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Reference levels in School Mathematics Education in Europe

National Presentation

THE NETHERLANDS

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1. General description of the Dutch school system

Compulsory education in the Netherlands consists of eight years of primary education (age 4-12) and four to six years of secondary education. A choice about the type of secondary education to be followed has to be made in the final year of primary school. Parents, teachers and children make this decision together, with the results of an obligatory test weighing significantly in the choice. The four options are (in increasing academic attainment levels):

1. 4 years pre-vocational education (VBO)
2. 4 years general secondary education (MAVO)
3. 5 years general secondary education (HAVO)
4. pre-university education (VWO).

During primary education pupils advance to the next grade at the end of each school year, whereas during secondary education pupils may be obliged to repeat a certain grade if their results are unsatisfactory. Education is compulsory till the age of 16 years.

VBO is a four-year course of pre-vocational education specializing in technical, home economics, commercial, trade, and agricultural studies. MAVO is a four-year program after which students may take a shorter or longer senior secondary vocational education course, join an apprenticeship scheme, or enter the employment market. In 1999, VBO and MAVO merged to become pre-vocational secondary education (VMBO).

HAVO is a five-year program designed to prepare students for higher professional education. A HAVO certificate also allows pupils to go on to pre-university education (VWO). VWO is a six-year program that leads to university. There are two types of VWO program: *atheneum* and *gymnasium*. They are similar but *gymnasium* includes Latin and Greek in the curriculum.

The *gymnasium* is often a small (~500 pupils) independent school, whereas the other school programs are often part of a larger (1000-2000 pupils) comprehensive school.

These four school types all finish with a final national examination (*eindexamen*). To be more precise, 50% of the final examination is national, while the other 50% is the school's responsibility (partly in the form of continuous or project assessment). The final mark is the average of the marks for these two parts. The examination syllabuses for all the different school types are in a state of change, as described in the following sections.

1. Core curriculum with attainment targets

In 1993 a new common core curriculum for Basic Secondary Education, the *Basisvorming*, was introduced in all Dutch secondary schools. This core curriculum includes fifteen subjects, with the Ministry of Education defining the attainment targets. It takes from two to three years to complete and is compulsory for all school types. It aims to provide a broad, general education for all students aged between 12 and 15 years. The core curriculum consists of:

- Six general attainment targets, including several skills and topics to bridge between subjects. The subject-bridging topics are derived from societal phenomena, for example, the relation between man and nature, the significance of technological development for society, art culture, and emancipation.
- Attainment targets for the fifteen compulsory subjects.

The attainment targets describe the standards that students are expected to attain in terms of knowledge, understanding and skills, but contain no explicit specification of levels of achievement. Each school is free to define the achievement levels for its own students, within the boundaries the school sets for itself, and those of its secondary school type. It is assumed that teachers will 'place the bar as high as possible', depending on the students' potential and interests.

In order to be able to adapt the educational content regularly to the changing demands of society, the Secondary Education Act specifies that the attainment targets are to be redefined every five years. The first adaptation of the targets took place in 1998, for the period 1998 - 2003.

2. Revision of pre-vocational secondary education

In 1999 a new type of secondary education was introduced: pre-vocational education or VMBO. This VMBO is replacing the old MAVO and VBO school types, so that by 2003 the old MAVO and VBO curricula will have disappeared and been replaced by a sophisticated system of sectors and streams (*leerwegen*).

There are *four sectors*:

1. Engineering and technology
2. Care and welfare
3. Economics
4. Agriculture

And within each sector there are *four different streams*:

I. Basic vocational stream

II. Vocational stream

III. A combined theoretical and vocational stream

IV. A theoretical stream

The first stream prepares for vocational training at the lowest level. The others aim at further professional training at secondary vocational educational level. The first national and final school examinations under this new system will be held in 2003.

3. Revision of senior secondary education

HAVO and VWO are in a state of change as well. The freedom which pupils currently have to choose their exam subjects during the senior secondary years of HAVO and VWO will largely disappear, to be replaced by set subject combinations. It is hoped this change will lead to students being better prepared for higher professional education and university courses. It may also help to reduce the number of students who leave higher education without qualifications. There will be four subject combinations or profiles (*profielen*) to choose from:

- Science and Technology
- Science and Health
- Economics and Society
- Culture and Society

Thus, there are now eight different examination syllabuses at senior secondary level, one for each of the four profiles, for both HAVO and VWO levels. The implementation of the four

profiles means that all the examination syllabuses for senior secondary level have been changed.

In the Netherlands the final examination consists of two parts. The first part is a national central (mostly written) examination that is the same for all schools. The second part is organized by the school itself and is known as the 'school exam'. The school exam will take the form of an *examination portfolio*. This may be a list of grades or an exam booklet, or it could be a folder of project work. The requirements the school exam must meet are described in the examination syllabus. The first nationwide examinations according to this new system of subject combinations/profiles will take place in 2001 (HAVO) and 2002 (VWO).

Another new feature of the HAVO and VWO systems is the emphasis on *independent learning*. This means the role of teachers is changing and instead of them being in control of the teaching/learning process, students are now responsible for their own learning process, while the teachers switch to supervision and encouragement.

Another new concept is the 'study load' (*studielast*). At the moment, a school day consists of five to eight 50-minute lessons covering different subjects. In the new situation each subject will have a fixed total number of hours of student work per year, instead of a fixed number of 50-minute lessons per week. The study load for the second phase of HAVO (last two years) is 3,200 hours while for the second stage of VWO (last three years) it is 4,800 hours. This time includes attending lessons at school, and preparing lessons both at home and at school. Project work, reading books, using a multimedia resource center or library, and taking part in school trips are also taken into account.

The Science and Technology profile at VWO has a total study load of 760 study hours for mathematics, which represents about 16% of the total study time in the senior phase of VWO. The mathematics study load is distributed as follows:

- Calculus 320 hours
- Geometry 160 hours
- Probability and statistics 140 hours
- Optional topic 40 hours

The profile with the least mathematics is Culture and Society (360 hours or 7.5% of total study load).

4. Direction of the changes

In the coming years all Dutch secondary education students will face a completely revised education program characterized by:

- Encouragement of a broad, personal development and social education for all students;
- A focus on active, independent learning;
- Acknowledgement of the differences between students;
- An emphasis not only on facts but also on learning skills.

For schools, teachers and pupils this revision of secondary education is an enormous change. The implementation of this change is expected to take at least ten years.

2. Main mathematics objectives

Both general objectives and attainment targets related to different content fields have been formulated for the core curriculum in Basic Secondary Education.

The general objective of mathematics education is to enable pupils:

- To develop a mathematical disposition based on systematic and methodical working, generalization skills, the ability to critically assess data and results, and a creative approach to problem solving.
- To acquire proficiency in the use of mathematical language as a means of communication and to develop some feeling for mathematical thinking.
- To gain an appreciation of mathematics and to increase students' confidence in their own mathematical abilities by developing some feeling for mathematical thinking and taking pleasure in (collective) mathematical activities.
- To gain insight into the application of mathematics in other disciplines.
- To acquire mathematical knowledge, insight and skills, and also to facilitate decisions regarding further education, subsequent employment, and social activities.

The attainment targets for the content fields are described below.

3. Basic contents

1. Attainment targets for Basic Secondary Education

For Mathematics 29 attainment targets have been formulated for Basic Secondary Education. These can be divided into four content fields:

- *Field A: Arithmetic, measurement and estimation (7 targets)*
  Pupils should be able to: solve problems, choose between mental arithmetic, use of pocket calculator, or written calculation; use a pocket calculator properly, convert fractions, percentages, roots and powers into finite decimals; estimate the results of a calculation or measurement; work with common units of length, area, volume, time, angle and monetary value; perform calculations with ratios and scales; organize, add and subtract negative numbers which relate to meaningful situations; understand how ratios, fractions and decimals relate to one another and be able to perform simple calculations involving ratios, fractions and decimals, by making use of mathematical models.

- *Field B: Algebraic relations (11 targets)*
  Pupils should be able to: describe a simple relation between two real variables using an expression, a table, a graph or a (word) formula, or conversely, to deduce such a relation from a description in any of these forms; describe changes in the relation between two real quantities, using the four forms referred to above; convert a description in one of the four forms into one of the other forms; read, compare and interpret relations and use them in the solving of realistic problem situations by using expressions, tables, graphs and (word) formulae; recognize and interpret the characteristic properties of simple relations, such as maximum and minimum values and the values of a given quantity which are relevant in a particular context; determine, express and project regularity in numeric patterns and tables; determine whether a constant, rising/falling or periodic relation exists by reference to a given graph, possibly at a given interval; draw conclusions regarding the situations depicted by reference to specific points in a graph and to its shape; substitute figures for variables in a (word) formula and calculate the value of a remaining variable; determine or estimate approximately whether simple relations give similar results and determine the intervals within which one relation is greater than another; use simple computer programs to solve problems involving relations between two quantities.

- *Field C: Geometry (6 targets)*
  Pupils should be able to: interpret two-dimensional representations of three-dimensional entities and describe them, visualize them in three dimensions and depict them to scale; perform practical tasks with tangible objects and by reference to representations of three-dimensional figures; estimate, measure and calculate the angles, dimensions, areas and volumes of two- and three-dimensional objects; when drawing and calculating angles and dimensions and when reasoning, demonstrate familiarity with the properties of angles and with geometric terms such as ‘parallel’, perpendicular’ and ‘direction’; describe regularities in and the properties of geometric patterns and objects, and use their knowledge of these matters when making calculations and when extending and modifying such patterns and objects; use instruments to support drawing, making calculations, performing practical tasks and reasoning (these instruments include those made by the pupils themselves or a computer).

- *Field D: Information processing and statistics (5 targets)*
  Pupils should be able to: make use of graphs and other visualizations of information when solving realistic problems and to determine whether a given visualization presents the information in an appropriate manner; read and interpret statistical representations, process and modify data, in the form of a table, graph or diagram, as well as characterize them using center indicators; systematically gather, describe and organize data for statistical study purposes; use computer programs for the statistical processing of data, as well as interpret the associated output; use models to make judgements regarding possible future events and developments in simple, practical situations.

Officially students have three years to reach these attainment targets. In practice, students in VMBO will certainly need three years for this, while students in HAVO and VWO can reach these targets in two years of schooling. The Dutch National Institute for Educational Measurement (*CITO*) has compiled a test to assess the attainment targets. The schools are obliged to use this test but they can grade the scores in their own way. There is no national exam to assess Basic Secondary Education.

2. Examination syllabus for pre-vocational education

In May 1999 the government decided on the new exam syllabus for the four years of pre-vocational education, VMBO. An official English translation is not yet available. The core curriculum is described in terms of general basic skills, more specific general and strategic skills related to mathematics, and the attainment targets related to the five different content fields. According to the general basic skills requirement, the pupils should be able to: learn in an independent way; make use of information- and communication technology; use the Dutch language in a functional way; apply basic computational skills; handle verbal and numerical information in a skilled way; collaborate adequately with others.

The strategic skills for mathematics are comparable with the general objectives as formulated for Basic Secondary Education (see above). The attainment targets for VMBO at the exam level are grouped into five different content fields: Algebra; Arithmetic, Measurement and Estimation; Geometry; Data Processing and Statistics, and Integrated Mathematical Activities.

3. Examination syllabuses for senior secondary level

The examination syllabus for senior secondary level is divided into different domains. The table shows the study load for these domains in the four subject combinations (profiles) for the last three years of the VWO stream (age 16-18).

Domain	Culture and Society	Economics and Society	Science and Health	Science and Technology
Functions and graphs	100	100	100	100
Discrete calculus	40	40	40	40
Combinatorics and probability	100	100	100	100
Geometry		40	40	40
Differential calculus and applications		80		
Statistics and probability	80	80		
Graphs and matrices	40	40		
Discrete dynamic models		40		
Linear programming		40		
Differential and integral calculus			120	120
Trigonometric functions			40	40
Continuous dynamic models			40	40
Normal distribution and inferential statistics			40	40
Advanced geometry				120
Advanced calculus				80
Optional topic		40	80	40
Total no. of hours	360	600	600	760

The attainment targets (in Dutch) can be found on the website of the Dutch teachers' association: www.nvvw.nl

4. Topic examples

1. Quadratic equations

Since the introduction of Basic Secondary Education in 1993, quadratic equations have played only a minor role in the Dutch curriculum and the algorithm for solving quadratic equations is not on the list of attainment targets for VMBO level. For HAVO and VWO 'using an algorithm to solve quadratic equations' is still one of the attainment targets.

One of the goals of mathematics education in the Netherlands is that students learn how to construct formulae by themselves. Of course, this is not an easy goal to reach - it is part of a prolonged learning process. By means of carefully chosen, realistic problem situations the students' informal knowledge is used, and they are motivated to develop more formal strategies. This helps them develop their algebraic language and concepts, and time is taken for this.

There is a shift towards more general strategies for solving equations, instead of teaching and training students in a specific algorithm that is only applicable for one type of equation. In junior secondary education students become familiar with tables, graphs and formulae to represent a situation in which there is a relationship between two variables. Tables, graphs and formulae are seen as mathematical tools that can be helpful in the process of modeling a context situation. Depending on the situation, the students choose the appropriate tool, and are supposed to switch flexibly from one to another.

In this new approach the study of relationships between variables remains, but has a different emphasis. Relationships are presented in realistic problem situations. Not only linear and quadratic relationships are explored, but also exponential and more complex relationships, even in the lower attainment levels. Concepts like linear growth and exponential growth are developed parallel to each other, together with strategies that can be applied in more than one specific situation. Equations are solved either in graphically or by using a table, through a process of stepwise refinement.

At the higher attainment levels (HAVO/VWO) the text books struggle to find a balance between the traditional approach and the new, contextualized approach with graphs and tables. At the senior level (age 16+) the graphics calculator is integrated in the text books.

2. Pythagorean theorem

Pythgoras' theorem is part of the curriculum on all levels. The theorem is 'discovered' by the pupils and either proved or made plausible by working through examples, depending on the

approach of the text book and the level of the students. Many applications, including 3D ones, can be found in the text books.

3. Similarity

In the Dutch text books, similarity is, like all geometry topics, presented in a contextualized way, although there are differences between books. For the lower levels the topic is kept at a very practical level and related to enlargement and drawing to scale, making frequent use of ratio tables. For the higher levels some books are more explicit about the similarity properties of triangles.

4. Word problems

Dutch mathematics education is strongly contextualized. Context situations are not only used in applications, but also to introduce and develop new concepts. And the national final examinations also emphasize contextualized mathematical tasks (see the section on 'Quadratic equations' above). In the Netherlands we do not call this approach 'word problems'. A Dutch translation of 'word problems' would be *redactiesommen*, but these are more limited, providing some applications only at the end.

5. Percentages

Using percentages is seen as one of the problematic topics of primary education. In 1993 this topic was therefore explicitly introduced into Basic Secondary Education, together with fractions and ratios. Different models are used to develop the concept of what a percentage is, like the double number line, pie charts and ratio tables. Much attention is paid to the relation between a percentage and a multiplication factor, and to the relation between a percentage and a growth factor when the exponential function is introduced at a more advanced level.

6. An additional topic: Vision geometry

In the Netherlands, so-called 'Vision geometry' is also part of Basic Secondary Education. Freudenthal argued that 3D geometry should come before 2D geometry in education, because we live in a 3D world: Freudenthal called this 'grasping space'. The translation of the 3D world in which we live into a 2D representation, is a rich source for geometrical activities. An important concept that can be developed here is the 'vision line'.

5. Other issues

7. Regional characteristics

In the Netherlands there are almost no regional differences. All official documents are formulated at a national level, and the final examinations are also nationwide. So formally there are no differences at all. Of course there are differences between schools and the school populations. In a city like Amsterdam, more than 50% of the pupils are from ethnic minorities (Dutch Antilles, Morocco, Turkey, etc.), while many schools in the countryside are 100% Dutch. All schools in the Netherlands are co-educational. Another important characteristic of Dutch schools is their religious background but these differences do not have implications for mathematics education.

8. Implementation strategies

In the 1980s and 1990s several major changes were made to the mathematics curriculum, both at junior and senior secondary level. In general, the implementation strategies were as follows:

- Formulation of new curriculum and attainment targets by a committee, set up by the Minister of Education
- Start of a 3- to 5-year project, to work out the proposed program in more detail and collect information from a pilot project with some schools, including:
  - Design of experimental classroom materials and observations at pilot schools
  - Revision of classroom materials and dissemination of information, also based on the experiences at the schools
  - Design and holding of trials to assess the new curriculum, including experimental examinations
  - Contribution to in-service teacher training activities.
- Implementation of the new curriculum on a national scale, accompanied by in-service courses for teacher training.

Several institutes in the Netherlands participate in these innovations, each having their own role. The process as sketched above is not linear, but cyclic. New curricula and new exams are developed simultaneously and mutually influence each other.

9. Teacher training

In the Netherlands, teachers are trained at universities and at colleges of education. For secondary education there are two different degrees: a lower degree (four years of college)

and a higher degree (five years of university, or lower degree plus an additional course at a college). The lower degree qualifies teachers to teach in VMBO and in the lower grades of HAVO/VWO. A higher degree is required to teach at HAVO/VWO senior secondary level.

10. Resources available for teachers

About 30% of the secondary school mathematics teachers are member of the Dutch Association of Mathematics Teachers (*Nederlandse Vereniging van Wiskundeleraren*, NVvW). Two journals are important sources of information for teachers: the *Nieuwe Wiskrant* (http://www.fi.uu.nl/wiskrant), published by the Freudenthal Institute, and *Euclides*, published by the NVvW.

Several colleges and institutions offer in-service courses. The schools have their own budget for in-service activities and they can take the courses they like, following their own policy.

There are several conferences and study meetings throughout the year, organized by different institutions. For example, in the week after the national examinations, there are meetings to discuss the grading of the examinations and to reach agreement on details of the grading.

Publishers of text books also organize meetings for teachers who use their textbooks. The publishers explain the backgrounds to their text books, and teachers have the opportunity to share their experiences.

The role of internet as a resource is growing. Since 1997 the NVvW has had a very informative website (http://www.nvvw.nl), which is updated weekly. It contains all the official information on the syllabuses and the national examinations. The Freudenthal Institute maintains the *Wisweb* (http://www.fi.uu.nl/wisweb). This site for mathematics (*wiskunde*) education is more content-oriented than the NVvW site and contains many applets.

11. Problems and improvements already detected

The three major changes in education that are ongoing in the Netherlands are the revision of pre-vocational education, the revision of senior secondary education, and the introduction of information and communication technology (ICT).The implementation of these changes is an enormous task, both for the schools and for the government.

There are some general problems which hinder implementation, for example:

- An aging cohort of teachers, lack of newcomers;
- Shortage of teachers, including mathematics;
- A growing gap between junior and senior secondary education;
- Low social status of the teaching profession;

- High teaching loads, 26 periods of 50-minute is normal in the Netherlands;
- No facilities or time for teachers to prepare for these demanding changes.

There are also problems more specific to mathematics, for example:

- Little progress in algebraic skills at lower secondary level, which leads to a bad link-up with the senior level;
- Very limited integration of ICT in mathematics lessons;
- Not enough clarity yet about the impact of the graphic calculator (GC) and computer algebra systems;
- Enormous reduction of contact hours in senior secondary mathematics education (some schools have dropped from 5 classes to 2 or 3 classes per week).

12. Data of general/local results

Recently a large survey was performed by the Dutch Inspectorate to evaluate Basic Secondary Education. For mathematics 120 schools were visited and 670 lessons attended. The Inspectorate found that at 20% of the schools, the quality of the mathematics lessons was below the expected standards. Another conclusion was that 80% of the attainment targets were reached at the appropriate level. Attainment targets that were not reached lie in the field of data handling, use of computers, and integrated mathematical activities. More than 25% of the teachers mentioned problems with the link-up from Basic Secondary Education to the senior secondary level.

13. Examples of inspiring activities

There is a growing culture of additional mathematical activities, both within and outside schools. Besides the well-known international mathematics Olympiad, these include:

- Pythagoras, a mathematical journal for pupils;
- The Kangaroo contest;
- The A-lympiad: a contest at senior level for teams of 4 pupils, oriented towards applied mathematics and mathematical modeling;
- Summer camps.

Moreover, some universities organize their own competitions and other activities, e.g. the National Mathematics Days, an annual two-day conference when teachers can sample the inspiring world of mathematics.

References

The content of the first part of this report is based mainly on two official publications of the Dutch Ministry of Education: 'Attainment targets 1998 – 2003' and 'Secondary school – A guide for parents, guardians and pupils 1999'.

Other references are:

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