Country Reports

Netherlands

The Netherlands has been found to have a particularly successful approach to maths in the post-16 vocational sector and may be of particular use and/or relevance to the UK context. Its particular success may be most evidently associated with the use of Realistic Mathematics Education (RME), an approach to teaching maths that emphasises the use of real-world examples. The Dutch approach to mathematics in general lends itself well to vocational settings, as students will already be accustomed to applying mathematical knowledge to real-life situations.

1.1 Relevant Policy

A general national curriculum framework is set by the Ministry of Education, Culture and Science, including suggested time allocations for subjects and indications of what students should know and be able to achieve following their education at each level.[1] As long as schools meet these attainment targets, they have autonomy to teach the core subjects (including mathematics) as they see fit.[2]

Consultations on curriculum development are built into the system at several levels.[3] The Education Council and the Consultative Committee for Primary and Secondary Education are consulted before the development of curriculum frameworks, and the government-funded National Institute for Curriculum Development provides independent advice on major education reforms.[4] At the local level, schools are required to establish a participation council representing staff, parents and students; parents and staff are also able to create separate councils to provide advice on curriculum implementation.[5] Together with these councils, each school must create a school plan setting out objectives, teaching methods, school organisation and assessments, and submit this to the Education Inspectorate (an autonomous body under the Ministry) for approval.[6]

The competencies required in order to complete a vocational qualification are set out in qualification files produced by the sector-based Centre of Expertise (*kenniscentra)* and approved by the Ministry of Education.[7] Schools design their training programmes based on these qualification files, and are free to make their own decisions as long as they keep to the competencies outlined by the *kenniscentra.*[8] The introduction of this system saw a shift in focus towards core tasks and work processes, and away from underlying knowledge; whereas previously the qualifications system had included a detailed list of attainment targets in maths, the new qualification files often list only very general requirements such as 'basic mathematics'.[9] The need to set out the mathematical requirements of specific occupational competencies more clearly led to the work of the Freudenthal Institute to establish a framework for mathematical literacy in occupational competencies (see below).[10]

1 http://www.ncee.org/programs-affiliates/center-on-international-education-benchmarking/top-performing-countries/netherlands-overview/netherlands-instructional-systems/

2 http://www.ncee.org/programs-affiliates/center-on-international-education-benchmarking/top-performing-countries/netherlands-overview/netherlands-instructional-systems/

3 http://www.ncee.org/programs-affiliates/center-on-international-education-benchmarking/top-performing-countries/netherlands-overview/netherlands-instructional-systems/

4 http://www.ncee.org/programs-affiliates/center-on-international-education-benchmarking/top-performing-countries/netherlands-overview/netherlands-instructional-systems/

5 http://www.ncee.org/programs-affiliates/center-on-international-education-benchmarking/top-performing-countries/netherlands-overview/netherlands-instructional-systems/

6 http://www.ncee.org/programs-affiliates/center-on-international-education-benchmarking/top-performing-countries/netherlands-overview/netherlands-instructional-systems/

7 http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf

8 http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf

9 http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf

10 http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf

	Number, quantity, measure	Space and shape	Data handling and uncertainty	Relations, change and formulas
Z2	Is capable of mathematically modeling, at a professional level, a practical or theoretical problem situation in the area of numbers, amounts and measures, of judging the validity of the model and analyzing the problem with- in that model, of generating solutions and reflecting critically on them	Has an understanding of advanced mathematical methods in geometry, for instance from analytical geometry and linear algebra, can apply these at a professional level for modeling a geometrical problem situation and can use them to analyze the situation and reflect critically on the whole model	Can independently set up a statistical study at a professional level and analyze data using advanced techniques and draw sound conclusions from that analysis.	Is capable of using, at a professional level, advanced mathematical instruments in the area of relations and changes to independently model and solve complex problem in the personal/ public domain and in the workplace.
Z1	Uses numbers, amounts and measures in complex, non-standard situations, can work with a mathematical model of the situation and adapt it if necessary, is capable of developing procedures to reach a solution to a problem.	Interprets and analyses complex situations in 2D and 3D using geometrical concepts, properties and techniques. Can set up a mathematical (geometrical) model of the situation and calculate, construct and reason within that model to solve a complex problem.	Collects, combines, interprets and analyses data, including in very complex situations, while utilizing statistical methods and models. Can formulate a (mathematical) of the situation and calculate and reason within that model to solve a complex problem from daily life, the workplace or education.	Is capable of typifying, analyzing and describing connections and changes in complex, non- standard situation, using mathematical symbols, notations and concepts.
Y2	Uses numbers, amounts, measures and efficient procedures in somewhat complex and new situations, and can, if necessary, let go the relation to the situation and use a mathematical model of the situation.	Reasons and calculates with the aid of geometrical concepts, properties and techniques in 2D and 3D, and can, if necessary, let go the relation to the context and work with a mathematical model of the situation at a more abstract level.	Collects and processes data, also in new and unique situations, through using statistical methods. Combines and analyses complex (numerical) information from various sources, can let go the relation to the concrete situation.	Recognizes, interprets and uses connections in complex situations; can analyze and combine different representations of a relation, using mathematical symbols, notations and concepts, and is capable of developing a strategy to solve a practical problem.
Y1	Uses numbers, amounts and measures, and applies familiar procedures and argumentations in simple non-standard situations, is capable of interpreting the results and reporting on them.	Understands and uses geometrical concepts and techniques to create images and constructions in more complex situations, and to calculate and reason with shapes and situations in 2D and 3D.	Interprets and combines (numerical) data from different charts and diagrams, collects numerical data, summarizes the data and can represent it in various way in diagrams or numbers, following known procedures.	Recognizes, interprets and uses connections and relations in somewhat complex (including unfamiliar) situations, can describe a relation between quantities for a concrete task in chart, graph and (word) equation, and can apply known standard procedures in an argued and reasoned manner.
X2	Uses numbers, amounts and measures, performs familiar calculation and measuring tasks in concrete, somewhat complex but orderly situations and can interpret the results.	Understands and uses common geometrical concepts surrounding orientation; understands and uses geometrical concepts and simple prescribed techniques to describe and construct shapes, figures and orderly situations in 2D and 3D.	Reads information from charts, schemes and diagrams, and collects simple numerical data, can represent this in an understandable way, for concrete tasks in familiar situations with little complexity in the personal/ public domain and in the workplace.	Recognizes and uses regularity, patterns and simple connections in familiar situations with little complexity, can compare representations (text, chart, graph, rule of thumb) with each other in simple situations and can do calculations based on simple rules of thumb for concrete tasks.

XI	Uses numbers, amounts and measures, performs simple calculations and measuring tasks in concrete, unequivocal and familiar situations.	Reads and understands everyday geometrical concepts on orientation, shapes, figures and situations (2D and 3D) for concrete tasks in unequivocal and familiar situations.	Reads information from simple charts, schemes and diagrams for concrete, explicit tasks in familiar situations with little complexity, will know in this sort of situation whether something is a case of coincidence and uncertainty (chance).	Notices, understands and uses regularity, patterns and relations (connections) in concrete, unequivocal and familiar situations where numbers or quantities are represented in text, chart or graph.

Schools have a significant degree of autonomy in the Netherlands and there is little direct government involvement in addressing low achievement in mathematics.[11] The Ministry does, however, support research projects and experts' meetings aimed at promoting individualised remedial teaching and increasing parental involvement.[12] The government has also set national targets on low achievement in mathematics based on results in standardised tests.[13] Policies to boost motivation to study mathematics have mainly focused on the upper secondary level and on encouraging students in STEM subjects to continue their study at tertiary level.[14]

However, as of 2009, the Netherlands had one of the lowest figures in the EU for the proportion of graduates coming from STEM fields, at around 15%; for female STEM graduates it is the lowest in the EU.[15] The European Commission has identified a shortage of qualified maths teachers and a need for more know-how in maths teaching at the lower secondary level as key challenges for the Netherlands.[16] Low levels of continuous professional development among teachers are also an issue: only around 40% of students have teachers who have received some form of CPD.[17]

1.2 Institutions and Courses

General System

Dutch students attend primary school from the age of five until the age of 12, at which point an exam determines which type of secondary school they are eligible to attend.[18] There are three tracks at the secondary level: general (HAVO), academic (VWO), and vocational (VMBO); however, for the first two years of lower secondary education the three share a largely common curriculum and moving between the different streams is possible.[19] Since 2007, students have been required to remain in education until the age of 18, or until they achieve a basic qualification from one of the upper secondary programmes.[20]

Vocational Courses

Around 60% of Dutch 12 year olds enter the VMBO pathway, and at 16 a large percentage of these students move into the upper secondary vocational track (MBO).[21] A small number of students from HAVO and VWO also move into MBO at this age each year.[22] MBO is the largest and most diverse part of the Dutch upper secondary education system, with over 500,000 students annually.[23]

1.3 Practice and Pedagogy

The Ministry sets out nine key attainment targets in mathematics for the first two years of lower secondary education (these apply to HAVO and VWO as well as VMBO).[24] They specify that students should learn:[25]

- To use appropriate mathematical language to organise their own thinking and to explain it to others, and learn to understand the mathematical language of others.
- To apply mathematics to finding solutions to problems in practical situations, both alone and working with others.

[11] http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/132en.pdf
[12] http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/132en.pdf
[13] http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/132en.pdf
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[18] http://www.ncee.org/programs-affiliates/center-on-international-education-benchmarking/top-performing-countries/netherlands-overview/netherlands-instructional-systems/
[19] http://www.ncee.org/programs-affiliates/center-on-international-education-benchmarking/top-performing-countries/netherlands-overview/netherlands-instructional-systems/
[20] http://www.ncee.org/programs-affiliates/center-on-international-education-benchmarking/top-performing-countries/netherlands-overview/netherlands-instructional-systems/
[21] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[22] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[23] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[24] http://www.rijksoverheid.nl/onderwerpen/voortgezet-onderwijs/documenten-en-publicaties/besluiten/2010/09/17/kerndoelen-onderbouw-voortgezet-onderwijs.html
[25] http://www.rijksoverheid.nl/onderwerpen/voortgezet-onderwijs/documenten-en-publicaties/besluiten/2010/09/17/kerndoelen-onderbouw-voortgezet-onderwijs.html

- To set up mathematical arguments, to distinguish opinions and assertions, and to give and receive mathematical criticism with respect for others' ways of thinking.
- The structure and coherence of positive and negative numbers, fractions, decimal numbers, percentages and ratios, and to work with these in meaningful and practical situations.
- To carry out exact estimates and reasoning based on an understanding of accuracy, order of magnitude and margins that are appropriate in a given situation.
- To measure, learn the structure and coherence of the metric system, and learn to count with sizes and quantities that are applicable in a given situation.
- To use informal notation, schematic representations, tables and graphs to develop their understanding of the relationships between quantities and variables.
- To work with flat and spatial forms and structures, to make and interpret images of these, and to calculate and reason using their properties and dimensions.
- To describe systematically, organise and visualise information, and to assess critically information, representations and conclusions.

Cultural and linguistic pedagogical issues present particular challenges with teaching mathematics in vocational settings in the Netherlands, since learners from minority communities (mainly Turkish and Moroccan) are over-represented in the vocational stream.[26] These learners may lack the foundation in abstract language skills needed to build success in mathematics; the existing RME-based curriculum has a tendency to rely on examples that are highly dependent on Dutch culture.[27] These learners may also be more culturally familiar with a rote-learning and memorisation approach to education that does not sit well with the dominant Realistic Mathematics Education pedagogical approach (see below).[28]

Realistic Mathematics Education

The Netherlands is the birthplace of Realistic Mathematics Education (RME), an approach to teaching maths - since adopted widely elsewhere, including the UK - that emphasises the use of real-world examples, activities that encourage pupils to move from informal to formal representations, and 'making sense' rather than learning formal ideas in the early stages of maths.[29] RME has been praised by the European Commission as one solution to existing preconceptions of maths as difficult, abstract, boring and irrelevant to real life, by organising lessons around interdisciplinary themes and making explicit connections to other subject areas.[30] RME developed as a reaction against the prevailing 'mechanistic' approach to mathematics teaching in the Netherlands in the early 1970s, emphasising social relevance and mathematics as a human activity rather than a subject matter to be transmitted.[31] In educational contexts, this puts the emphasis on activity - on giving students guided opportunities to 're-invent' mathematics by doing it.[32] Problems are presented in a contextualised fashion throughout the learning process, in contrast to traditional approaches which only use context as a way to illustrate what has been learned abstractly.[33] In RME, working on contextualised problems is used to develop learners' mathematical tools and understanding; these can then be used to solve related problems and eventually to form the basis of more formal mathematical knowledge.[34] RME was strongly influenced by socio-constructivist theories of education, seeing the student as an active participant in the learning process who develops mathematical insights and tools rather than passively receiving information.[35]

Curriculum Development Foundation Handbook

From 2010, the qualification guidelines for training in vocational schools, based on the source document *Leren Loopbaan en Burgerschap* (Learning, Career and Citizenship) have included requirements relating to achievement in arithmetic and mathematics.[36] The national Curriculum Development Foundation (Stichting Leerplanontwikkeling) has produced a handbook for training providers with suggestions and ideas for delivering mathematics education (and assessments) in vocational education at the MBO level.[37] This document takes the broad approach that, in the vocational context, mathematics education should be linked closely to work processes, and mathematical competencies developed alongside core work activities such as analysis, decision making and task-specific competencies.[38]

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26 http://www.fisme.science.uu.nl/en/news/RMEinMT.pdf
27 http://www.fisme.science.uu.nl/en/news/RMEinMT.pdf
28 http://www.fisme.science.uu.nl/en/news/RMEinMT.pdf
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FREUDENTHAL INSTITUTE FRAMEWORK FOR MATHEMATICAL LITERACY

Target Group:

Teachers, trainers and other professionals in the MBO sector.[39]

The Context:

The Freudenthal Institute at the University of Utrecht has developed a 'framework of reference' for mathematical literacy in upper secondary vocational education (MBO), which aims to allow the mathematical requirements of all 241 occupations covered by MBO training to be mapped on a single framework.[40] The creators of the framework found that the introduction of a competency-based approach to vocational education in the Netherlands had led to a severe loss of the *'visibility and accountability'* of mathematics in vocational curricula. Competency-based qualifications made very little explicit reference to mathematical requirements, and as a result there were few incentives to assess students' mathematical knowledge or abilities or to pay attention to mathematical literacy as part of vocational training courses.[41]

Nature of Intervention:

In response to this situation, the institute worked with several other institutions to create a framework modelled after the Common European Framework of Reference for Languages (CEFR), which was already well known and extensively applied within vocational education settings.[42] The institute identified four criteria that the framework would need to meet in order to satisfy stakeholder requirements:[43]

- The framework must support improved communication about the general role of mathematics within vocational education.[44]
- The framework must be usable by stakeholders who do not have training as mathematics teachers, and enable them to identify the areas and levels of mathematical competence required for their specific areas of expertise.[45]
- The framework must 'create common ground and support for mutual understanding'.[46]
- The framework must be aligned to existing instruments known and used by stakeholders within the MBO system.[47]

The fourth criterion inspired the decision to model the framework after the CEFR. In place of the latter's six levels (A1, A2, B1, B2, C1 and C2) the labels X1, X2, Y1, Y2, Z1 and Z2 were adopted, to avoid confusion between the two frameworks.[48] A summary of the descriptors for each level across four broad domains of mathematical competence is given in the table above, under Section A8.1.[49] The designers of the framework aimed to follow Steen's (2003) precept that '*mathematics in the workplace makes sophisticated use of elementary mathematics rather than, as in the classroom, elementary use of sophisticated mathematics*'.[50] Reaching a formulation that would be meaningful for vocational trainers and employers as well as for mathematics educators was a particular challenge and one that required extensive stakeholder engagement.[51]

Results / Impact:

The framework succeeded in making mathematics more visible and explicit within the competency requirements of vocational education in the Netherlands. In the 2009/10 qualification files, for example, the 18 *kenniscentra* included mathematical literacy requirements, based on the framework, in 614 out of 642 occupational profiles.[52] Two thirds of *kenniscentra* also produced justifications for the specified levels of mathematical literacy, which helped to make the relationship between mathematical skills and core work competencies clearer and more explicit.[53]

Lessons Learned:

The framework designers identified the inclusion of clear examples from work situations, which helped users to identify the mathematics 'hidden' within specific tasks and work processes in the qualification files, as a key factor in the success of the framework. These facilitated communication between 'mathematical' and 'vocational' stakeholders and helped each to recognise the other.[54] Carefully planned communications, and consistency in terms of the

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[39] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[40] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[41] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[42] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[43] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
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[51] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[52] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[53] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
[54] http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf

individuals involved in communicating the framework, helped ensure that non-mathematical *kenniscentra* staff were able to judge and value the mathematical content and levels in qualification files.[55]

Analysis of the use of the framework in qualification files also raised questions about the suitability of existing mathematics curricula in the pre-vocational phase[56]. In the domains of 'Number, Quantity and Measurement' and 'Data Handling and Uncertainty', most intermediate level occupations tended to show a similar requirement, whereas for the domains of 'Space and Shape' and 'Relationships, Change and Formulas' there was much greater variation in the requirements of different occupations.[57] The framework designers state that this implies a need to shift pre-MBO mathematics education towards the more generic requirements of the first two domains, which are currently neglected in the Dutch system.[58]

Platform Beta Techniek

Target Group:

The initiative aims to raise interest in maths and science among young people at all educational levels, to increase the numbers choosing to study STEM subjects, and subsequently to retain them in the field.[59]

The Context:

The Platform Beta Techniek was commissioned by the Government in co-operation with the Dutch education and business sectors in order to ensure a sufficient supply of workers with a STEM background in the country.[60] It aims not only to make scientific careers more appealing, but also to inspire and challenge young people through the introduction of educational innovations.[61] Its goal is that 40% of graduates from all educational streams at the secondary and tertiary levels should have a STEM background.[62]

Nature of Intervention:

The platform facilitates contact between schools, universities, employers, national and local government, and sectors.[63] Its strategy includes four main principles:[64]

- Educational institutions are always central.[65]
- Institutions determine their own ambitions together, with support from the Platform in realising these ambitions.[66]
- Institutions are provided with relevant knowledge and expertise where necessary. The Platform brings relevant parties together, or helps establish contact, at the local or project level.[67]
- Performance agreements are made between the Platform and participating institutions, and progress against these agreements measured on the basis of peer discussions. The Platform helps participating institutions identify any problems and develop solutions.[68]

The Platform takes a '*chain approach*' that includes intervention at all levels from primary through to tertiary, in order to broaden the potential pool of talent as far as possible.[69]

The Platform runs a number of initiatives; in the vocational education sector the key programme is the Centres for Innovative Craftsmanship (*Centra voor Innovatief Vakmanschap*) programme.[70] The Centres, which are run on a public-private partnership basis and are expected to be self-funding, bring together entrepreneurs, scientists, teachers and students to develop curricula and innovative approaches to MBO education.[71]

Results/Impact:

- The Platform Beta Techniek's programmes have been found to be particularly successful at promoting partnerships between secondary education institutions and higher education institutions. For the vocational education sector, these partnerships have tended to focus mainly on the development of new educational content for mathematical and scientific disciplines, and on enabling the shared use of facilities.[72]

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55 http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
56 http://www.fisme.science.uu.nl/staff/arthur/wijers2010EIMI.pdf
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69 http://www.platformbetatechniek.nl/organisatie/strategie
70 http://www.centravoorinnovatiefvakmanschap.nl
71 http://www.centravoorinnovatiefvakmanschap.nl/over-civ.html
72 http://www.dialogic.nl/documents/2009.029-1225.pdf

- Content development tends to be given much greater weight in partnerships within the vocational sector compared to those within the general and academic streams, where strengthening connections between different levels of education and improving transfers between them are more important.[73]
- Efforts to establish connections between educational institutions and businesses through the programme appear to have been more successful for the general and academic than for the vocational stream.[74]
- Across all educational streams, the results show a strong tendency towards localisation, with few partnerships developing across provincial or regional borders.[75]

1.4 Key Points of Learning

The Netherlands is the birthplace of Realistic Mathematics Education (RME), an approach to teaching maths - since adopted widely elsewhere, including the UK - that emphasises the use of real-world examples, activities that encourage pupils to move from informal to formal representations, and 'making sense' rather than learning formal ideas in the early stages of maths. In RME, working on contextualised problems is used to develop learners' mathematical tools and understanding; these can then be used to solve related problems and eventually to form the basis of more formal mathematical knowledge.

The Dutch approach to mathematics in general, encapsulated by the principles of RME, lends itself well to vocational settings, as students will already be accustomed to applying mathematical knowledge to real-life situations.

Investment in the development of networks to improve mathematical and scientific teaching and learning has paid off, but more work is needed to understand the impact in the mathematical domain specifically.

Improvement in the teaching and learning of mathematics for work purposes may be easier to achieve through local-level partnerships than through national policy measures.

The development of a framework for assessing students' mathematical competencies that can equally be understood by mathematics specialists, educational institutions and employers is a complicated but valuable process; using a successful existing framework can simplify the task.

[73] http://www.dialogic.nl/documents/2009.029-1225.pdf

[74] http://www.dialogic.nl/documents/2009.029-1225.pdf

[75] http://www.dialogic.nl/documents/2009.029-1225.pdf