updating goals and content more often come from specialists in the academical subject. It has happened that chemistry educators rather suddenly were confronted with decisions by policy makers to adapt the chemistry education programmes.
It would be interesting to know how innovations of goals and contents take place abroad and to discuss what would be the most appropriate way for inducing innovations.
Another important question is: what is the role of goals and contents in the educational practice in schools? Is it worth stating goals and contents that have hardly any influence on what teachers are doin ? Would it be suitable to study what goals and contents teachers realize in class and then to formulate realistic goals and contents with practice as a basis?

With respect to reflective learning it was stated that pupils should not only be taught knowledge but also to think about the way this knowledge is gained in science, mathematics and technology. Pupils should for example be aware of the fact, that all observations are biased by previous knowledge. It is important to make clear to them in what structure of knowledge the subject matter is positioned. From that perspective they should also be able to transfer this subject matter to context situations. Education should help them to solve problems in a process of both thinking and acting.

A third issue that has been discussed is the question of whether or not it is suitable to use education as a means for changing people's behaviour. This question came up in particular after the presentation on environmental education. It seems as if education becomes more and more normative. Pupils are more and more confronted with morals in the field of sex equity, environmental behaviour, etc. It was suggested that in education we should show pupils the various ideas about these issues that are found in society, in order to help them in developing their own. Especially in environmental education this awareness development plays a vital role.

A special problem is the relationship between the subjects science, mathematics and technology with respect to goals and contents. Each subject has its own jargon and it is hard to communicate in such a situation. Even the fact that this meeting is one of the very first in which educators and researchers from the three subjects meet in one place underlines this.
Not only the jargon, but also the status and the scientific background of the subjects differs. Technology has a special problem here: the conceptual structure of this subject is hardly known yet. Some common themes were identified: legitimization of goals, the use of contexts, the role of theories of knowledge, the relationship between knowledge and behaviour, the balance between developing goals by policy makers and by educationalists, the issue of problem solving in the various subjects.
It was sometimes questioned whether or not it is appropriate to think in separate subjects at all. Especially young people experience reality as a whole and not as differentiated in subjects. On the other hand, subjects can help them to structure reality and enable them to find their way in reality.

In the Netherlands we have seen some examples of innovations that were not as effective as had been hoped and expected, because the innovation was too drastic. Teachers found it hard to implement such a change in their educational practice. The lesson that can be learned from these experiences is, that it is important to make sure that the majority of teachers is able to keep pace with the innovators.
This, however, means that there is a danger that too much of the innovation is sacrificed to todays practice and the fact that education has a tendency to be conservative.

Finally, the importance of updating the teachers knowledge and didactical skills was dealt with in the discussions.
Innovations can only be realized with teachers that are both willing and able to make changes.
In primary education there is much interest to implement technology education in the programme. Teachers, however, have no or hardly any technological background. This means that it is necessary to provide ready-to-use learning materials. This creates a danger of lessons being defective in content, because teachers lack knowledge and skills.
In a way, the same goes for the other subjects as well.

During the discussion a number of questions were stated, of which participants felt, that it would be useful to answer them in the international surveys that will be carried out in the SMT Education project of OECD:

1. how does the development of (new and innovative) goals and content take place? What forces act upon this process? What is an appropriate process here?
2. to what extent is a knowledge base conditional for teaching the problem solving process?

3. what are various interpretations of the term 'problem solving' and how can this be seen in learning materials? What should be the level of difficulty for stating problems? And what is more effective: field work or classroom work?
4. how do pupils' attitude changes through educational programmes take place?
5. in how far is education normative? And in how far should it be normative?

3. The theme 'Settings and methods'

3.1 In search of contexts in mathematics for 12-16 year-olds

Hans Krabbendam,
National Institute for Curriculum Development (SLO), Enschede

Introduction

One of the subjects referred to by the OECD for consideration within the part-project "Mathematics, Science and Technology" is "Methods and Settings". Within the framework of each of these three subjects, the use of contexts is one of the teaching methods used. In this contribution, the use of contexts in mathematics is explained on the basis of examples taken from the project "Mathematics for 12-16 year-olds". The points of departure for the development are illustrated after placing the project within the context of theoretical developments in teaching mathematics. The examples give a clear impression of the elaboration in terms of student courseware. Finally, one paragraph will deal with the suitability of contexts in education in mathematics.

Position of the project Mathematics for 12-16 year-olds

Teaching realistic arithmetic/mathematics

Under the influence of Wiskobas, a department of the IOWO which was dissolved in 1981, the programme for arithmetic/mathematics at primary school level has undergone drastic changes within the last two decennia. The result of those changes can be found in "De proeve van een nationaal programma voor het reken/wiskundeonderwijs op de basisschool" (Treffers & De Moor, 1989). The examination syllabus for mathematics at advanced secondary level has just recently been revised. The mathematics in the courses Mathematics I and Mathematics II has now become Mathematics A and Mathematics B after considerable adaptations had been made. Mathematics A focusses upon applications, whereas Mathematics B, which is more theoretical, is intended more as a form of preparation for further courses in the science-orientated subjects.

The nature of the mathematics in the HEWET project which has resulted in these adaptations is characterized by realistic mathematics which can be again be characterized by five learning principles based upon the theory of realistic education (Treffers, 1986):

a. Phenomenological exploration by means of contexts
b Bridging by vertical instruments
c. Pupil's own constructions and productions
d. Interactive instruction
e. Intertwining of learning strands; the broader connection

To a large extent, these principles determine the form of mathematics teaching, even though, as we shall see, these principles have an effect on the content of the subject matter. With the HEWET project serving as a model, at higher levels of secondary education in the Netherlands (HAVO-level = Higher General Secondary Education) experiments are presently being undertaken which must result in the introduction of the Mathematics A and B syllabus in schools for higher general secondary education. This so-called HAWEX-programme which must be integrally introduced is based upon the principles of teaching realistic mathematics.

Social changes
In addition to arguments in support of a theoretical approach, there are also arguments in support of changes based on social motives. During the last decennia, in our present society other kinds of problems have also played an increasingly important role, namely:

- issues relating to traffic, trade and infrastructure;
- problems concerning decision making in respect of significant social topics, such as energy and the (natural) environment, decision science;
- questions in the field of information science, such as working with flow-charts and the organisation and structurization of computer files/data;

In order to be able to function in such a highly technological society in which mathematics becomes increasingly less apparent (Keitel, 1989: "So what about the contradiction of increasing mathematization of modern society, together with potential demathematization of its members") other skills are required than those several decennia ago. In their book entitled "Descartes' Dream", Davis & Hersch (1986) provide a list of the skills required in a mathematized society:

- the ability to symbolize, abstract and generalize the primary experiences of counting and spatial movement. A sharper sense of quantity, space and time;
- the ability to dichotomize sharply: YES/NO; TRUE/FALSE; 0,1.
- the ability to discern primitive causal chains, e.g. : If A then B. The ability to concatenate and reason about such chains.
- the ability and willingness to extract from the real an abstract surrogate; correspondingly, the willingness to accept formal manipulations of the abstract surrogate as an adequate representation of the behaviour of the real.
- the ability and desire to manipulate and play with symbols, even in the absence of concrete referents, thus creating an imaginary world which transcends the concrete.

The author re-arranges the list of skills directly related to the use of computers as follows:

1. Algorithmic thinking
2. Modular thinking
3. Systems thinking
4. State thinking
5. Metathinking

The consequences for mathematics education

As a result of the previously mentioned changes, the Mathematics syllabus at junior secondary level is intended for pupils between the ages of 12-16, dates from 1968 and is characterized as being relatively formal and analytical, being based upon collective-theoretical principles, has now ended up between two modern syllabi, which makes adaptation inevitable. Consequently, the Dutch Ministry of Science and Education has assigned the COW - the Committee for

the Development of Mathematics Education - the task of developing a new curriculum for Mathematics based on extensive experiments. This new curriculum must be ready by 1992 so that it can integrally introduced in schools as from 1993.
The SLO at Enschede and the specialist group OW & OC (Research group on Mathematics Education and Computer Centre) of the State University of Utrecht will be responsible for the implementation of this project.

As far as the content and the form of the new syllabus for junior secondary level is concerned, the above implies that it will be necessary for specific attention to be paid to such skills as:
- finding structures for problems
- making schematic outlines of given situations
- making models
- a critical view of models

In addition, as far as content is concerned, the described changes also imply:
* (small or large) *shifts of emphasis* in existing syllabi such as:
  - a broader and more qualitative approach and treatment of graphs in algebra and analysis;
  - less emphasis upon formal aspects of mathematics;
  - emphasis on applied spatial geometry;
  - specific attention to arithmetic, which was previously only occasionally treated at secondary level;
  - paying increasing attention to statistic activities;
* the introduction of completely *new subject matter* such as that which is related to situations in which structures play a role within finite clusters.

This extensive positioning of the project Mathematics for 12-16 year-olds should be considered as being a sketch of the backgrounds of the use of contexts in the junior secondary level syllabus for mathematics in general secondary education.

The use of contexts in teaching mathematics

The call for extra-mathematical elements in mathematics education is not just of recent years. Traditionally, the scientific structure of mathematics has always determined the content of mathematics education.
This means that the construction of mathematics which had gradually developed over the centuries was reflected in the structure of the subject in education. Making advancements in mathematics meant going up to the next stage. The elaboration of mathematics as an abstract cognitive subject with its own specific structures also alienated the subject mathematics from its application in daily practice. Initially, this was permitted, especially in respect of its educational value, but later the desire to return to the fundamentals of mathematics, i.e. reality, became much stronger. Initially, this desire was met with by enabling the context as a *field of application* and as *a climate for exercising specific mathematical skills*. This was called the 'livening up' of school mathematics, as well as the use of contexts as *introduction*, often in the form of *motivation*. The use of applications alone seemed to meet with the call for a return to reality insufficiently.
Freudenthal advocated ue the genetic method, the rediscovery of

mathematics, was a good opportunity to enable children taking mathematics in the first phase of secondary education to personally experience the subject in a rapid and controlled manner. He used the context as a *possibility to develop mathematical concepts* in which the context takes the form of a *phenomenon of a mathematical structure*. This concept meant that contexts taken from the real world, and also from the world of fantasy, could serve to allow mathematical concepts to develop, to give them significance and, in doing so, allow them to function as a reference framework for the children. In this connection, such terms as horizontal and vertical mathematization were mentioned. By horizontal mathematization is understood, the mathematization of the situation so that a situation is created that can be investigated with the use of mathematical means. By vertical mathematization is understood, the course taken throughout the previously mentioned personally formed mathematical structure in search of further, more abstract mathematical structures. The realistic theory of education (Treffers, 1986) distinguishes four roles of contexts:

- concept formation
- model formation
- applicability
- training in applied situations

The didactical phenomenology

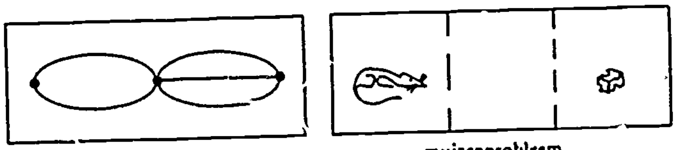
In what way can such a use of contexts be achieved in education? In his later works on didactical phenomenology, Freudenthal advocates this particular approach. The contexts proposed by Freudenthal and others too, (e.g. Torwel, 1986) were 'rich' contexts, i.e. with rich mathematical structures from which many (mathematical) questions can be derived. Freudenthal himself mentions as an example of a rich structure the collection of toys from which a small world can be built and as an example of a poor structure, a collection of building blocks. In his opinion, education should be directed from a rich structure to a poor structure. This does not mean that Freudenthal advocates a link with the structure of mathematics which is presently the case, partly resulting from the influence of Bourbaki. He draws a distinction between the structure of the mathematics and the mathematical structures themselves. Mathematics is an activity; it is the re-creation of mathematics. He sharply opposes attempts to structurize education according to scientific structure. Freudenthal (1984) briefly characterizes this didactical phenomenology as follows:

> *starting from those phenomena that beg to be organised and from that starting point teaching the learner to manipulate these means of organising. Didactical phenomenology is to be called in to develop plans to realise such an approach. In the didactical phenomenology of length, number, and so on, the phenomena organised by length, number, and so on, are displayed as broadly as possible. In order to teach groups, rather than starting from the group concept and looking around for material that concretises this concept, one shall look first for phenomena that might compel the learner to constitute the mental object that is being mathematised by the group concept. If at a given age such phenomena are not available, one gives up the -useless- attempts to instill the group concept.*

And Treffers (1986):

The novelty in the realistic conception is that reality does not function in the way of embodiments, but as a source of concept formation, i.e. in order to develop intuitive notions, or in Freudenthal's terminology. to constitute mental objects.

The search for contexts which, didactically and phenomenologically, are useful for the desired mathematical structure - also designated as paradigmatic contexts - is one of the tasks assigned to the project group Mathematics for 12-16 year-olds. Examples of this can be derived from development work which has been carried out at primary level and at the upper level of advanced secondary education (HAVO/VWO). In this connection, Treffers (1986) mentions e.g. the road problems, the grains on the chessboard and Gulliver's Travels.



wegenprobleem   muizenprobleem

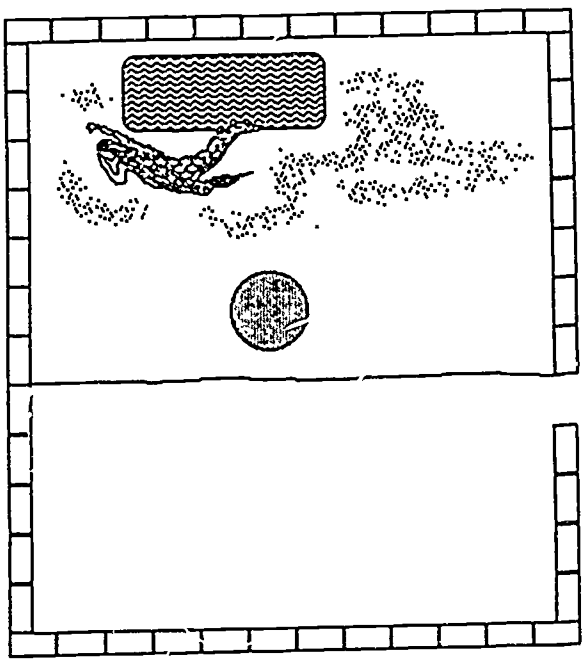
from: Wiskobas doelgericht

An example from the HEWET project for the upper secondary level is the concept 'growth' in the rats context of Maarten 't Hart (De Lange, 1987).

Examples of contexts for Mathematics for 12-16 year-olds.

Let me explain a specific use of contexts within the project Mathematics for 12-16 year-olds by giving several examples.

Example 1: a geometrical structure



Het zaaltje is vol met mensen die zich vergapen aan Koosje. Koosje is de naam van de zeemeermin, gevangen door een Katwijker visser bij de Doggersbank. Zij is genoemd naar zijn vrouw.

Een handige ondernemer heeft de zeemeermin gekocht van de visser. Hij heeft een deel van de visafslag gehuurd. Van veilingkisten heeft hij een zaaltje gebouwd met een ruimte voor Koosje. Hij heeft zand, schelpen en zeewier neergegooid, een tuinvijver ingegraven en kippegaas gespannen.
Een pilaar van de visafslag belemmert het uitzicht op Koosje die steeds op dezelfde plek ligt te treuren.

De ondernemer maakt de mensen wijs dat Koosje af en toe zingt. Zo kan hij de plaatsen waarvandaan niets te zien is ook nog verkopen.
De ingang is een nauwe opening in de wand van veilingkisten waar één mens tegelijk door kan.
Bij de ingang hangt een bordje:

PRICES OF THE DIFFERENT POSITIONS

ƒ 10,- to see Koosje entirely

ƒ 5,- to see Koosje partly

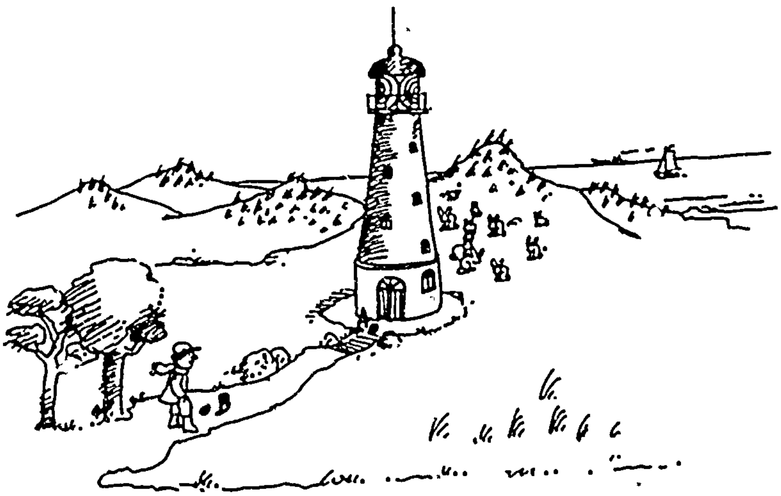
ƒ 1,- just to hear her sing.

1. De floor is painted in three colours to point out the different positions.

   > colour the floor of the room.

A nice context which is certainly not an easy one for pupils to understand and which contains a lot of geometrical activities. The solution automatically comes from the search for tangent points, 'half-shaded areas' and 'shaded areas'. The mathematical structure, i.e. constructions with circles and tangent lines, is then achieved.

A previous form (from: Zie je wel?) was as follows:

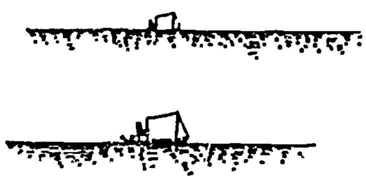


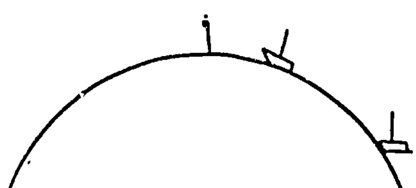
At which position will the lighthouse-keeper see the most rabbits (at A or B)?

Do you see the similarity in mathematical structure? Here, too, the circle, tangent lines and shadow and half-shadow force obtrude and a geometrical sketch becomes self-evident.

In both situations, we are concerned with the same mathematical structure.

Would a further quest enlighten us on these issues, implying that there is apparently question of an important mathematical structure which, in many cases, presents itself to us? If this is the case, a search must be made for the context which, didactically, represents the mathematical structure best of all.





from: Zie je wel

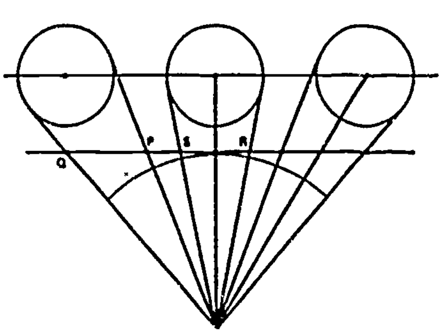
Not so long ago, we put the following problem to a group of teachers present at an afternoon post-training session on geometry:

Measure the width of the pots. Try to find an explanation

photo: Aad Goddijn

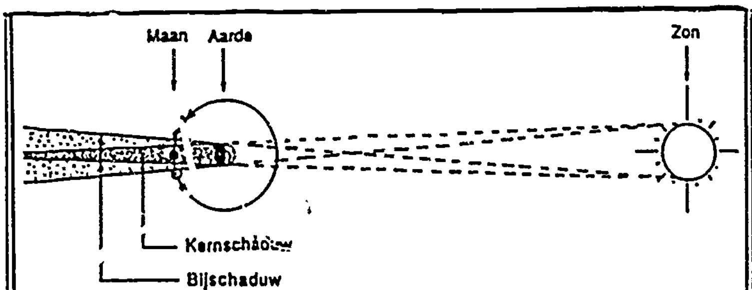
A lot of surprised faces, disbelief and suspicion towards the photographer because the consequence of the fact that the pots of paint on the outside look or 'seem' bigger than those on the inside is certainly shocking. The reason being because, for example, this would also mean that if you look at a house, the bricks on the outside seem wider than the others. The circle and tangent line structure was very helpful that afternoon, although the actual solution to the problem still had to be found since projection onto a flat surface (the photo) also plays an essential role. In Dan Pedoe's book entitled 'Geometry and the Liberal Arts', this example is presented in the form of a paradox.

Leonardo verwijst naar een duidelijke paradox in de perspectieftheorie die nog steeds interessant blijkt te zijn. Deze wordt ook besproken door Pierro della Francesca. Als u voor een rij zuilen staat, zoals die van een voorgevel van een tempel, en u tekent ze, dan zien de zuilen aan de zijkanten er breder uit dan die in het midden, hoewel de buitenste verder weg staan. Natuurlijk veronderstellen we dat alle zuilen dezelfde breedte hebben. Een dwarsdoorsnede laat een aantal cirkels op een rij zien. Het is voldoende om er drie te bekijken (figuur 28). Zoals we in de tekening zien, zijn de beelden van de buitenste twee cirkels groter dan het beeld van de binnenste. Dat wil zeggen, *PQ* is groter dan *SR*.



from: Perspectieven doorzien, Pedoe

The 'sun, the moon and the stars' are soon discovered when in search of the context which, didactically speaking, is best suited to these geometrical structures. The nice thing about it is, for example, that within the framework of the phenomenon 'moon eclipse', the same structure can be used in order to clarify 'shadow' and 'half-shadow'.



Het verloop van de maansverduistering. Zodra de maan in de bijschaduw van de aarde komt, waar een deel van het zonlicht haar nog bereikt, begint de verduistering. Die doet zich voor als een donkere „deuk" op de maanschijf. Als de maan helemaal achter de aarde komt is de verduistering totaal.

Maan vanavond ruim een uur totaal verduisterd

Van onze astronomie-medewerker
GOVERT SCHILLING

AMSTERDAM — Vanavond is er bij helder weer in Nederland een totale maansverduistering te zien. Het verschijnsel duurt van half zeven tot even na tienen. Een volledige maansverduistering ontstaat wanneer de volle maan zich in de schaduw van de aarde bevindt. De zon kan de maan dan niet meer verlichten.

Het verschijnsel begint om 18.29 uur. Vanaf dat moment is er aan de oostzijde van de maan (links) een klein donker „deukje" te zien dat steeds groter wordt. Om 19.41 uur is de maan geheel in de schaduw van de aarde verdwenen en is de verduistering totaal. De maan is dan niet helemaal onzichtbaar, maar zal gehuld zijn in een oranje-rood schijnsel. Dit schijnsel ontstaat door zonlicht dat via de dampkring van de aarde toch nog op de maan terecht komt en bij de lange reis door de dampkring rood gekleurd wordt, net als zonlicht bij een zonsondergang.

De maansverduistering duurt vijf kwartier, tot 20.55 uur. De maan heeft dan nog een uur nodig om geheel uit de schaduw van de aarde tevoorschijn te komen. Het verschijnsel is om 22.06 geheel achter de rug. De volgende maansverduistering die [illegible] Nederland te zien zal zijn, treedt [illegible] weer op 20 februari 1989 op.

from: Volkskrant 17/10/'86

The 'richness' of the context 'Sun, Moon and Earth' is very useful in explaining the given geometrical structure. From this, it seems very possible for pupils to develop an understanding of these structures. In this connection, this particular context has been provisionally selected in the project Mathematics for 12-16 year-olds.

Based upon the fact that the mathematical content mentioned, i.e. the use of circles and tangent lines is a good one, a phenomenological analysis of this structure can be made. So, how does this structure present itself to us? Several examples have already been given. The next step is to select the option which, didactically speaking, is suited best of all, and the context 'Sun, Moon and Earth' seems a good one. Other factors which play a role in the selection are addressed in the discussion paragraph of this present report.

Let me first show some examples, namely of a structure which plays a role within the framework of concrete mathematics and another in the field of equations.

Example 2: A discrete structure

The subject 'discrete' is a relatively new phenomenon in mathematics education. As indicated in paragraph 1, there are, however, sufficient arguments in support of incorporating this as learning content in mathematics education. This is already the case in the upper grades of advanced, pre-university secondary education (VWO) and also in experimentations in the upper grades of higher general secondary education (HAVO).

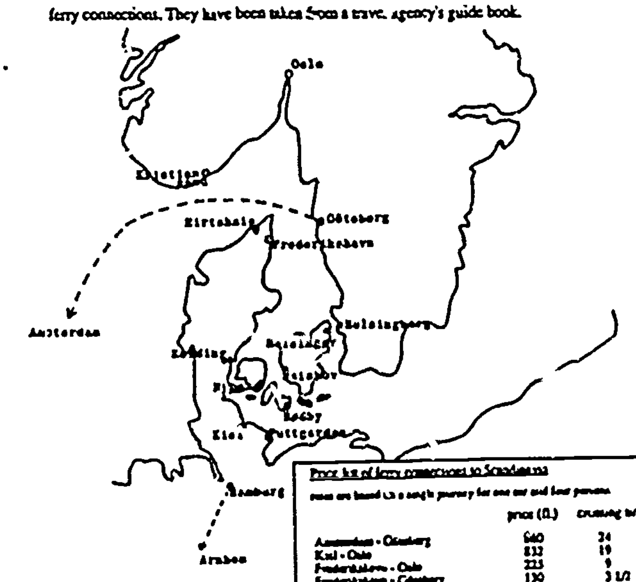
The phenomenological structure of the 'discrete is expressed by the points and relations between the points. The geographical position is not relevant and, in some cases, can even be annoying, particularly if weights are allocated to the connections between the points and if algorithms are needed in order to discover the 'shortest', 'quickest' or 'cheapest' possible path to follow. In the introduction of the 'discrete' concept at junior secondary level, this placed us in a didactical dilemma.
One can select a geographic context as the basis from which to work, for instance, the construction of an underground railway network in the city of London, or one can choose a context which is not related to any specific geometrical structure, such as, e.g. a 'tournament graph' so as to emphasize the essential elements of the 'discrete' concept, i.e. the independence of the position of the points and the length of the lines. For various reasons, in the project Mathematics for 12-16 year-olds, we opted for the geographical context as an introduction. In the elucidation that was chosen (refer to the worksheets entitled "Journey to the North), the progressive schematization plays an obvious role where one increasingly abandons situational aspects, in this case the geographical aspects. In the end, the step taken towards the mathematically rich grid structure which plays an important role, both in a combinatorial sense and algorithmically, is only a small one.

Going North

Maricke and Yvonne live in Arnhem. This summer they are going to Oslo, perhaps even farther, with their parents by car. In any case part of the journey will have to be by boat.
They can travel in many different ways. Let's find out which is the cleverest way of travelling.

a. What should they all know in order to determine the cleverest way? How can they find out?

You don't have to sort out all the material yourselves. We'll start with a map and a list of ferry connections. They have been taken from a travel agency's guide book.

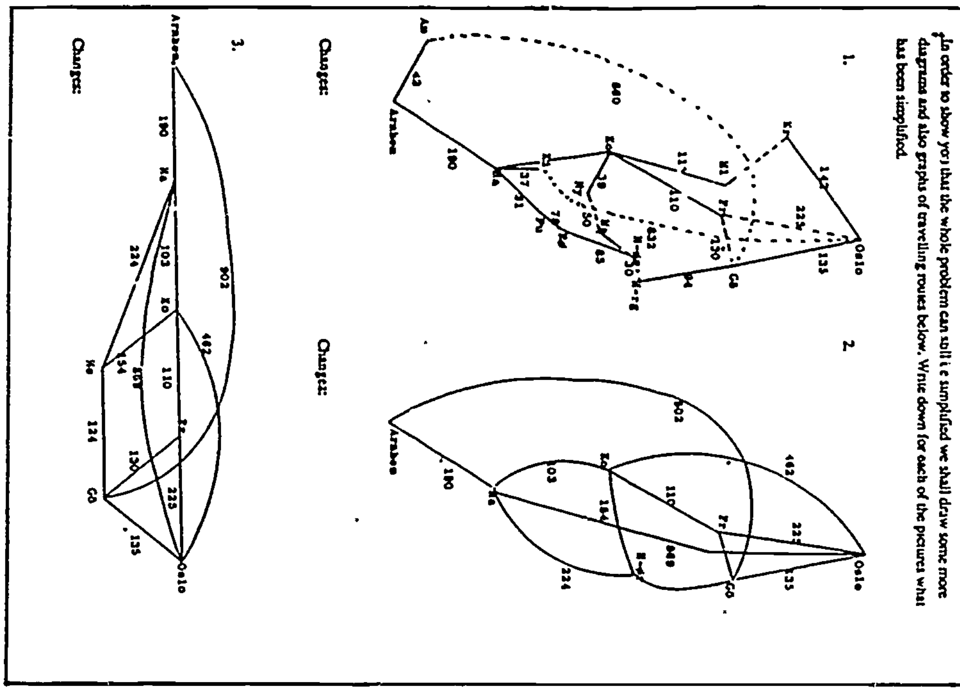


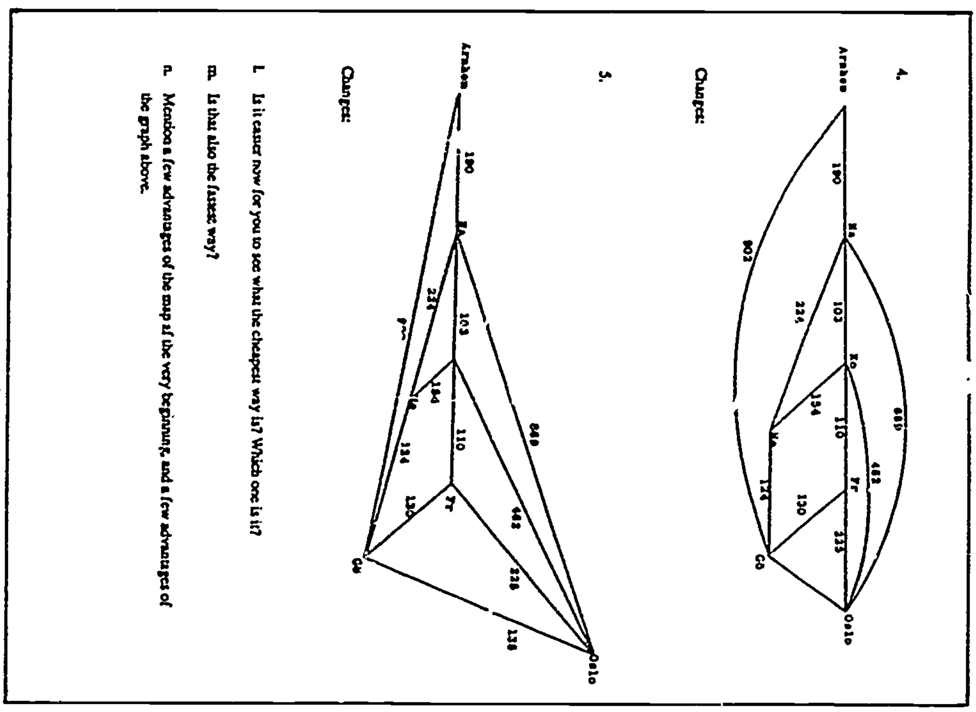
Price list of ferry connections to Scandinavia

	price (fl.)	crossing time (h)
Amsterdam - Göteborg	640	24
Kiel - Oslo	832	19
Frederikshavn - Oslo	223	9
Frederikshavn - Göteborg	130	3 1/2
Hirtshals - Kristiansand	209	4 1/2
Puttgarden - Rødby	78	1
Helsingør - Helsingborg	30	1/2
Nyborg - Halskov	[illegible]	1

b. Which countries are on the map? Have you ever been there yourself?

c. Draw all the ferry connections into the map in dotted lines (work neatly please!)





from: De kortste weg, W12-16

The Journey to the North

Although limited, the experiences with these worksheets are every encouraging. The pupils follow the steps taken with relatively great ease. We also see that the increasing styling of the model gives perspectives to arrive at a better and more justified solution. We also discover the essentials of creating models and that the attributes of the phenomenon 'discrete' become increasingly clearer. Even so, the link with reality remains continually within reach while, at the same time, there is a clear motive for the activities carried out. This is because they simplify the solution to the question. The abstraction, as it were, arises automatically from the manner in which the question is raised.

The applicability of contexts in teaching mathematics

In almost all examples, contexts are applied to designate mathematical structures and to explicate them. We are concerned here with the recognition of the mathematical structure and to enable it to be applied in various situations. The point of departure in the use of contexts therefore is the creation of a model (horizontal mathematization) and the mathematical construction ertical mathematization). The search for the contexts whic from a didactical and phenomenological point of view, make the structures the most accessible is the right direction in which to search as far as the project Mathematics for 12-16 year-olds is concerned. The fact that such contexts can be found becomes apparent from the examples given above. It is also the direction which is most preferable, as far as the theory of teaching mathematics is concerned. Even so, its implementation is only partially successful. There are many aspects which should be taken into account in the use of contexts in teaching mathematics.

Considered from the perspective of the subject content

A. The process of sequencing the content f subject matter is no longer dependent upon the structure of the mathematics, but is partly determined by the contexts themselves. The fifth teaching principle derived from the teaching theory: 'Intertwining of learning strands , the broader connection' is not easily achieved. Arrangement of the content at a local level is quite feasible, but longitudinal planning is rather difficult.

B. For some of the subject matter, it seems difficult to find the required contexts. Negative numbers are a good example of this. Many attempts in recent years (Goffree, 1989) have been undertaken in order to find phenomenologically justified contexts for these negative numbers. As yet, these attempts seem to have produced only few results. Intentionally, no example has been given of a good context for an algebraic structure. As yet, this has not really been found, although a lot of work has been done in this field and still is being done (Ten Hove, 1989). The (ultimate) consequence of this could be that some of these topics could not or should not be incorporated into the curriculum for these pupils, as Freudenthal remarked in his publication entitled 'Didactical Phenomenology' (Freudenthal, 1984).

C. From a phenomenological point of view, some of the subject matter contains so many aspects that no suitable context can be found to cover all of these aspects. When using such contexts, it could be that pupils envisage an incomplete picture of the intended structure.

D. Criteria for the choices made to determine the content of subject matter both greatly determine and restrict the choice of contexts. This becomes apparent from expressions like: 'Mathematics is useful', 'Mathematics must also be significant to girls' and ' Mathematics should be geared to the world in which the pupils live'.

E. An interesting context can disguise the mathematical structures to be learnt in such a way that the pupil does not use the planned mathematical instruments naturally, but instead chooses an instrument with which he or she is more familiar, or even chooses a solution within the context itself.

From a teaching point of view

The *ability to teach* a subject is an issue which requires the utmost attention, since the ability to implement is greatly determined by that factor. Among other things, the ability to teach is determined by the following factors:

A. The pupil must be willing 'to step into and experience the context'. In doing so, account must be taken of the emotional barriers of pupils when confronted with certain contexts. Likewise, the distance between the pupil and the given context can be too great resulting in the fact that the context is not adequately geared to the pupil's own world. In the eyes of the pupil, the context can also seem too far reaching which is often related to the invisibility of the mathematics in that particular context.

B. Teachers must be capable of dealing with the given contexts themselves. The teacher is confronted, for example, with 'context interference', i.e. both the positive and the negative reactions of the pupils to the given context. Teachers must be aware of the context itself and must be able to introduce the context swiftly. The use of contexts often results in different solutions and ways in which to solve a given problem. Teachers must learn how to apply these differences positively. The assessment of contextual mathematics also requires specific attention when using contexts.

After more than two years of development work on the project Mathematics for 12-16 year-olds, the following (provisional) conclusion could be drawn:

Despite many promising results, the use of contexts as a steering instrument in teaching mathematics to 12-16 year-olds seems much more difficult than was anticipated. As yet, it seems to be much more difficult to find contexts which are of significance to the teaching of mathematics to 12-16 year-olds than it is or has been for pupils at primary level and in the upper grades of advanced general secondary education and at pre-university level (i.e. HAVO/VWO).

Literature

Brink, F.J. van den (1989), Realistisch rekenonderwijs aan jonge kinderen, OW&OC, Utrecht.

COW-plan (1987), Commissie Ontwikkeling wiskundeondrwijs, voorheen Commissie Onderbouw Wiskunde, Enschede.

Davis, P.J. en Hersh R. (1986), Descartes' dream, Harvester Press Letd, Brighton.

Dolmans, F., Krabbendam, H., e.a. (1984), Situatiebeschrijvingen in wiskundeteksten, SLO, Enschede.

Freudenthal, H. (1983), Didactical phenomenology of mathematical structures, Reidel publishing company, Dordrecht.

Goffree, F., e.a. (1989), Tegengesteld, Bekadidakt.

Lange, J. de (1987), Mathematics, Insight and meaning, OW&OC, Utrecht.

Hove, J. ten (1990), Algebrei, in: Goffree, F., (red.): Educatieve ontwerpers over hun vak, SLO, Enschede.

Pedoe, D. (1976), Geometry and the Liberal Arts, Harmondsworth, Penguin.

Team W12-16 (1989), Raamplan W12-16, Utrecht/Enschede.

Terwel, J., Dekker, R. en Herfs, P. (1985), Rijke contexten bij wiskunde, paper ORD.

Terwel, J. (1984), Onderwijs maken, SVO.

Treffers, A. (1986), Three dimensions, Reidel, Dordrecht.

Treffers, A., Moor, E. de, Feijs E. (1989), Proeve van een nationaal programma voor het reken-wiskundeonderwijs op de basisschool, deel 1, Overzicht Einddoelen, Zwijsen, Tilburg.

Onderwijsleerpakketten: Zie je wel (IOWO), Regelrecht (SLO), Op de hoogte (W12-16), Trappers (W12-16).

3.2 Teaching physics and context in the Netherlands

Pieter Licht,
Department of Physics Education, Free University of Amsterdam

A brief retrospective view

In 1974, the 'Committee for the Modernization of the Physics Curriculum' (CMLN), expressed the need for development work to be undertaken and for subject-oriented educational research to be carried out in preparation and in support of a new curriculum. A positive aspect here was the fact that the Project Group for Curriculum Development for Physics (PLON) was assigned the task of commencing with this development at junior secondary level. In doing so, the discussions about the innovation of education in physics were to take place 'from the basis upwards'. It was no longer university level Physics that primarily determined the form and content of physics at secondary level. This new point of departure offered the opportunity to base teaching on the capabilities and interests of pupils at junior secondary level and to gradually adapt and extend the curriculum as the discussion moved on to school-types at higher levels catering for different categories of pupils.
From the start, the PLON opted for an important shift of the emphasis upon education in physics directed at a curriculum providing functional knowledge of physics within the context of a variety of situations in both the physical and technical world, as well as in the world of research. The innovative element of this form of education is that the context of the practical relevance of the subject is taken as a starting point and placed in a framework within which specific concepts and rules of physics are discussed. The form in which the teaching of physics takes place is then thematic instead of systematic. Moreover, use is made of an wide variety of pupil activities, laying emphasis upon the active participation of pupils. The changes pursued imply an extensive adjustment of the way in which physics had always been taught in schools up till now. The following summary of problems, as listed by PLON staff (Kortland & van der Loo 1986), indicates that, towards the end of the 1970s, many of those involved in teaching physics were clearly not ready for this kind of change:

i) the time available for teaching the subject is based on a non-contextual approach of the examination syllabus. A contextual approach of this curriculum either requires more time, or results in a reduction of the subject content;
ii) from the teacher's point of view, the previous certainties with regard to subject content and subject structure disappear and the teacher's authority on controversial social issues diminishes. Many teachers find it difficult to cope with these situations;
iii) a passive and consumptive attitude of pupils does not adapt to the new approach. Pupils have difficulty with their active role. Moreover, most of those involved in education have their own views on the 'ideal' learning process, with clearly

demonstrable steps in the way of acquired knowledge and understanding which do not correspond with the impressions they have from classroom situations.

A breakthrough of the kernel ideas of the PLON on a more national scale did not occur until the 1980s. Discussions on new examination syllabi therefore, do not only relate to the content of new subject matter, but also to the contexts within which the subject matter must be presented. In the following section, I shall address the concept of context itself, since the word often leads to confusion. Subsequently, I shall discuss in detail, the functions of contexts in teaching and the possible design of teaching in contexts. Finally, attention will be paid to developments anticipated in relation to the use of contexts in teaching physics in the Netherlands.

The concept of 'context'

The various meanings of the term 'context'

Van Genderen (1989) lends various meanings to the word context:

(i) Context is the environment of a (part of a) text in as far as it affects its form, meaning or function. This can also mean calling upon the use of information not contained in the text itself, such as historical, cultural or social information. The latter forms the context in a much broader sense;

(ii) in literature on psychology, the word 'context' can be considered as being any 'peripheral' information which might affect the processing of the required information;

(iii) in educational psychology, the term 'context' is applied to denote a problem situation, or a type of problem, particularly when one is concerned with the maneuverability or transfer of knowledge, in which case one then speaks of the application of concepts and skills within a new context.

None of the above definitions specifically relate to learning or teaching and are therefore unsuitable as a definition of the word 'context' in an educational sense.

The use of 'Context' within the framework of the Physics syllabus in the Netherlands.

The 'Physics Syllabus Project Group' (the WEN) defined the word context as follows: (Experience) cntext: a structural part of the reality of the pupil (the way in which the world is perceived by the pupil) in which concepts, phenomena and events are in some way interrelated (WEN, 1984). In defining the word 'context', the WEN draws a distinction between 'school contexts', e.g. scientific experiments, and 'contexts outside of school', such as the weather, traffic, electrical appliances in the home and the human body. Here, the question arises as to the extent in which an examination syllabus can contain references to the world as it is perceived by pupils. In this connection, the conclusion of Boersma and Sc[illegible] is that: 'The world as it perceived by the pupil is an attribute [illegible] the individual pupil and if teaching is to relate to that world, with a view to the learning process of the individual pupil, we will have to search for ways in which this can be achieved.

The content of subject matter of a curriculum therefore cannot relate to the way in which the individual pupil perceives the world. Of course, the content of subject matter can be derived from or related to contexts recognizable by pupils' (Boersma & Schouw, 1985). However, yet another problem arises from the definition of the term 'context' as given by the WEN. In the definition, we read that, for the pupil, a specific part of reality already has a structure. We may assume that, for most pupils, this does not include a physical structure. On the contrary, the ideas and images pupils form of reality often differ substantially from the physical image. Bridging the gap between pupil structure and subject structure offers us the opportunity to relate to the world as it is perceived by the pupil. Whether or not the WEN has considered the consequences of the given definition is doubtful. This also smells rather much like state-imposed didactics which is rather odious in a country like the Netherlands which is well-known for its free views on education. It is questionable whether the pupil should form part of the definition of the word 'context'. I shall come back to this in the next paragraph.

Context as a subject-related educational concept
It was as early as 1985 that Van Genderen suggested an alternative to the definition of the word context as proposed by the WEN (Van Genderen, 1985).
Later, he adjusted his definition somewhat and indicated that it is possible to choose a description for the word 'context' in such a manner that it becomes a clear and usable concept within the framework of subject didactics (Van Genderen, 1989). He chose as a point of departure the original link between context and text and formulated the following definition:

> The contexts of a physical rule are the situations to which this rule is applied.

He explained the definition as follows:
a. A familiar situation does not necessarily imply a familiar context;
b. 'situation' refers to a category of similar situations;
c. a situation can become a context of an increasing number of physical laws;
d. and be, or become, a context of types of laws, e.g mathematical laws;
e. or even alternative laws (pupils' own laws, P.L.);
f. the definition does not include optional criteria in relation to situations best suited or desirable as contexts.

In Van Genderen's opinion, contexts are as much part of the subject matter as are the laws. The contexts themselves constitute a physical topic. In addition, he draws a distinction between 'practical contexts' and 'school contexts'. In this sense, practical contexts are situations occurring in the physical or technical world, or in the world of research. However, these are often of such complexity that they are not suitable for direct study. It then becomes necessary to make use of situations specifically created for educational purposes, such as demonstrations and practical laboratory experiments and practical exercises in relation to specific issues.
These special situations become 'school contexts' of physical laws; then, those laws can be applied to real-life situations which then assume the function of 'practical contexts'. School contexts are applied as an aid to linking the physical laws of nature with practical contexts.

However, the definition of context given by Van Gelderen does confine situations to the field of physics, but the motivational and insight-encouraging effect of contexts often assumed cannot be deduced from such a definition. In his explanatory notes, Van Gelderen indicates that no optional criteria have been included in the definition. As a result, although the concept is well-defined as a subject-related educational concept, unfortunately, the possibilities of applying the concept in the design of a curriculum are rather limited. In principle, any practical context can be chosen which can be 'conveyed' to the pupils by way of a school contexts in physical terms.
By excluding the 'pupil' from the definition of context, the entire definition seems to become objective and therefore suitable as a definition within the framework of a syllabus or curriculum.

A different approach considers contexts as situations in which the pupils concerned undertake specific activities as if by intuition. Although the thinking and acting thus incited by the context might be considered as being spontaneous, they may not always be considered as adequate. This is also where there is the possibility of an important learning moment for the pupil, i.e. where this relates to the possible improvement of the pupil's thinking and acting considered as a matter of course. Whether something is a context or not does not depend primarily on the 'didactical translation' provided by the teacher, but rather on the pupils' interpretation of the situation. A definition of 'context' which suits this approach is:

> The contexts of an intuitive rule, or a rule as perceived by the pupil are situations in which the pupil applies that specific rule.

By explicitly including the pupil in the definition of context, the whole definition seems to become subjective and therefore, at first glance, unsuitable to be incorporated as a definition in an examination syllabus or curriculum.

In my personal opinion, the entire definition only becomes of any relevance for the purpose of curriculum design if the situations referred to in both of the definitions are the same. If that is the case, both definitions can be integrated to form the following definition:

> The contexts of an intuitive rule or a rule as perceived by the pupil and of a physical rule, are those situations to which these rules are applied.

Such a definition does set specific requirements for situations derived from the real world of the pupils and, similarly, for situations in the school environment, or in the world of physics. They must be situations for which pupils already have the disposal of a specific language and behavioural repertoire, but also situations which, from within the framework of physics, also provide the pupil with a new language and new behavioural repertoire. It must be admitted that even this definition does not contain well-defined criteria for the choice of contexts.
They must be at least situations to which pupils can relate their own specific rules. The definition only gains in practicability in relation to curriculum design if we know beforehand which specific

intuitive rules or rules of experience are applied by many pupils in specific situations. Here lies an important point of application for subject didactics. After all, both nationally and internationally, subject-related educational research into the content and nature of the intuitive notions of pupils is a focal point of interest. We already know from many situations from various subject fields which intuitive rules or rules of experience are applied by many pupils to those situations.

Therefore, if specific physical rules can also be applied to these situations, they would appear to be suitable as contexts. The definition of context I have given can be incorporated in an examination syllabus or curriculum, provided we have sufficient knowledge of the rules most frequently applied by pupils to specific situations. My definition of context has to do with the function of contexts within education in the way in which I have come to view this over the past years. However, before going in to this in further detail, the concept of context has to be further differentiated and distinguished from other concepts.

Differentiating the concept of 'context'

In relation to the laws in a specific part of a subject, e.g. the laws of Mechanics or Electrical Science, a wide range of situations qualify as practical contexts. These can be categorized according to 'areas of reality', such as the solar system, space technology (travel), traffic, electricity in the home, thunder, electric power stations, etc. In the teaching of contemporary physics, practical contexts are selected from all of these areas. However, it is also possible to select practical contexts which all fit into the same 'reality area'. This is then referred to as a context area. Also frequently used in this respect, are the terms 'broad context' and 'smaller context'. The 'broad context' is then the context area and the 'smaller context' a practical context within a specific context area.

Besides the concepts school and practical contexts' and 'broad and smaller contexts', we also distinguish between 'acquisitional' and 'applicational' contexts. An acquisitional context is a school context or practical context used in the learning stage of the development of specific concepts. An applicational context is a school context or practical context used during the applicational stage of concept development.

The function of contexts in teaching.

Contexts in teaching Mathematics

Before we look at the function of contexts in teaching physics, it is wise to examine the situation in teaching mathematics. In literature on the methodology of mathematics education, mathematics in practical contexts is often referred to as 'realistic mathematics teaching'. The development of this type of mathematics teaching in the Netherlands has commenced considerably earlier than was the case for physics and has already been implemented on a wide scale. For example, the mathematics A syllabus at upper secondary level (aimed at students preparing for university degree studies such as Economics, Medicine, Psychology, etc.) is based entirely upon 'realistic' models. Within the framework of the innovation of mathematics teaching in the Netherlands, various different functions are ascribed to contexts. Dekker c.s. (1985) draws a distinction as follows:

a. It is a means of relating to child-like notions;
b. It is a means of verifying the use of a concept;
c. It is a means of motivating;
d. It is a means of demonstrating the characteristic features of a concept (representation)
e. It is a means of applying concepts in daily-life situations and, as such, a means of providing a clearer insight into everyday life.

Treffers and Goffree (1985) mention yet again slightly different functions of contexts than Dekker c.s., namely:
a. the forming of concepts i.e., that they should suggest conceptions by which the situation can be approached;
b. model forming. On account of its structure, the context functions as a model in similar situations;
c. practicing and applying skills.

From Dekker's choice of words, it is clear that a context is an aid in achieving concept forming and concept application. The ultimate objective is not a better insight in the context, but the best possible insight in the subject. I consider the approach of Treffers and Goffree much the same as that of Dekker c.s., in as far as the function of context is concerned, except that the former emphasize the proto-typical nature of a context. The context structure should be so clear and transparent to pupils that it can be used as a model in similar situations.

Context in teaching physics

In the development of teaching physics in the Netherlands, the emphasis is also laid upon the correlation between context and concept development. The arguments in favour of the use of realistic contexts in teaching physics are found both in the cognitive and affective fields, as is the case with mathematics.
Only the cognitive aspects are interpreted differently because of the earlier mentioned definition of the concept 'context' (see page 68).
'Cognitive' arguments include:
* an opportunity to elicitate the pupils' own intuitive ideas (experiences, actions) in relation to a specific realistic context and to confront and translate them in terms of problems;
* the subject concepts yet to be developed are more effectively adapted to the cognitive structure of the pupil because they are related to relevant experiences and actions;
* the scope of the subject concepts developed by the pupil can be demonstrated in a variety of situations. In doing so, the chances that the significance of the pupil's own intuitive ideas diminishes in favour of the subject concepts is reduced;

An 'affective argument' includes:
* pupils are generally motivated (girls in particular) because both the social and personal significance of the subject becomes much clearer;

Another argument relates to the nature of the subject itself:
* the discovery of physical laws in realistic contexts is an essential aspect of practicing the subject.

Moreover, if the contexts are incorporated into the examination syllabus, the following argument can be added:
* further clarity is provided to both teachers, pupils and examiners with regard to which concepts and skills may be presumed familiar and in which specific context.

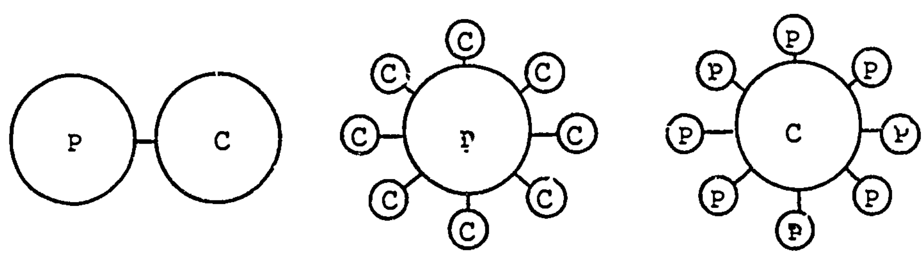
However, it should be noted that, as yet, the arguments brought forward are still only, to a limited extent, supported by subject related educational research.

While the function of the broad context is specifically motivational, aimed at both girls and boys, the smaller context must provide sufficient basis for concept development. Here, the point of departure is that pupils are inclined to accept the cognitive complications of smaller contexts if it is obvious that these smaller contexts are part of a broader context in which useful applications are possible. Moreover, a context should result in the recognition of particular intuitive structures and should help the pupil to construct new, physical structures.
The fact that specific broad contexts are at least as appealing to girls as they are to boys is demonstrated in subjects such as Medical Science and Bio-physics.

In my own work with a group of eight physics teachers, the role of the broad context was also primarily one of motivating the pupils. And this is also the way pupils perceive this in practice. The selected context of a module entitled 'Electrical Provisions in the Home' (grade 4, general higher secondary education/pre-university education) is greatly appreciated by the majority of pupils on account of its recognizability and applicability. However, this does not mean that the same pupils therefore appreciate the complete series of lessons. Apparently, they are quite capable of drawing a distinction between context and physics and of understanding that the objectives involved go beyond gaining insight in the selected context. In addition to this, school contexts involving battery connections and electrical lights fulfil an important role in exposing the intuitive ideas and rules of experience used by pupils. Also in relation to the module entitled 'Thunder', (grade 5, pre-university education), much appreciation is expressed for the broad context. Nevertheless, more than 3/4 of all pupils still find the theory of electrical fields (very) difficult to grasp. The latter is not a negative result of working with contexts. The fact is that the function of contexts cannot be that of simplifying the theory, but it is clear that the pupils' willingness to learn increases and that they express enthusiasm with regard to the practical relevance of the studied framework of concepts. As opposed to the situation in mathematics, where contexts have primarily retained the function of encouraging concept forming, in recent years in teaching physics, a shift of emphasis has become visible, directed at gaining insight in the selected context itself. The context then becomes an educational objective.

The correlation between physics and contextual learning
Depending on the educational objectives involved, there can be question of a correlation between physics and context in different ways. Illustration 1 represents three possible situations with regard to the correlation of physics and context.

figure 1 Possible correlation between physics (P) and context (C)



possibility 1 possibility 2 possibility 3

Possibility 1 appears suitable in order to achieve the following two educational objectives:

a. Increased insight in the broad context itself; and
b. the development of a framework of concepts that can be applied in a variety of (broad and smaller) contexts.

The correlative framework of concepts (N) is capable of describing and explaining of a large number of objects and phenomena in a correlative broad context (C). In possibility 1, the balance between physics and context is placed somewhere in the middle.
Possibility 2 places physics in a central position and applies it to a variety of contexts. This means that only objective b, as mentioned above, is aimed at and not objective a. This possibility results in systematic subject-teaching in which the balance between physics and context leans towards physics. After all, the smaller contexts run the risk of being forced into a secondary role in respect of physics. On giving this possibility its specific content, suitable contexts are selected to match a previously selected framework of concepts. Moreover, the contexts do not necessarily have to bear any relationship to each other.
Possibility 3 places the context in the centre in which a range of different topics related to physics are then discussed. This means that it only aims at the objective mentioned under a. and not at objective b. This possibility results in thematic teaching in which the balance between physics and context leans towards the context. After all, it is doubtful whether, when using this possibility, a framework of concepts can be developed that could be applied to a variety of contexts.

After having discussed possibilities 1 - 3, it is possible to retain in at least two ways an even balance between context and physics: either by making use of the previously mentioned possibility 1, or by combining possibilities 2 and 3. Furtheron I shall come back to this.

The extent of correlation in examination syllabi
In designing the new examination syllabi for MAVO (lower general secondary education), HAVO (higher general secondary education) and VWO (pre-university education), the WEN project group envisaged the following changes:

1. towards 'environmental' physics;
   The emphasis shifts from subject matter which particularly supports the building structure of theoretical physics towards subject matter which is directly applicable in everyday life;
2. towards applications of the knowledge of physics and skills in technology and society;
3. from knowledge of physics in concrete situations towards more abstract nations;
4. towards knowledge of physics acquired by personal experience; in this respect, we do not only imply experimentation, but also participation in discussions, reporting, literature research, etc.;
5. towards further knowledge of physics in contexts; Here, the WEN project group not only envisages applications of physics (see 1 and 2), but particularly the learning situation of concepts and laws of physics;
6. towards a more realistic view of physics;
   This does not only mean that the syllabus should include more up-to-date topics, but also that the pupil must acquire a true idea of the way in which physics is currently applied and an

understanding of the value of the reality of specific physical statements.

This list of shifts can be summarized in terms of an aim towards teaching physics in a more realistic manner, following the development in the approach to the teaching of mathematics. In this respect, it should be noted that the relation between the realistic problem and physics is often more complex than it is in mathematics.

The WEN project group has gone furthest of all in combining subject content and context in the examination syllabus for MAVO (lower general secondary education). This syllabus includes so-called 'broad contexts' which can serve as points of departure in teaching the subject. An example of this is the context 'the human body'. The WEN project group draws a distinction between three aspects within each context, i.e.:

i) physical aspects - here, the function of the lungs (in terms of lung pressure and lung volume), the ear, the eye and the muscles;
ii) personal aspects - here: safety and health in relation to the pollution of the atmosphere, radiation, noise nuisance and damage to the hearing sense;
iii) social aspects - here: physical techniques in healthcare.

The correlation which has been established between physics and context in the MAVO examination syllabus (lower general secondary education) makes it possible to teach physics based on one of the three possibilities mentioned on page 72.

It has become clear from discussions on this syllabus that we still have insufficient knowledge of the use of contexts. Questions such as 'what exactly are contexts , or 'what are suitable contexts in respect of achieving specific objectives', or 'which contexts do pupils really find relevant and interesting', are only now being raised. We may expect answers to these questions when more progress has been made in the development of physics teaching and the subject-related educational research related to that development.

Perhaps this lack of clarity in respect of the function and position of contexts in education has contributed to the fact that the proposals submitted by the WEN project group with regard to the HAVO and VWO curriculum are far less radical. These curricula also include contexts, but only in relation to particular, specific components of the subject content. Moreover, in respect of large sections of the subject content, it may be added that this merely concerns examples of contexts.

This means that the required 'manoeuvrability' of concepts in many areas of the subject matter is just as great as it was before. At VWO level (pre-university education) a more 'restricted manoeuvrability' is only required in the subject areas physical informatics, nuclear physics, atomic physics, bio-physics and physics relating to celestial bodies and satellites. In developing examination assignments within these subject areas, examiners are not to tread beyond the bounds of specified contexts.

In the examination syllabi for HAVO and VWO, emphasis is laid upon physics. Possibilities 1 and 3, as mentioned on page 72 seem difficult to achieve. Possibility 1 can only be put into practice if, in making choices when compiling the examination syllabus, we allow ourselves to be guided both by the structure of the framework of physical concepts, as well as by the structure of the broad contexts thus selected. The pressure of tertiary education or possibly othe: social influences apparently on't seem to allow a change in the HAVO-VWO syllabus in the same way as has taken place in the MAVO syllabus. In view of the differences between MAVO, HAVO and VWO, it can be concluded that the balance between physics and context depends upon the category of pupil.

In a nutshell, the most significant changes in respect of previous examination syllabi are as follows:

1. restriction of subject matter (at lower-general, higher-general and pre-university level);
2. defining context areas (at lower-general secondary level) and specific contexts (at all levels);
3. the distinction between 'flexible' and 'flexible only to a certain extent' (at higher-general and pre-university level); 40% of the questions in examinations at higher-general secondary level and 60% of the questions in examinations at pre-university level will refer to subject areas which include 'flexible' concepts.

Dealing with contexts in practical teaching situations in the upper grades of secondary education.

Four ways in which contexts can be applied
Roughly speaking, there are four methods of applying contexts within the framework of the conditions specified for the new examination syllabus for the upper grades at higher and pre-university level (HAVO/VWO). I shall present these methods here in their true forms. In practice, however, the lesson material is likely to be of a mixed nature.

Both the first and second method are related to possibility 2 (page 72), in which the balance between physics and context leans towards physics.
The first method relates most to traditional physics. Physics is initially presented according to systematic conventions and in student assignments 'trips' are made to other contexts. All contexts used are so-called application contexts and bear little or no relation to one another.
The second method makes a shift in the direction of working in contexts. Physics is still presented according to a systematic approach, but during this stage of presentation the objective is ~~to~~ work with so-called 'acquisitional contexts'. However, in its entirety, these acquisitional and applicational contexts show little or no relationship at all. The relationship is determined by physics. Methods 1 and 2 will occur particularly in all existing teaching methods which in view of the introduction of the new examination syllabus, will have to undergo a 'facelift'. Both methods fit in well with the new examination syllabus.
The third and fourth method should be considered as attempts to shift the balance between physics and context slightly more in the direction of the context as is the case with methods on ' two.
The third method is a combination of thematic and systematic teaching (possibilities 2 + 3 of page 72). In the thematic stage, one specific context is selected and an attempt is made to expose its physical structure. In doing so, it is possible that specific subject concepts are discussed which are relevant to a better understanding of the context, but which in fact lie beyond the scope of the examination syllabus. The relationship is determined by the

selected context. In the systematic stage, the starting point is formed by the physical structure from the thematic stage. This structure is extended and applied in a wide variety of situations. In broad terms, this is the method chosen by the PLON for the curriculum of the upper grades of secondary education. The teaching material developed by the PLON consists of themes and modules.
The fourth method is systematic physics presented within one broad context. Within the frameworks of the WEN syllabus, this is the most difficult method to put into practice because the WEN project group, in selecting subject contents for the syllabi at higher and pre-university levels, did not have a broad context in mind for each topic. This method is by no means suitable to be applied to all parts of the examination. A project group of the Free University of Amsterdam is presently implementing this fourth method in the form of teaching material which consists of 'modules'.

In the following I shall discuss methods three and four in further detail because, in my opinion, these are the most fascinating in relation to possible future developments.

Method 3 in practice
One of the combinations of thematic modules is entitled 'Energy and Labour'. The theme is set within the broad context of 'energy supply in the Netherlands' and within this context it gradually works towards the law of energy conservation. Within this module this law is taken as a theoretical point of departure and applied in a variety of (smaller) contexts. One of the didactics experts working within the framework of 'thematic modules' expressed himself as follows with regard to the contexts mentioned in the examination syllabus: 'So far, there doesn't seem to be any reason for rejecting any of the specified contexts. A more concise formulation would only be helpful if it would more clearly specify the ways in which contexts should be applied in teaching material and in education in general', (Dekker, 1989).
Based upon my own personal experience, in relation to the topic 'electricity and magnetism', I would agree with this statement, but I would also like to add a few comments to this. It seems that those in favour of method 3 find it relatively easy to fit their products within the new examination syllabus. In the thematic stage they focus upon one broad context and then, roughly speaking, they simply see which specific topics from the field of physics can be chosen usefully from the examination syllabus (possibility 3, page 74). During the course module physics takes up a central position while the objective is also a broad application of the framework of concepts and it is therefore quite acceptable if this includes components from a wide variety of contexts (possibility 2, page 74). The balance between physics and the context is positioned somewhere in the centre by creating various teaching periods (first the theme, then the module) with a different emphasis. An important question is whether it is possible, when applying structure of thematic modules, to address all components included in the examination syllabus, because the impression is given that this method of teaching requires more teaching time than a systematic approach to the subject.

Method 4 in practice
Those in favour of a systematic physics in a broad context can make things easier for themselves by selecting possibility 2, (see page 72). In my opinion, this possibility pursues neither of the two

educational objectives previously mentioned and the balance then leans towards the side of physics. But shifting the balance through method 1 (see page 72) in the direction of the context is very difficult. In the syllabus for higher and pre-university level secondary education (HAVO-VWO), the WEN project group hasn't chosen specific broad contexts in which smaller contexts can be integrated, thus forming a harmonious overall structure. Nevertheless, should one attempt to work within a broad context in which, in principle, all relevant physical concepts of that topic should be discussed, a number of concepts and relationships remain that only function within a number of school contexts (i.e. experiments, assignments) and not within the broad context selected. However, within the structure of systematic physics placed within a broad context, you can't take the decision to temporarily exclude those components. After all, the structure doesn't include teaching periods with different emphases. So, you'll have to include them in the teaching material and, consequently, it becomes impossible to work on the basis of a central issue in a specific series of lessons.
It then requires considerable effort to keep track of the broad context and spend sufficient time on the physics required by the examination syllabus at the same time. In general, experience gained in relation to a module entitled 'Thunder' has been quite positive, but even so, when dealing with subject matter, pupils seemed to have great difficulty in drawing a distinction between topics of importance and of less importance. They found that theory was concealed too much between issues relating to the context. This is a significant didactical problem. In practice, interim summarizations of the subject matter seem a possible solution, but must be more closely assessed.

A comparison of methods 3 and 4
For the time being, the conclusion is that method 3 (the theme-module structure) lends itself relatively well to a didactic translation of the new examination syllabus. Method 4 (the systematic approach to physics placed within a broad context) includes the distinct danger of the balance leaning over towards the physics side, while the context is merely included in the form of a few examples and applications. The practical realization of this possibility may well remain confined to a number of topics in which physics and broad context may successfully be linked, despite the requirements of the examination syllabus (see Licht, 1989). A complete curriculum based on this method would only be possible if examiners would allow themselves to be guided by the broad contexts selected when selecting course and subject content.

Future developments in relation to the use of contexts

The trend, initiated in the 1980s, still continues. In the new plans for basic education for all secondary students in the age group of 12-15, attainment targets for Physics & Chemistry have been selected within the framework of ten broad contexts. Among others, these context areas include: 'the use of water', 'Substances and materials in the home' and 'Hearing and producing sound'. Following the examination syllabus for lower general secondary level (MAVO) drawn up by the WEN project group, the broad contexts largely determine the actual subject content to be dealt with in the classroom. In the textbooks which have been recently introduced on the market for use by pupils in the lower grades of secondary education, contexts also play an important role. For the time being, the methods which dominate are those which are applied according to methods 1 and 2, i.e. with a lot of application contexts and relatively few acquisitional contexts. However, if these methods of dealing with contexts were to be placed within the framework of an implementation strategy, methods 1 and 2 could be considered as being a first phase in the implementation of contexts in physics.

It can be expected that some teachers will get stuck at this stage, while others will 'develop' towards methods 3 and 4 in dealing with contexts.

In the short term, no major developments are anticipated with regard to the examination syllabus for the upper grades. After all, this programme has just recently been approved by the Minister in September 1989 (Uitleg 21, 1989). With a certain anxiety, everyone is now looking forward to the 'translation' of this syllabus in terms of new methods. It is expected that the traditional and widely used methods will contain more context-related material than in the past, but will probably not include any drastic changes. As yet, it is unclear just exactly how new methods are going to perform on the educational book market, such as PLON upper secondary level and modular physics, in which contexts are explicitly placed in the course material. Among other things, important issues with regard to the future assessment of working in contexts include:

a. to what extent are the pupils motivated by the broad context?
b. will teaching in contexts cost a lot more time than before?
c. are pupils capable of keeping track of a specific line in concept development amidst a wealth of context-related information?
d. to what extent will pupils be capable of transferring their knowledge to new, unfamiliar contexts?

It would take some presumptuousness to introduce the described changes in physics without first having answered the above mentioned questions. However, on the other hand, there are sufficient indications that working with realistic contexts will make physics much more attractive and appealing to both pupils and teachers. However, it is both desirable and necessary that new developments are critically followed.

Literature

Boersma, K.Th. en J.C. Schouw (1985), Aansluiten op (de leefwereld van) leerlingen: uitgangspunt voor het schoolvak (kennis der) natuur. Tijdschrift voor B-didactiek, 3, 1, 44-57.

Dekker, R., P. Herfs, J. Terwel (1985), Contexten en begripsontwikkeling bij Wiskunde. Tijdschrift voor B-didactiek 3, 3, 169-183.

Dekker, J. (1989), Persoonlijke communicatie.

Examenprogramma's natuurkunde VWO en HAVO (1989), O&W-regelingen, Uitleg 21, Ministerie van O&W, Zoetermeer, 20 september 1989.

Genderen, D. van (1984), Context als B-didactisch begrip, Tijdschrijft voor B-didactiek, 3, 3, 183-194.

Genderen, D. van (1989), Mechanica - onderwijs in beweging, proefschrift, Rijks Universiteit Utrecht.

Kortland, J., Loo. F.A. van der (1986), Natuurkunde als gereedschap bij besluitvorming. In: H.M.C. Eijkelhof e.a. (red.) Op weg naar vernieuwing van het natuurkunde-onderwijs. Een verzameling artikelen ter gelegenheid van de afronding van het PLON, SVO, Den Haag.

Licht, P. (1989), Onweer in klas 5 VWO. NVON-maandblad, 14, 9, 416-419.

Treffers, A., F. Goffree (1985), Rational Analysis of Realistic Mathematics Education. In: L. Streefland (ed.), Proceedings of the 9th. International Conference for the Psychology of Mathematic Education. Vol. 2, 97-123, Utrecht: OW&OC.

WEN (1984), Werkgroep Examenprogramma's Natuurkunde, Concept examenprogramma D-niveau, Enschede: ACLO-natuurkunde.

3.3 Settings and methods in education in technology in the Netherlands

Marc de Vries,
Pedagogical Technological College, Eindhoven

Introduction

The third of the five main themes included in the OECD project 'Science, Technology and Mathematics Education' is entitled: Settings and Methods for Students' Learning.
This paper deals with settings and methods with regard to teaching technology in the Netherlands. I shall discuss six issues: the role of contexts in presenting the subject matter, the role of practical work and experimentation, the role of problem solving as a didactical method in teaching technology, the role of visits to industry, the role of interdisciplinary project work and the role of 'informal' learning.

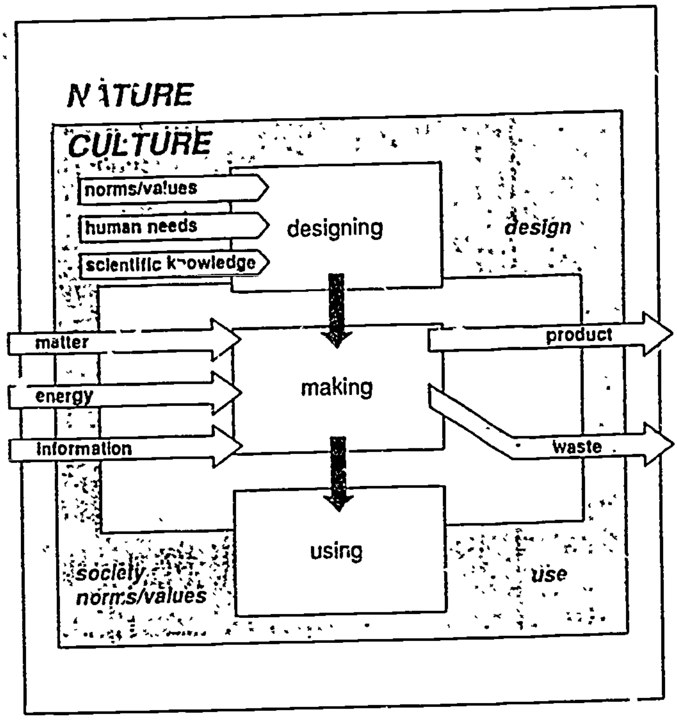
The use of contexts in teaching technology

In general, daily-life situations can be used in two ways: - an aim in itself, or as a context in teaching something else.
In the case of technology, both produce specific problems.
The use of daily-life situations as an aim poses a problem with regard to the choice of situations, since the number of situations applicable to technology is enormous. Technology involves all aspects of our lives. It is difficult to say which part of our lives is affected most by technology.
Attempts have been made to divide all possible situations into a few major groups. In the USA, for example, topics from technology are selected from the broader fields of Transport, Communication, Production and Construction (Todd/McCrory/Todd 1985). Initially, these broader areas may seem rather complete, but it is not quite clear where, for example, domestic appliances or medical equipment belong.
In the Netherlands, the National Institute for Curriculum Development (SLO) has proposed the following themes: the Living Environment, Leisure, Work and Professions (SLO 1986). Later, the committee who had drawn up the aims and objectives for teaching Technology in Basic Education (Basisvorming) added the topic 'traffic' to this list of themes and explicitly mentioned Medical Technology as belonging to the category denoted as 'Work and Profession' (Eindtermencommissie Techniek, 1989). It is clear that these four areas are merely a selection and that completeness has not been pursued. The entire field of Communication, for instance, has been omitted.
These categories are an important improvement in comparison to conventional subdivisions such as: Wood-Metals-Textile (and sometimes plastics), as they existed in the past in schools for lower vocational education (Ploegmakers-Verstegen, 1985).

However, the problem of apparent incompleteness still remains. This becomes even more evident when further selections have to be made within each of these areas, resulting in the selection of topics of which it is not always clear why they have been selected and why other possible topics have been rejected. The following example illustrates this: in the SLO's 1986 curriculum proposal, the chosen themes for a two year curriculum included bicycle maintenance, technology and living, machines, levers, cybernetics, technology and drinking water, and energy. The same publication also included proposals with regard to other themes. Apparently, a variety of choices can be made, but the reasons for these choices are not always evident.

An alternative is to take the 'laws and principles of technology' as a starting point and to use daily-life situations as a context for learning these 'laws'. Here, a rather unique problem arises, which makes the discussion on teaching Technology different from the discussions on teaching Science and Mathematics (and most other subjects, too): we hardly have sufficient knowledge of the laws and principles of technology. Universities have faculties of Electrical engineering, Building Engineering, Mechanical Engineering, Chemical Engineering, etc., each developing and using its own specific laws and principles, but no faculty of technology. The laws and principles that are more general in scope and more common among the various technological subdisciplines have only just recently been investigated. A well-known example of such a principle is the systematic approach to the description and development of technological objects (De Vries 1989).
A second example is the 'function triangle' in which relationships between functions, forms, materials and processing methods are described.
The Pedagogical Technological College (PTH) has initiated the development of a general philosophy and concept with regard to technology and the development of various subjects which deal with this concept as a whole and with the various aspects and parts of this concept. (Peters/Verhoeven/De Vries in De Klerk Wolters/Mottier/Raat/De Vries 1989). Figure 1 illustrates this particular concept. It briefly describes the process of technology as follows: each technological development starts with human needs. To a certain extent, human standards and values determine whether and how we want to fulfil these needs with the use of technology. We also have the availability of scientific knowledge as an input, after which a process of designing, making and using takes place. Here, 'Production' is applied in the sense of: taking matter, energy and information and transforming these into products and waste. The use of technological products takes place in a society in which standards and values affect the way in which we use technology.

figure 1: The PTH concept of Technology



With the development of such a programme, we became aware that we weren't only developing a teacher training programme for a specific subject, but also for the very subject itself. We were also aware of the fact that previous attempts to formulate general technological principles and to transform these principles into educational programmes weren't always successful. (In this context we may refer to the publication by the Engineering Concepts Curriculum Project entitled 'The Man-made world'). Nevertheless, it seemed to us that an understanding of the way technology functions in practice forms an important component in the pupil's education.
With regard to this option, the choice of contexts is not essential to learning about technology. The principal objective here is to help pupils understand the nature of technology. The lessons should be designed in such a way that pupils recognize this concept as a constant throughout all the examples of technology they come across. It not only helps them deal with a choice of contexts, but also understand other possible contexts. Research into pupils' concepts on technology has shown that many pupils have indeed understood other possible contexts; De Klerk Wolters 1989). In general, pupils aren't aware of the human aspects of technology. They are inclined to consider technology as a broad array of various appliances and machines. They hardly ever mention words like 'designing', 'developing', and 'creativeness' when talking or writing about technology. On the other hand, they can give an extensive array of examples of technological objects, many of which they would like to learn more about. It would be a valuable result of teaching Technology if pupils were to be provided with a concept of technology that would help them understand all of these various objects, and not just a selected group of objects.
In selecting contexts, one should be well-aware of the differences which exist between the ideas of girls and boys with regard to technology. In general, girls have a more limited concept of technology and are less interested in technology than boys.

Therefore, a very careful selection of contexts should be made which relates to the interests of both girls and boys.

The situation in the Netherlands also seems to be one of two streams:

- The first stream considers the production of technical products and the ability to use and maintain technical objects as a principal aim. It then seems evident that learning from daily-life situations is an objective in itself;
- On the other hand, the second stream considers the need to give students an understanding of technological objects and phenomena as a principal objective. In this case, the manual or machine production of products and the use and maintenance of appliances serves as a context in achieving this objective.

In lower vocational schools, where a kind of Technology is taught under the heading 'General Techniques', the first option is usually advocated. Most of those who advocate the second option are found in the main core of lower secondary education. Undoubtedly, this is related to the category of pupil found in those two types of education.

The committee which has drawn up objectives for teaching Technology at Basic Education (Basisvorming) level has not yet made a clear choice. There appears to be a kind of conceptual organization of objectives, but this organization is not based on a clear concept of technology, nor is it based upon a set of technological laws and principles. The contexts are mentioned independency of this organization and seem to serve as a kind of criterion for the selection of topics.

The introduction of Technology in all types of lower secondary education may provide further clarity in respect of the choice between these two options. As yet, there is no research data available with regard to the effect the use of contexts has on the learning of technological concepts.

Practical work and experimentation in Technology

Some remarks have already been made with regard to the role of practical work and experimentation in Technology. Practical work concerns the production of technical objects, whereas practical experimentation deals with existing technical objects. In teaching Technology in the traditional way at lower vocational level, i.e. General Techniques, emphasis was principally laid upon the teaching of practical handicraft skills which were considered as the principal aim of the subject. On the other hand, at lower vocational level, cognitive skills were considered less relevant to pupils. Again, the problem of selection arose because of the wide variety of technical handicraft skills from which to choose. Wood and metals were the materials usually chosen to work with. A second option is to use practical experiences to help pupils understand the nature of Technology.

As opposed to the first option, it should be emphasized that the second option doesn't necessarily lead to a more theoretical approach to the subject Technology.

The option thus selected will also affect the way in which the classroom is equipped. The traditional classification of tools is as follows: tools for wood-working, tools for metal-working, etc. This approach is usually taken when practical work is considered the most important objective. A curriculum for Technology aimed more at the understanding of technological principles will probably result in a different approach, e.g. one in which tools are classified according to the kind of process in which they are involved, i.e. the integration of materials, the forming or deforming of materials, or the separation of materials. The way in which the classroom is equipped can certainly contribute to a better understanding of the principles of Technology.

Problem-solving as a method of teaching Technology

Whether or not problem-solving should be an aim in itself has been discussed in the paper presented by Van der Velde. In this connection, I shall confine myself to the topic of 'problem-solving' as a method of teaching. It is a generally accepted viewpoint that problem-solving is a useful method in teaching Technology. The National Institute for Curriculum Development of the Netherlands (SLO) has chosen to describe this method in four stages, i.e. Thinking, Drawing, Making and Assessment (Dutch abbreviation DTMC (C stands for control)) (SLO 1986). In reality, however, this scheme is only partly used. Most of the time, the process is confined to the reading (interpretation) of drawings and production. (In their description of schools, Feteris and Streumer mention only a few examples of real problem-solving in teaching Technology). Designing is not often done by the pupils themselves. Assessment hardly ever leads to fundamental adaptations/modifications of designs. The failure of the four-stage method probably results from the fact that teachers have never been trained in dealing with the outcome of the pupil's creativeness. The process of dealing with a technological problem requires proper guidance by the teacher. The lack of such guidance frustrates the entire process and teachers will lose faith in the process itself.

In the United Kingdom, problem-solving is a commonly used method in the subject CDT (Craft, Design and Technology). In this subject, pupils are initially taught the basic knowledge and skills necessary for solving technological problems. (Kees, 1988; Toft, 1988) They start to solve technological problems, first assisted by the teacher, then independently. This has proven to be a feasible approach. However, it should be noted that in the United Kingdom more teaching time is allocated to this subject than to the subject Technology in Dutch schools. Still, the problem-solving approach could be the right direction for teachers to take. With regard to teacher training, this would mean that teachers will need to be trained in the guidance of pupils, with the objective of increasing the independence with which pupils deal with solving technological problems.

Visits to industry

A number of aims for teaching Technology in Basic Education (Basisvorming) relate to technology in industry. Pupils should therefore learn how technological processes take place in industrial plants and companies. Of course, this can be taught from textbooks, but obviously the best way to gain insight in these processes is by organizing visits to industry. Up till now, relationships between schools (in particular schools providing general education) and industry have been very weak. Visits to industry are a new phenomenon in general education.

Some years ago in the United Kingdom, a special 'Industry Year' was organized by people involved in education and industry. The objective was to stimulate collaboration and relationships between schools and (often local) industries. (Cook, 1986). People involved in industry visited schools to discuss their work. Teachers were given the opportunity to 'work' in a factory for some weeks and teachers and classes visited industrial plants. Once the subject Technology has been introduced in both vocational and secondary education, it could be beneficial to organize our own 'Industry Year' in the Netherlands.

Interdisciplinary project work

The subject Technology is related to various other school subjects, e.g. physics, chemistry, biology, mathematics, history, geography, economics, languages and crafts. It could even be argued that these relationships are essential in order to gain an understanding of the nature of technology, in which case specific attention should be paid to our settings and methods (Harrison in Raat/Coenen-van den Bergh/De Klerk Wolters/De Vries, 1988).
In this connection, I should like to refer once more to the United Kingdom as a source of useful information. In a number of schools in the United Kingdom, interdisciplinary projects were undertaken as part of the school's Technology activities. A specific technological problem was selected and the various subjects all contributed to the discussions on possible solutions to the problem. This is often referred to as 'Technology across the curriculum' in which technology functions as an adhesive component between the various disciplines.
Although experiments with project work in the Netherlands have had some popularity, there was never a full break-through. In most schools in the Netherlands, project work involving a variety of subjects is rare. A second problem is that, traditionally, the subject Technology, or rather, 'General Techniques', has been more closely associated with Crafts than with Science and Mathematics. As it stands, the content of the subject does not offer many opportunities for links with Science and Mathematics.
Moreover, the discussions between the groups who formulated the aims and objectives for Basic Education (Basisvorming) with regard to the subjects Physics and Technology have led to a bundling of topics, so that the teaching of physics and technology will not contain any common topics at Basic Education level. Perhaps experience can be initially gained from technological project work in primary education, where interdisciplinary work is much more commonplace. It seems to me that project work in the near future in secondary education will be rather exceptional in Dutch schools.

Informal learning of Technology

We are becoming increasingly aware of the fact that the learning process does not only take place in school, i.e. in formal learning programmes. In the case of Technology, research has shown that pupils already have some knowledge and ideas about technology when they first embark on education in technology. Unfortunately, their ideas are often distorted and incomplete, as I previously stated. Various groups of people attempt to stimulate the interest of youngsters in technology by taking an informal approach to the teaching of technology. Examples of this include: Technika 10 (specially for girls), (Hylkema-Knotenbelt and Nauta in Raat/Coenen-Van den Bergh/De Klerk Wolters/De Vries, 1988), De Jonge Onderzoekers (Young Explorers), the Museum of Technology (NINT) in Amsterdam and the Evoluon Museum at Eindhoven (which has just recently been closed down). Another informal teaching project is the one entitled 'Kijk op Techniek' (Vision of Technology). This multimedial project resulted in a television series on technology, textbooks on technology for the junior level of general secondary education and a conference on the societal aspects of technological innovations.

It is still unclear how these different ways of informal learning will contribute to the teaching of technology as a whole. It seems that, until now, television programmes have only limited pupils' images of technology in relation to modern technological equipment and machines.

However, attention is rarely paid to the human processes which result in the production of these products. Practical activities such as 'Technika 10' and 'De Jonge Onderzoekers' could broaden the scope, but on the other hand, they could also confine the pupil's concept of technology to the manufacture of products only. The combined use of various methods of informal learning may, or may not lead to a balanced concept of technology on the part of the pupil.

Literature

Cook, T. (1986), Why do industrialists ignore schools? Physics Education 21, 321.

Eindtermencommissie Techniek (1989), Advies over de voorlopige eindtermen basisvorming in het voortgezet onderwijs. 17. Techniek. 's Gravenhage: Staatsuitgeverij.

Engineering Concepts Curriculum Project (1971), The Man-Made World. New York: McGraw Hill.

Feteris, A. en J.N. Streumer, Techniek: een nieuw vak. Stand van zaken techniek in het voortgezet onderwijs. De Lier: ABC Publishers.

Jong, R. de (1989), Probleemoplossen binnen het vak Techniek (diss). Groningen: RION.

Klerk Wolters, F. de, Mottier, I., Raat, J.H. en M.J. de Vries (eds.) (1989), Teacher Education for School Technology (report fourth international conference Pupils' Attitude Towards Technology, PATT). Eindhoven: PTH.

Klerk Wolters, F. de (1989), The Attitude of Pupils Towards Technology (diss). De Lier: ABC Publishers.

Ploegmakers-Verstegen, B. (1985), Algemene Technieken. WB 10 bij Basisvorming in het onderwijs. 's Gravenhage: Staatsuitgeverij.

Raat, J.H., Coenen-van den Bergh, R.M.M., Klerk Wolters, F. de en M.J. de Vries (eds.) (1988), Basic Principles of School Technology (report third international conference Pupils' Attitude Towards Technology, PATT). Eindhoven: University of Technology.

Raat, J.H. en M.J. de Vries (1988), Techniek in de basisvorming. In: Ahlers, J., e.a. (eds.), Handboek Basisvorming. Deventer: Van Loghum Slaterus.

Rees, D. (1988), GCSE CDT-Design and Realization. Essex: Longman Group Ltd.

Stichting voor de Leerplanontwikkeling (1986), Leerplanvoorstel Techniek. Inhoud van Techniek in de basisvorming (2 volumes). Enschede: SLO.

Streumer, J.N. 1988), Evalueren van techniek. De Lier: ABC Publishers.

Todd, R.D., McCrory, D.L. and K.T. Todd (1985), Understanding and Using Technology, Worcester, USA: Davis Publications.

Toft, P. (1988), CDT for GCSE. Oxford: Heinemann

Vries, M.J. de (1988), Techniek in het natuurkunde-onderwijs (diss). Eindhoven: Technische Universiteit Eindhoven.

Vries, M.J. de (1989), Technology in perspective (educational module). Eindhoven: OPEN TECH/PTH.

3.4 Discussion report

In three groups the second theme, 'Setti. ,s and methods' was discussed.

Correspondence and differences between science, mathematics and technology.

An important corresponden:e between science and mathematics is that both of these subjects try to select learning contexts for concepts of the subject. In physics ıcation contexts have been defined as a scurce of empirical rules a. applications of physical laws. Preconcepts are regarded as empirical rules that have been 'learned' in specific contexts. In science and mathematics it is constantly questioned how contexts (realities) and concepts of the subject (mentalities) can be tuned. A difference between physics and mathematics seems to be that in mathematics contexts are balanced more carefully.
However, both in science and in mathematics there is a tendency to look on contexts as a goal and to relate the selection of contexts to the existence of suitable contexts. When there is no suitable contexts it is questioned whether the concept should be learned at all. An example of this is the concept of 'negative numbers'. So far we have not been able to find an appropriate context.
Technology seems to be different in nature. Here contexts are often regarded as starting point and goal.

An important difference between the subjects is the selection of contexts. On the one hand one can find the criterion of subservienc of the contexts to the concepts, on the other hand there is the criterion of the relevance of the context for later use. Here the cr.terion is not just what the engineer needs, but what the citizens need. Relating education to society cannot be accomplished without the use of contexts. In education we want to help pupils to bring order in reality, which often seems to be a chaos, and make them feel comfortable in it. It would be nice if we could find contexts that include a potential problem, maybe a dilemma.

There are other contential differences between the subjects. Biology and technology for a major part are phenomenological in nature, while mathematics and physics historically seen are more theoretical and decontextualized in nature. It is not surprising that the call for contexts mainly comes from mathematics and science.
Distributing contexts over the various subjects seems to be a rather random process. It would be possible to find clusters of skills, for example dealing with 'surviving', 'controlling', producing', that are interdisciplinary. Especially by using this type of clusters bringing together the subjects could be realized.
The heart of technology seems to be problem solving, an issue that also plays a role in other subjects.

Correspondences and differences often can be explained by the role of tradition in science and mathematics education. Technology, however, is a new subject, that besides that cannot build on a basis that has been prepared in primary education.
The conceptual structure of technology is yet very unclear, the structure for the other subjects has been determined already. In those subjects there is a distinction between the structure of the subject and the structure of the education of the subject. In those subjects overall theories have been developed. From those detailed theories can be derived, that can be transformed into an educational structure for that subject.
Technology maybe can be typified as a school subject with a certain conceptual kernel (for example using a systems approach) and with applicational contexts from other school subjects (science in particular). In that perspective, technology can be compared to environmental education, which also is a way of reflection. Both in technology and in environmental education making decisions is essential.

Problems

Problems with respect to the use of contexts for curriculum development or in school practice, are now discussed.

A first problem is the selection of contexts. For pupils often other contexts appear to be relevant than the ones chosen by the curriculum developers.
'Learnability' is an important criterion for the selection of contexts. By far not all contexts from the living environment are interesting and even contexts from far away can arrest pupils' attention. Should contexts always be fed by experiences and the living environment? Or is it sufficient to look for 'new' and 'challenging' contexts? We still do not fully draw from the pupils' own environment. Their basic experiences should be completed in order to stimulate conceptual growth.
It should be admitted that ultimately concepts of the subject are the aim. Pupils note that very well and that reduces the effect of using the context. Another problem is, that youngsters of ages 8-14 often do not romance very much any more. Finding contexts that are related to the culture of that youth is very hard. A 'thinkable' reality for such cases may be even more successful than a 'real' one. Age therefore should be one of the criteria for the construction of education.

In general problem solving is regarded as a curricular organizer. A problem is that the type of situations to be chosen depends on the skills and knowledge that pupils have. The level of openness and complexity of problem-situations should link up with their problem solving skills.

A second problem is that learning in contexts is time/consuming, and time is precious for mathematics and science education because of the exams. Using contexts therefore could mean that exams (and content in general) must be reduced.

A third problems comes from school practice. Some pupils even in thematical phases cannot be held back from giving subject-systematical answers. This can increase pupils' uncertainty.

In other cases obscurity can be induced by not clearly distinguishing between knowledge of the context and concepts of the subject, so that pupils can not decide whether or not knowledge can be relevant in certain contexts. A clear distinction between these is important from the perspective of transfer of knowledge.

A fourth problem is the conflict between the need for pupils to identify their own constructs and the need to relate contexts with concepts of the subject. It is not always clear to pupils that concepts can have a meaning in reality.

A fifth problem is the consolidation of gender roles, which in secondary education is even stronger than in primary education. Often, educators are not aware of the differences between girls and boys. In doing experiments it is important to make sure that girls do not constantly serve as secretaries. Separate classes for girls and boys in certain situations can stimulate the girls' learning results. In Belgium examples of this can be found. Learning from each other, however, is reduced by this.
In the various subjects there are sufficient opportunities for working on this problem seriously. The choice of contexts is important here.

A sixth problem is implementation. Teachers judge from their own frame of reference. Then a dilemma can grow between what they themselves regard as useful and new insights of which they do not immediately see the relevance.

Questions to be studied in the OECD project

From the various discussion groups questions on the first theme have been stated, of which participants thought it would be relevant to have them answered in the OECD project.

1. What do we generally mean by 'contexts'? To what extent does youth culture play a role here?
2. In what ways contexts can be used? Can they be used to derive theoretical concepts? Can they be used to apply these concepts?
3. Is it possible to derive criteria from reality, so that certain matters should not necessarily be dealt with in education?
4. What is the relation between learning achievements and the use of contexts? Does knowledge that is gained from contexts more easily lead to behavioural changes than knowledge that has not been gained from contexts?
5. Are there experiences with the implementation of contexts in education? To what extent does using contexts play a role/in the education of teachers?
6. How should the conceptual structure of a subject and the didactical and educational structure be related? Are there experiences in member countries?
7. Where do we find obvious interfaces between the three subjects? What interfaces have been explored? What concepts from the subjects yield opportunities for a common approach?
8. What are results of projects that are especially aimed at reducing gender differences?

4. The Dutch participation in the OECD project 'SMT Education'

4.1 Opinions on the Dutch participation

Part of the conference was a discusion on the question whether or not participants thought it would be useful to participate in the OECD 'SMT-Education' project.
Here we describe an overall impression of that discussion

Doing survey studies in the OECD project seemed to be valuable for us in the Netherlands. For technology expectations are higher than for other subjects, because of the fact, that technology is just being introduced now; several other countries have more experiences here.
Surveying the various questions that are relevant more accurately was regarded as useful. It initiated a discussion on our final aims for the three subjects. At a national level we have not discussed that systematically in the Netherlands with the three subjects together, nor for each subject separately. It is important that barriers between the subjects are pulled down.
It is important to note here, that as 'Science education' as such does not exist in the Netherlands, SMT might not be the most appropriate point of view (but rather something like 'Physics, Chemistry, Biology, Environmental Education, Mathematics and Technology Education').

In the OECD project the following issues should be dealt with.
In education we see a conflict between choosing content from an educational and developing point of view or from the perspective of the academical discipline (bottom-up versus top-down). In the Netherlands it seems that we are still undecided. This could be studied in the surveys.
What lacks in the Netherlands at this moment is an underlying relationship between concepts that make the subject a unity. We do find certain concepts from the structure of the academic discipline. When that structure is removed we may find more room and make better use of the differences between the subjects. An important issue for the OECD project can be the coherence between the various contents. Possibly that will reveal correspondences between the subjects. Now we often look for those in issues like 'problem solving' or 'reflective learning'. A number of participants do not regard that as an appropriate approach. There is a danger that such correspondences are raised to be content, which is not always desirable.
Another important issue for the OECD project can be the implementation of new contents in relationship with the/production of pupils' and teachers' materials, teacher training programs and in-service-training of teachers.

A general impression was that participation in the project can be useful, provided that the questions that will be stated are relevant and well-considered.

4.2 Specific Dutch contributions and expectations for the project.

In a final discussion session, for each of the subjects Science, Mathematics and Technology, both contributions and expectations from our Dutch perspective were listed.

For science the Netherlands seems to have been active and rather successful in the development of teaching in contexts and research into preconceptions and the way in which pupils learn concepts of science. Other strongly developed areas are: conceptualization in environmental education and the analysis of concepts in chemistry that are taught.

The group was interested in further information on the way the problem solving process should be dealt with in education, developing science education for primary schools, teaching norms and values in science education and the selection of goals and contents that should not be thrown away when an innovation takes place.

For mathematics education the following strongly developed issues were identified: the development of a theory of learning and teaching mathematics and the didactics for primary school mathematics.

A yet unsolved problem in mathematics education, as we in the Netherlands experience it, is the way we should deal with mathematical proofs.

Technology education in the Netherlands is just about to be implemented as a general subject in all kinds of secondary education. There is some experience with technology in vocational education.
Still, there are a number of potential Dutch contributions here. Several research studies have been carried out: research into pupils' concept of and attitude towards technology, research into the way pupils learn to solve problems in technology education, research into the way pupils learn psychomotor skills.
Development work is also being done in the fields of relating theory and practice in technology education, the search for a conceptual structure for technolgy, introducing technology in the teaching training programmes for primary teachers. In many studies special attention is paid to differences between boys and girls.

Participants would be interested in information on the way technology teachers are educated in other countries. In the Netherlands recently a number of such programmes have started. Another point of interest was the interaction between research, developmental work, policy and teacher training in innovations.

As can be seen from this list, participants noticed both Dutch contributions and expectations for the OECD-project Science, Mathematics and Technology Education and therefore were inclined to be positive about possible Dutch participation in the project.

Appendix:

List of participants

Mrs. A.J. Bekker-Holtland, Hogeschool Midden Nederland, Utrecht.

Mr. P.C. Beukenkamp, Rijksuniversiteit Utrecht, Utrecht.

Mr. W. van Bochoven, CPS, Hoevelaken.

Mr. K.Th. Boersma, SLO, Enschede. *

Mrs. J.M.J.M. te Braake-Schakenraad, KPC, Den Bosch

Mr. H.G.B. Broekman, IVLOS, Rijksuniversiteit Utrecht, Utrecht.

Mr. F. Cornelissen, PABO Domstad Academie, Utrecht.

Mr. B.G. Doornekamp, Universiteit Twente, Enschede.

Mr. J. van Dormolen, Utrecht. *

Mr. H. Eijkelhof, Rijksuniversiteit Utrecht, Utrecht.

Mr. P. Herfs, ISOR, Rijksuniversiteit Utrecht, Utrecht.

Mr. H. Jansen, VALO wiskunde/informatica, Enschede.

Mr. R. de Jong, RION, Rijksuniversiteit Groningen, Groningen.

Mr. H. Krabbendam, SLO, Enschede. *

Mr. J. Leisink, Technische School St. Jozef, Nijmegen.

Mr. P. Licht, Vrije Universiteit Amsterdam, Amsterdam. *

Mr. J.A. ter Pelle, SLO, Enschede.

Mr. M. Pieters, SLO, Enschede.

Mrs. B. Plo makers, SLO, Enschede.

Mr. A.G. Plug, VALO natuurwetenschappen, Enschede.

Mr. J.L.M. Smits, Hogeschool Katholieke Leergangen Sittard, Sittard.

Mr. J. van der Velde, SLO, Enschede. *

Mr. W. de Vos, Centrum voor B-didaktiek, Utrecht.

Mr. M.J. de Vries, PTHN, Eindhoven. *