mascil
mathematics and science for life

Analysis of the Dutch policy context

mathematics and science for life

mascil

mascil aims to promote a widespread implementation of inquiry-based teaching (IBL) in math and science in primary and secondary schools. It connects IBL in schools with the world of work making math and science more meaningful for young European students and motivating their interest in careers in science and technology.

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1.4 National Report of Netherlands

PART 1: A DESCRIPTIVE, EVIDENCE-BASED ACCOUNT OF THE NATIONAL CONTEXT

<u>*Introduction:* Organization of education in Netherlands</u>

A Table that summarizes the main educational structure in each country as a starting point for further description.

<table>
<tr><th>Gr</th><th>Age</th><th>Type of school[1]</th><th>Disciplines[2]</th><th>Type of teachers[3]</th><th>Initial training[4]</th></tr>
<tr><td>-3</td><td>3</td><td></td><td></td><td></td><td></td></tr>
<tr><td>-2</td><td>4</td><td rowspan="8">primary</td><td></td><td rowspan="8">G</td><td rowspan="11">+4,
PHS,
disc/ped
Dida

(New option for lower secondary: Uni; disc +3 incl. educational minor)</td></tr>
<tr><td>-1</td><td>5</td><td></td></tr>
<tr><td>1</td><td>6</td><td rowspan="6">M&S</td></tr>
<tr><td>2</td><td>7</td></tr>
<tr><td>3</td><td>8</td></tr>
<tr><td>4</td><td>9</td></tr>
<tr><td>5</td><td>10</td></tr>
<tr><td>6</td><td>11</td></tr>
<tr><td>7</td><td>12</td><td rowspan="3">lower secondary (A)</td><td>M&B</td><td rowspan="6">1D</td></tr>
<tr><td>8</td><td>13</td><td>M&B&P</td></tr>
<tr><td>9</td><td>14</td><td>M&S3</td></tr>
<tr><td>10</td><td>15</td><td rowspan="3">upper secondary (A)</td><td>M&S3</td><td rowspan="3">Three options:
a. masters study in PHS (part time)
+3
disc,Dida

b. Uni
disc +3
ped/dida+2</td></tr>
<tr><td>11</td><td>16</td><td>M&S2 (B)</td></tr>
<tr><td>12</td><td>17</td><td>M&S2 (B)</td></tr>
<tr><td>13</td><td></td><td></td><td></td><td></td><td></td></tr>
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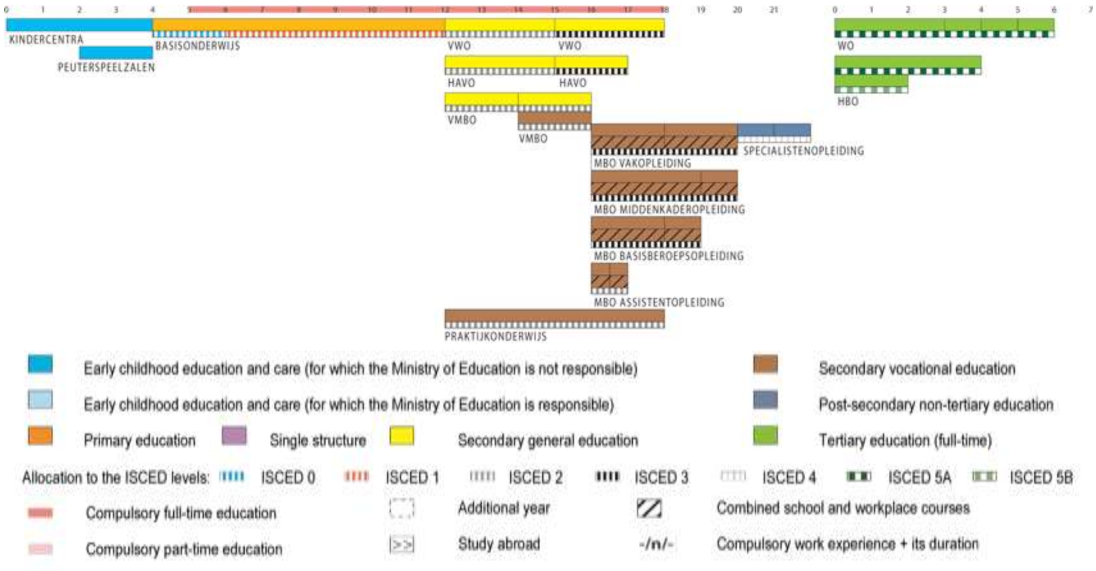
1. Nursery, primary, upper-primary, lower secondary, upper secondary, vocational
2. Maths and sciences not separated (One), maths and integrated sciences (M & S) – 2 or 3 subjects in
sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)
3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…
4. Number of years in tertiary education of training (+n), type of institution (Uni, PHS – Pedagogical High
School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)



See: http://www.fisme.science.uu.nl/en/wiki/index.php/Dutch_Educational_System

Theme 1: State of affairs-recent changes

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www.mascil-project.eu

Wider policy perspectives

In 1993, as a result of 10 years of discussion on the structure and contents of the last stage of compulsory education (age 12–15), a curriculum offering a broad education for all was implemented in junior secondary schools in the Netherlands. The debate which had preceded this decision had been closed by a study by the government's Science Policy Council, which contended that a broad education for all was important. Beginning in 1993, schools were required to offer a prescribed set of 15 subjects to all pupils (with the freedom to offer more). Physical science, a combination of physics and chemistry, formed an exception to the pattern of separated subjects.

After the formulation of the attainment targets for all subjects, the Ministry of Education and Science realized the risk of fragmentation in the prescribed framework and an implementation agency was given the task of bringing more coherence into junior-secondary education. The strategies used to frame coherence were: (1) to stress the importance of all subjects paying attention to applications; (2) to emphasize the contribution of all subjects to the learning of general skills; and (3) to promote co-operation between teachers both by references in subject programs to the attainment targets of other subjects and by allowing the combination of subjects such as physical science and biology. In 1999, the Inspectorate published an evaluation of junior-secondary education that concluded that, in practice, the teaching of the separate subjects was incoherent, co-operation between teachers was lacking, and the combinations of subjects that were permitted were rarely offered due to the lack of integrated teaching and learning materials (Inspectie Van Het Onderwijs, 1999). The report also noted that many schools continued to offer physical science in the form of the separate subjects of physics and chemistry.

In 2001, the National Council of Education proposed limiting the number of obligatory subjects to core objectives and forming new learning areas such as 'Man and Nature', a combination of physical science, biology, technology, and care. The Ministry accepted this advice and a committee was given the task of proposing new curricula in close collaboration with schools. The concept 'integrated science' seems beyond discussion. Over the last 10 years, the debate on integrated science education has changed focus on the integration of science and mathematics.

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During the recent decades, various research projects have resulted in educational materials and strategies for implementing interdisciplinary teaching and use of IBL for science and mathematics. The Platform Bèta Techniek has been commissioned by the government to promote science education from primary to university education. Parallel to this Platform the government installed two national knowledge centres for science and mathematics teacher education (ECENT and ELWIeR). Teacher- and school-networks were developed for interdisciplinary activities (e.g. Technasium schools: http://www.technasium.nl, the Salvo-network, and the Universum-network).
NLT (Natuur, Leven en Technologie in English: Nature, Life and Technology) is a new, advanced and integrated science subject, which is recently introduced in upper secondary education in the Netherlands and possible to be chosen by schools as well as by students (not obligatory). This new subject offers many curriculum materials and possibilities for interdisciplinary teaching (Geraedts e.a., 2006).

However, some aspects in educational reform projects in the end of the twentieth century (e.g. the Basisvorming for lower secondary and also the Studiehuis for upper secondary education) failed and consequently the Ministry of Education decided to reduce their interference with pedagogical and didactical aspects of education. The ministry now mainly focuses on the core objectives of education. This accounts specifically for arithmetic and mathematics. For example, the ministry defined core objectives pertaining to mathematical skills for secondary education. Schools are at liberty to develop these according to their different ideologies and learning styles.

These core objectives primarily concern the application of (elementary) arithmetic skills, both in the lower secondary school and the senior years of secondary education (including the third year of HAVO and VWO).

In competence-based vocational education the position of mathematics there is a risk that mathematics becomes invisible and un-assessed, with deteriorating mathematical skills as a consequence. This is what happened in the Netherlands. The Freudenthal Institute developed a framework of reference for mathematical literacy in secondary vocational education (MBO) to counter this trend (Wijers, Bakker, Jonker, 2010). In addition, we formulated criteria that such a framework should fulfil in order to be a useful interface between representatives of school mathematics and of industry.

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The Platform Bèta Techniek is nowadays an umbrella organization funding initiatives in schools to focus more on mathematics and science in ways that support IBL. Many schools are taking part in this kind of activity. This has prompted a need for professional development.

Currently, all science and mathematics examination programs for senior high schools are being reformed, with the resulting programs starting at the national level in 2015. One of the main aims of renewing the single disciplines was to make them more coherent. All programs define common competences related to research in science. Pre-service and in-service teacher training programs that prepare for these reform programs will certainly profit from mascil.
IBL kind of activities may quite easily be implemented in NLT (see above) that has the following aims:

- To offer both a broader and more in-depth educational program for science and mathematics; in the current examination programs this is hardly possible
- To enable students to get familiar with a wide range of follow-up studies and professions, for instance medical science, health care, chemical technology, earth sciences, life sciences, electro-technology, physiotherapy, (mechanical) engineering, civil engineering, biomedical technology
- To let students experience the importance of interdisciplinary coherence in the development of science and technology (after all, many scientific issues and practical problems demand knowledge from different disciplines)
- To create a closer connection between science education and new developments in society, science and technology, in interaction with higher education, research institutes and the business community (NLT serves as an interface between school and the outside world)
- To offer more choices to teachers and students in the sciences at school, building on the teachers' expertise, the students' interests and the possibilities in the region (existing institutes and companies)
- To make a contribution to permanent innovation of science education: modules can be easily adapted or replaced, if developments in secondary or tertiary education require this.

In order to achieve these aims various means can be applied:

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- Interdisciplinary and in-depth modules, which do not (yet) fit in with the existing subjects in the sciences. Geared to the newest developments in science, technology and society they can increase the students' curiosity and involvement. They will also contain knowledge and skills that are important for various follow-up studies in the sciences and technology. The modules must challenge students to make an effort and give them the feeling that they are learning something special.
- Teachers have to develop skills in team teaching: taking into account the intended in-depth study and the wide range of aspects of the learning area it is almost impossible that only one teacher covers the whole NLT subject area. Teachers of mathematics should have a primary position in those teams, because in many disciplines of the sciences mathematics fulfils the role of language and/or tools. For students a team of teachers is also an example of interdisciplinary collaboration of subject experts.
- Establishing sustainable contacts between secondary education, tertiary education, research institutes and business community: in the past there was a big gap between those sectors, although in the last few years there have been many initiatives to establish contact. Building on those contacts, the aim is now to come to a structural collaboration in education.

The political impact of recent international comparative studies in science and mathematics education in The Netherlands:

1. The Dutch government has the ambition to remain in the top of the world in international comparative studies. The ambition is to increase the average Dutch scores in PISA every three years with 5 points in Mathematics, 4 points in Reading and 2 points in Science, resulting in the following levels in 2018: 541 (Mathematics), 520 Reading), 528 (Science). In order to reach these aims schools have to focus more on the learning results of their students by, for example, using standard diagnostic tests, systems to monitor the learning progress of each student and continuous professional development of teachers.
2. International studies such as TIMSS and PISA show that Dutch students score on average around place ten in the list but the percentage of high scoring students is remarkably low. This has motivated the government to invest considerable amounts of money in programmes to promote activities which are

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challenging for talented students, both in primary and secondary education, resulting in a more ambitious culture in schools.

3. In the development of new science curricula for junior secondary education (age 12-15) the nature of the PISA Scientific Literacy Framework is taken into account.

Sources:

Actieplan po Basis voor presteren, 23-5-2011, Ministry of Education, Culture and Science
Actieplan vo Beter presteren, 23-5-2011, Ministry of Education, Culture and Science
Wijers, M., Bakker, A., & Jonker, V. (2010). *A framework for mathematical literacy in competence-based secondary vocational education*. Paper presented at the EIMI 2010, Barcelona.http://www.fisme.science.uu.nl/publicaties/literatuur/2010_eimi_framework_wijers_bakker_jonker.pdf

The core objectives represent the contents of and provide guidelines for mathematics and science for primary education. They indicate the goals each school should at least strive for, not the way in which these are to be achieved. The core objectives do not prescribe any didactics.

However, the description of the objectives also says that during the arithmetic or mathematics, the children are expected to learn to solve a problem in a mathematical way and explain to others the solution in mathematical language. They learn to give and receive mathematical criticism with respect for another person's point of view. Explanations, formulations and notations, as well as the giving and receiving of criticism, are all part of a specifically mathematical method that will teach children to organize and motivate ways of thinking and to avoid mistakes, independently as well as together with others.

For nature and technology some of the objectives are more explicitly devoted to IBL related ideas:

42. The pupils learn to research materials and physical phenomena, including light, sound, electricity, power, magnetism, and temperature.

45. The pupils learn to design, realize and evaluate solutions for technical problems.

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These objectives give opportunities for mascil to focus its professional development on primary education.

As said above, schools are at liberty to develop the previously defined core objectives for mathematics according to their different ideologies and learning styles. The core objectives primarily concern (elementary) skills, both in the lower and the senior years of secondary education. It is expected that systematic attention for basic skills is of importance to realize continuing learning lines from primary education, via secondary education, to intermediate vocational education and higher education.

Nevertheless, one of the core objectives (number 20) might be related to IBL:
20. Independently as well as together with others, the pupil learns to recognize mathematics in practical situations and use it to solve problems.

In the subjects related to the science-oriented profile of upper secondary education more emphasis can be found on other competences than the mastery of basic skills. Eight core objectives cover a large area of content, concerning physical, technological and care-related subjects. These core objectives describe in global terms what is required: an investigative attitude towards nature, recognizing relationships and interactions, linking of theories and models to practical work and observation, promoting sustainability. Objectives related to IBL are for example:
28. The pupil learns to turn questions about physical, technological and care-related subjects into research questions, carry out research about such subjects, and give a presentation of the results.
31. In various ways, for example by carrying out practical work, the pupil learns to acquire knowledge about and insight into processes in living and non-living nature and their relationships with the environment.
32. The pupil learns to work with theories and models by carrying out research into physical and chemical phenomena, such as electricity, sound, light, movement, energy and matter.
33. By carrying out research, the pupil learns to acquire knowledge about technical products and systems that are relevant to him, and learns to assess this knowledge, and design and make a technical product in a structured manner.

NLT (see above)

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An increasing number of scientists from different fields are working together in interdisciplinary subjects in jobs and at university. For school science it is difficult to bring these interdisciplinary developments into the classroom. Pupils thus get an outdated view of science and of possibilities in science and technology for their future career. Also there are indications that interdisciplinary subjects are more attractive to pupils than classical science subjects, even more so for females. In the Netherlands one remedy for this is the development of a new interdisciplinary subject: NLT (Natuur, Leven en Technologie). This subject is offered to science stream pupils in senior secondary schools in addition to the regular subjects: physics, chemistry, biology and mathematics. A set of more than 60 modules has been developed as teaching materials for national use. Each module is developed by a team in which teachers of secondary schools and an expert of the subject work together. However this does not automatically lead to good teaching materials. For this reason a quality control procedure was developed for all NLT modules. In this procedure, teachers, pupils, scientists and science education experts all play a role in the evaluation of draft modules. The results of such a multi-perspective evaluation procedure are promising (Eijkelhof & Krüger, 2009).

Source:
http://betavak-nlt.nl/English/

Science and mathematics teacher education

A large and ambitious project oriented towards improving initial teacher education. The ministry offered a platform for pre-service teacher training institutions. One of the tasks is to come to the description of knowledge bases for teachers (e.g. the knowledge they must have of science and mathematics and of IBL-related pedagogies and of relations between the discipline and further vocational education although this is no at the foreground of the knowledge bases).
http://10voordeleraar.nl

Teachers are very dependent of their textbooks and are seldom willing to use other resources.
Teachers (and schools) that value IBL (and practical assignments) create learning lines for students 'doing research' in their schools.

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However, overloaded curricula with respect to the number of 'contact hours'. The central exam - especially for mathematics - focuses mainly on basic skills.
A large and ambitious project oriented towards fostering and improving in-service teacher education:
https://www.registerleraar.nl/

Implementation in the classrooms

Mathematics is one of the core subjects in school. At final examination, students are allowed to have only one 5 (on a scale from 1-10) for the core subjects mathematics and the languages Dutch and English. These government rules do have a direct influence on school practice.
For the professionalisation of teachers we see different aspects.

Primary level
See the information about extra attention for science in primary education (Dutch National Program to strengthen STEM education and the connection with industry[38])

General Secondary
Nature, Life and Science (NLT[39]) is a new, integrated science subject, which is introduced in secondary education in the Netherlands on 1st August 2007.
The general aims of NLT are the following: to make the natural sciences and technology more attractive and to create coherence in the different subjects of the sciences. It is going to be an optional subject within the science stream of upper secondary education, to be completed with a school examination. The Minister of Education, Culture and Science has commissioned the Steering Committee to develop a well-tested national examination programme.

To start with, the Steering Committee formulated a vision that forms the basis for the examination programme. The Steering Committee develops the subject content, together with secondary and tertiary education and based on a modular structure. The Steering Committee also takes care of the implementation of the subject including assessment,

[38]http://www.fisme.science.uu.nl/en/wiki/index.php/Techniekpact_2020
[39]http://www.fisme.science.uu.nl/en/wiki/index.php/NLT

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evaluation and adaptation of the draft curriculum during the first few years after the introduction. The duration of the project is five years, from 2006 to 2010. The project has resulted in an advice of the Steering Committee to the Minister of Education, Culture and Science concerning the adaptation of the national examination programme for NLT.

Vocational
There will be a further development on 'competence-based vocational education'. See for example: Van der Sanden, J. M. M., & Teurlings, C. C. J. (2003). Developing competence during practice periods: The learner's perspective. In T. Tuomi-Gröhn & Y. Engeström (Eds.), School and work: New perspectives on transfer and boundary-crossing (pp. 119-138). Amsterdam: Pergamon.

With respect to the implementation of IBL (primary, secondary, vocational):
Despite of all recent initiatives, a change towards inquiry based learning is hardly implemented in most schools. Main reasons for this are that the teachers lack sufficient educational materials, are not trained to use them and lack insight into IBL teaching methods. Moreover, in lower secondary education more emphasis should be put on preparing students for inquiry based learning as a preparation for problem based interdisciplinary teaching. In lower secondary education, mathematics and science are seen as distinctively separate disciplines in the Netherlands. Successful projects carrying out teacher training initiatives are rare. Efficient and effective pedagogical material for inquiry based learning as well as interdisciplinary and modeling approaches are needed. Specific training as well as well-planned dissemination is still required.

Structural difficulties for implementing IBL (inspired by Geraedts e.a., 2006):

- In most studies on IBL it remains implicit that IBL is a characteristic of the curriculum at the level of the classroom (micro-level). It is overlooked that IBL can be considered not only at the micro-level, but also at the meso-level (i.e. the school), and the macro-level (i.e. the district, state, or nation). The distinction between these three levels means that emphasis for IBL at one of these levels will not necessarily lead to change at the other levels.
- Arguments for IBL in subject-teaching may differ considerably, particularly when we relate it to the macro-, meso-, and micro-levels. In many countries, aims and attainment targets (core objectives) are defined at the macro-level, while the choice of an explicit pedagogy is the responsibility of schools.

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- It is overlooked that IBL is not an aim in itself, but a choice taken to overcome some specific difficulties. It is frequently suggested that there are only two possibilities: IBL or traditional science and mathematics education, and that stakeholders are simply for or against IBL.
- Finally, the advocacy of IBL does not emphasize appropriately the desirability of uninterrupted learning processes. In particular, more information is needed about whether IBL will overcome the difficulties around prior knowledge and transfer reported in the science- and mathematics-education literature.

The European dimension of this project can provide a vital stimulus and inspiration for development at all levels, including for teachers involved in the project, who can take inspiration from working as part of a European network.

Mascil can help to strengthen a network of teachers, teacher trainers and researchers by building upon the existing networks, by guiding the underlying ideas, pedagogy and by offering empirically tested activities for students and for professional development. A convincing list of best practices will inspire and support teachers for implementing inquiry based teaching.

Mascil can help to disseminate successful experiences and materials from the new Dutch subject Advanced Science, Mathematics and Technology across Europe.

Theme 2: Schooling and the world of work

The Dutch school system is geared towards streaming students from age 12 towards different levels of vocational education and further study.

- Recent decreases in the number of students choosing for technical studies has lead the ministry of education to make a plan for improving connections between education, the world of work and regional collaboration between schools and companies, called Techniekpact[40]. This pact contains 22 agreements between

[40] http://www.fisme.science.uu.nl/en/wiki/index.php/Techniekpact

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what strengthens the connection between education in the technics sector and the shortfall of technical personnel. Techniekpact knows three starting points: Implementation in regions and sectors. National and regional agreements that help the technical sectors into the realization of their goals.

- Cooperation between education, industry and employees. All contribute individual and cooperatively to the techniekpact.
- Technics education in its full widths. The pact aims to improve all layers of education; primary, general secondary education and vocational education.

Technics is used as the wide term and contains many related and interwoven subjects. It could be described as a combination of STEM – Science, technology, engineering and mathematics – related subjects. These subjects lead to a wide variety of professions covering all layers of education teaching pupils the technical knowledge to build and maintain machines, or maintain the operation of technical systems and implement news ideas, or build new scientific knowledge in sectors like health, nutrition, energy and ICT. Three actions strategies are followed: (1) Choosing for technics, students chose a STEM aligned education (2) learning in technics, students with a technics diploma work in the technics sector (3) work in technics, retain employees to stay employable in the technics sector.

This offers many opportunities for mascil to start support and use initiatives in relation to this plan.

Mostly in primary education STEM education and the World of Work (WoW) have gained importance. The Techniekpact states that all primary education should offer science and technology as a structural subject by 2020. Therefore SLO is designing core objectives in order for companies and teachers to design a learning pathway. Also recognizing talented science student in primary education is promoted especially at the teacher education level.

Teachers develop inquiry-based tasks together that can be positioned as benchmarks for scientific and mathematical competences. The teachers will try these tasks out and afterwards they will exchange experiences and improve the tasks. Reflection on

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experiences and discussing the tasks will result in a shared understanding of aims for general education and starting points for vocational education. The benchmarks support better understanding and expectations about content and proficiency level. This approach has proven efficiency in the Netherlands (Tempelaar e.a., 2011 and see also[41]).

The Netherlands has no formal educational provision for children under the age of four. Although compulsory education begins at the age of five, most children start attending primary school at the age of four. Children remain in primary education until the age of 12, after which they are advised regarding the most appropriate type of secondary education, each of which offers opportunities for further education (see Figure 1). The choice for a type is based upon the students' competencies, skills and interests, after completing primary school. This streaming in different levels at lower secondary education is rather different from the comprehensive systems in most countries. In the Netherlands, compulsory education applies until pupils reach the age of 16.

Preparatory secondary vocational education (VMBO) lasts four years. About 60% of Dutch pupils enroll in this type of education. After successfully completing all four years, VMBO graduates then move on to the job market or continue further education at senior secondary vocational education (MBO) level. In addition, young people can choose to transfer to another form of secondary education (e.g. after successfully completing VMBO, it is possible to transfer to the pre-exam year of HAVO).

Senior general secondary education (HAVO) lasts five years and is completed at age 17. HAVO graduates are eligible for higher professional education (HBO) at a university of applied sciences. Pupils may opt to transfer to another form of secondary education (e.g. after successfully completing HAVO, it is possible to transfer to the pre-exam year of VWO).

[41] http://www.fisme.science.uu.nl/vmbo/anderevakken/

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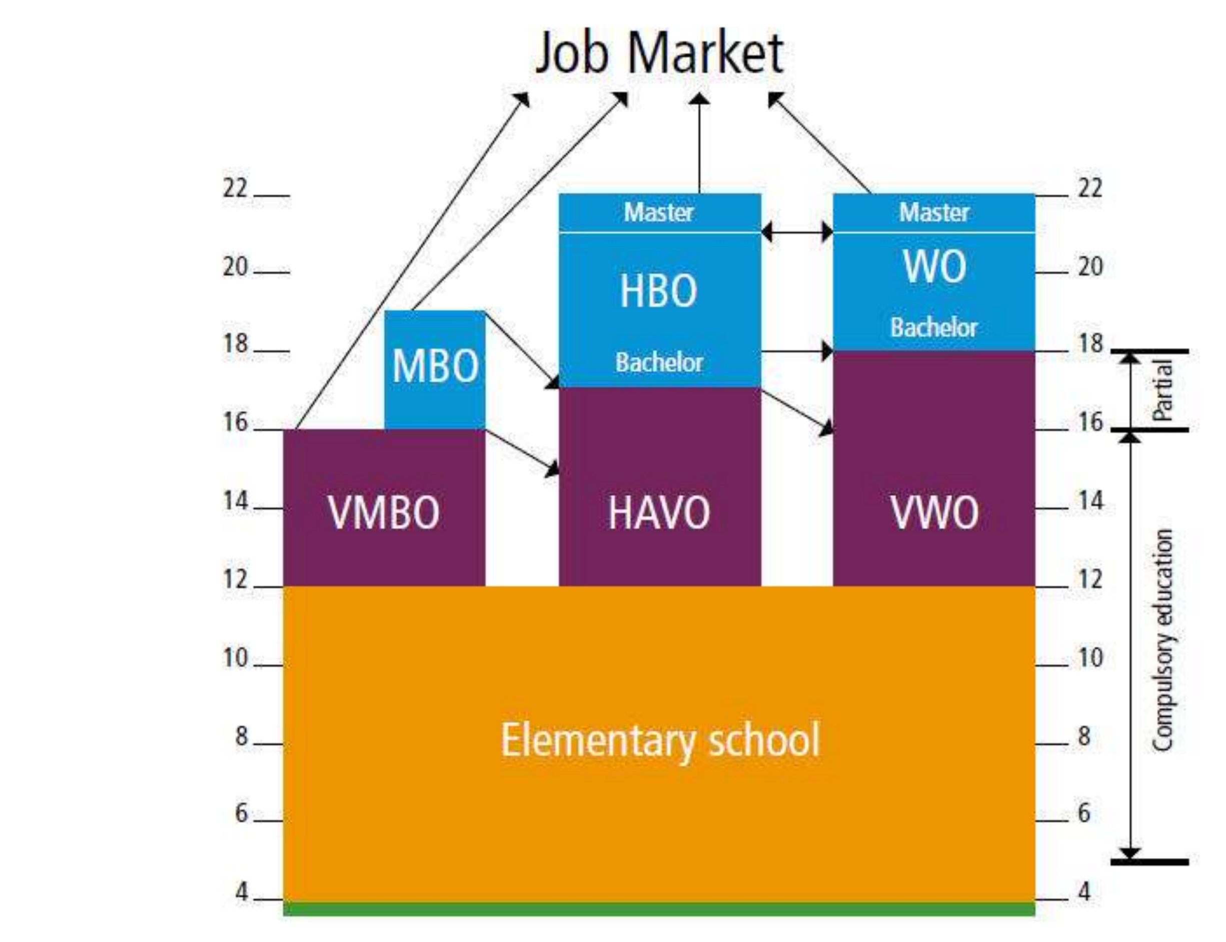

Figure: The Dutch Educational System (the width of a bar does not represent a percentage of students)

Pre-university education (VWO) lasts six years and is completed at age 18. Although VWO graduates are eligible for academic higher education (WO), universities may set their own admission criteria (e.g. profile requirements or subject requirements). In both HAVO and VWO education, pupils select a profile (i.e. a set of compulsory subjects, which comprise the majority of the curriculum in the final two HAVO years or final three VWO years). There are four profiles: Culture & Society (C&M), Economy & Society (E&M) , Science & Health (N&G) and Science & Technology (N&T). Each profile prepares students for specific fields in tertiary education. One of the goals of these profiles is to be

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able to foster alignment between subjects. For Mascil this means that upper secondary education is an important context for interdisciplinary student activities and professional development that is oriented towards interdisciplinary teaching. In addition, this change in upper secondary also made schools to think about how to prepare their students for doing (interdisciplinary) projects and how to acquire research competencies and a research attitude in the lower grades of secondary education.
VMBO, HAVO and VWO have final examinations. This examination has a local part (school exam) and a national part (national exam). Both parts form 50% of the final grade. For the national exam all students are at the same time working on the same exam paper in their own school. Teachers grade the work of their own students and that work is moderated by a teacher from another school. Within the school exams, schools are free to choose both content and format. One part needs to be a practical assignment for individuals or small groups. There is hardly any external control on quality of work from outside the school except that the Inspection will act if the differences between school and national exams are significantly large.

Senior secondary vocational education (MBO) is further education that focuses on vocational training and lasts between one and four years. After successfully completing four years of MBO education, students can either enroll in the first year of HBO or enter the job market. Dutch higher education (HBO and WO) consist of applied (professional education) or academic (university) studies. Both types of higher education offer Bachelors and Masters Degree courses.

Higher professional education

Higher professional education (HBO) is a more practice-oriented type of higher education. Its main objective is preparation for professional practice and entry of the labor market. HBO is offered at universities of professional education (hogescholen), but the new bachelor/master (bama) structure will also enable academic universities to offer HBO education. Educational programs in HBO last 4 years (240 credits) and they are divided into a propaedeutic year (the first year), followed by a main phase of 3 years. HBO is offered in 7 sectors: Teacher Training, Higher Education in Agriculture, Higher Technical and Scientific Education, Higher Education in Health Care, Higher Education in Economics and Management, Higher Education in Social and Community Work and Higher Education in Fine Arts and Performing Arts.

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The Dutch government has the constitutional duty to provide high quality education for everybody. What we understand by that is debatable. However, one thing is certain: it is the quality of the teachers that makes or mars education.
This reasoning caused the Dutch Parliament to pass the 'Professions in Education Act' in the summer of 2004. The essence of the act (shortly called 'BIO-Act') is that educational staff - teachers, assisting staff members, school managers - must not only be qualified, but also competent. For this reason sets of competences and its requirements have been developed for teachers, and are being developed for assisting staff members and (primary) school managers.

Schools are obliged to take competent staff into their employment and subsequently enable them to keep up their competences at a high level and to further improve them. Teacher training colleges use these competences as a guideline to their educational program.

At the request of the Dutch Minister of Education, Culture and Science the competences for teachers with their requirements were developed by a large representation of the professional group of teachers. SBL, the Association for the Professional Quality of Teachers, as a representative of the Dutch teachers' unions and of the professional associations, supervised and gave advice to this professional group of teachers during the process.
The competence requirements for teachers are now decided on and accepted by the government. They have been operational since august 2006.
The competences are:

1. Interpersonal competence
2. Pedagogical competence
3. Subject knowledge and methodological competence
4. Organizational competence
5. Competence for collaboration with colleagues
6. Competence for collaboration with the working environment
7. Competence for reflection and development

All teacher training at HBO is a “dual” education: students already start their teaching practice in their first year, next to their classes at the HBO.

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At Hogeschool Utrecht, the students write a portfolio on their competency-development and they are assessed during a one-hour oral assessment based on their portfolio, a video-presentation and the one-hour interview.

A diploma of senior general secondary education (HAVO) or pre-university education (VWO) is required for admission to HBO, in some cases with additional requirements regarding specific subjects. A middle management or specialist training certificate of secondary vocational education (MBO) also gives access to HBO. Graduates are conferred the degree of Bachelor, stating the professional field in which the degree was earned (Bachelor of Economics, Bachelor of Education). Graduates of HBO bachelor programs can also still opt for the 'old' titles, namely 'baccalaureus (bc.) and 'ingenieur (ing.)'. Universities of professional education are also allowed to offer master programs.

Source:
http://www.nlnrp.nl/current-educational-system.html

Issues regarding schools/institutes and schools/industry

On a National level there is a strong collaboration between industry and vocational education (see the recent foundation SBB[42])

Jet-Net, a good example of the schools-industry connection.

Teams of teachers from general education participate in a professional development course and within this course are supported by industry and individual teachers from vocational areas, when developing tasks (see list of National advisory boards). This approach has proven efficiency in the Netherlands within the project Jet-Net, Jet-Net – Youth and Technology Network Netherlands - is a joint venture between Dutch companies and general education schools in the Netherlands (http://www.jet-net.nl/?pid=76). Jet-Net companies help schools enhance the appeal of their science curriculum by using a wide variety of activities and also allow students to gain a better understanding of their future career prospects in industry and technology. These activities include guest lessons, workshops for teachers and big career events for students. A representative of Jet-Net is member of the Dutch NAB (National Advisory Board) for

[42] http://www.fisme.science.uu.nl/en/wiki/index.php/SBB

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Mascil. In addition, this spring (2013) the Freudenthal Institute and Jet-Net signed a cooperation-agreement (a first result of Mascil).

Informal learning

The National Centre for Science and Technology in the Netherlands highlight the efficiency of having teachers and students work in laboratories all of which offer equipment not available in schools and providing the possibility of working on questions from industry.

The Science Centre at School project (http://www.sciencecenteropschool.nl/) challenges pupils to design and create their own exhibits. An employee at a real science centre will be the principal for the construction of the exhibits. To round off the project the pupils will set up a science centre in their own school. They will present the results of their research into the science behind the exhibit. The project is part of a program for inquiry-based learning and learning by design.

Science center NEMO is Netherlands largest science centre or more than 10 years and attracts around 500.000 visitors yearly. NEMO contributes to the social acceptance of science and technology, helps to raise the amount of students choosing science & technology, and creates awareness that science and technology contribute to our cultural heritage and cultural education (http://www.e-nemo.nl/en/)

Also on smaller scales initiatives are taken to relate science and technology with the world of work and bring it closer to the students. An example hereof derives from Technodiscovery which is an initiative by the Christian University for applied sciences (in dutch Christelijke Hogeschool Ede) and partner companies. According to Technodiscovery they serve three themes: Living, formerly and now; Nutrition and agriculture; sustainability and lifecycles (http://www.technodiscovery.nl).

Theme 3: Science and Mathematics curricula and IBL

Implementation

We see that only a small amount of teachers is willing and able to work in new areas like inquiry based teaching. Very important to notice is that some individual teachers are able to work inquiry-based without support of professional programs. Of course it helps when the government supports inquiry-based teaching.

Curriculum support in secondary education for IBST

In general secondary education NLT[43] modules are taught to some of the students
In primary schools little curriculum support for IBL is given. Kenniscentrum Wetenschap en Techniek support science and technology lesson by using the research cycle of IBL. Some primary schools are connected with this centre and are offered great opportunities to improve their science and technology teaching (for example two regional centres: http://www.kwtg.nl/ in Gelderland and http://www.fisme.science.uu.nl/wiki/index.php/ktwt in Utrecht).

Assessment

In primary education in the final exam (National Test) a few questions in the area of science and technology are related to inquiry learning, but the relation could be stronger. In secondary education this is a diverse area, school disciplines have different histories in more or less inquiry based assessment. Some schools take their own responsibility in this area (a part of the exams is the responsibility of the schools themselves).
In vocational education we have a good situation that the exams are focused on work-related skills and this means that inquiry learning (within those specific work-oriented tasks) is part of the assessment.

Theme 4: Pre-Service teacher training in relation to i) IBL and ii) the world of work

[43] http://www.fisme.science.uu.nl/en/wiki/index.php/NLT

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Teacher training in the Netherlands is possible in different settings in Higher education[44]. Higher professional education (HBO) is a more practice-oriented type of higher education. Its main objective is preparation for professional practice and entry to the labor market. Future teachers in primary education and in the lower grades of secondary education (VMBO and the first three years of HAVO and VWO) have a four years fulltime course in which student teaching plays an important role besides professional development in subject content. Such a course can be entered right after finishing HAVO or VWO. The (still growing) group of people who already work in another sector, have the possibility of doing a part time course of 4 years to get a teachers license.

Future teachers for higher secondary education (grades 10-12) have a choice between doing masters at the university after finishing the bachelors stage or doing a part time masters in HBO. The first option is chosen by students in university; the second option is often taken by practicing teachers who completed a teaching bachelor in HBO.

Organization and structure

Primary:

To teach in primary education, students must enroll in a bachelors program. This bachelor program is either three (with HAVO certificate) of four years (with VWO certificate) and teaches the knowledge and skills needed to teach from grade -2 till 6. In order to start a bachelor the minimum requirement of Senior general secondary education (HAVO) has to be met. The bachelor is roughly separable into two main domains both learned by the student: Younger child (kindergarten, grade -2 till 0) and elder children (grade 1 till 6). During education several minors can be chosen to enlarge your understanding of pedagogics, special needs, psychology, school management etc. A primary teacher is allowed to teach all subjects except for gymnastics to all children in primary school independent from the minors chosen.

General secondary education:

General secondary education teachers must have at least a bachelors' degree in the subject they are teaching, by earning a second degree teaching certificate. For example a physics teacher needs to complete the physics teacher education bachelor, and is

[44] http://www.lerarenweb.nl/lerarenweb-english.html

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afterwards allowed to teach lower secondary students (grade 7 -9). In order to teacher upper secondary students a teacher must finish a masters' degree of his bachelor to become a first degree teacher and being able to teach all students in general secondary education. A bachelor program takes either three (with HAVO certificate) of four years (with VWO certificate) and the masters' program takes one or two years depending on the subject.

Vocational education:
All general secondary education teachers (both first and second degree) are allowed to teach in vocational education to all students.

The Dutch national expert centers for teacher training in mathematics (ELWIeR) and science (ECENT) aim to disseminate findings from educational research and curriculum innovation among teachers and teacher educators in the fields of primary and secondary education. Both centers are located at Utrecht University. Mascil will need to use these centers for professional development initiatives and dissemination purposes.
http://www.elwier.nl/ and http://www.ecent.nl/

There is a connection to IBL during the education of prospective primary teachers. IBL is taught as instructional design spilt in both inquiry based learning and designing.

Vocational education relates to the WoW by design competencies together with companies so that they optimize the transfer from school to work[45]. These designed competencies are ordered according to several disciplines and majors describing the competencies students need to acquire.

This depends on the teacher training institute. We see differences in relation to IBL. Some teachers (of teacher training institutes) have really implemented IBL-oriented tasks into their curriculum; others take less time to stress the importance of IBL.
Within the National cooperation for science and mathematics (ELWIER and ECENT) the teachers of teacher training institutes do meet and exchange ideas in this area.

[45] http://www.kwalificatiesmbo.nl

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Theme 5: In-Service teacher training in relation to i) IBL and ii) the world of work

Schools are obliged to employ qualified staff and subsequently to enable them to keep up and improve their competences at a high level.
How to support that? New governance principles are emerging in which teachers are challenged to take the responsibility for the quality of teaching into their own hands. The SBL association (see above) developed a register with the standards and competences for specific subject teachers. These standards are also supposed to foster further professional development of teachers. Jansma described the process towards professional development in this new political context (Jansma, 2005). He distinguishes between intrinsic and extrinsic aspects of professional development. The intrinsic aspect can be recognized by its basic pattern of professional practice, a regulative cycle in which observation and diagnoses are followed by design, planning, action and evaluation at which point the cycle starts a new. The extrinsic aspect of professionalism can be represented as an open ended list of characteristics such as status, high income, professional autonomy and legal closure (see Figure).

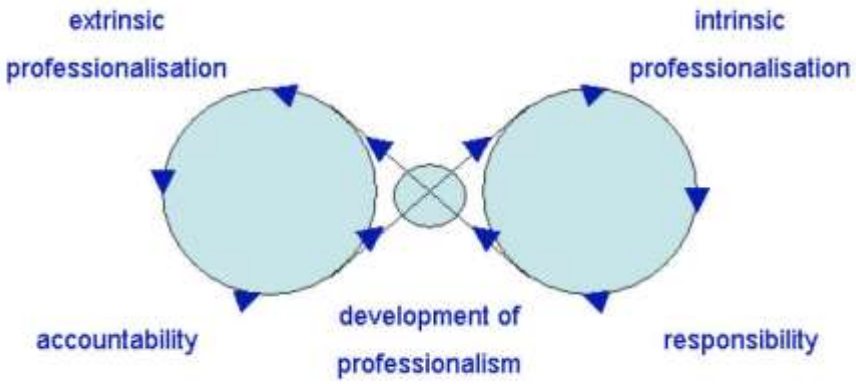

Figure: Extrensic and instrinsic aspects of professional development (Jansma, 2005; p. 3)

The current political context in the Netherlands shifts perspective from intrinsic to extrinsic. It is felt that teachers themselves should remain the masters of their own profession and professionalism. A privately administered register (by SBL) is clearly more

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appropriate to this aim than a 'state' register. This should result in more attention to innovation in the education process, the reduction of teachers' workload, and participation on the part of various groups (Ministry of Education, Culture and Science, 2008).

Still, governance principles must be implemented within the school and within the professional group. Teachers themselves have to be the agents of change. Mascil might offer intrinsic motives by engaging teachers in the development of their practice towards inquiry based teaching (e.g. creating a questioning culture, the art of problem posing) and the underlying ideas of inquiry based learning.

Especially, forms of professional cooperation with a greater emphasis on the design and innovative engineering aspects of professionalism might be successful. In these new roles forms of cooperation emerge in networks and knowledge communities (e.g. JCU[46]). Mascil can use these networks to further develop practice and knowledge in IBL.

When talking about competencies of teachers: teachers are trained to feel and be competent in the following competences:

1. Interpersonal competence
2. Pedagogical competence
3. Subject knowledge and methodological competence
4. Organizational competence
5. Competence for collaboration with colleagues
6. Competence for collaboration with the working environment
7. Competence for reflection and development

Professional development Primary level

The collective agreement of primary educators[47] states that teacher have a total of 1659 working hours each year. These hours contain a maximum of 930 hours teaching, and

[46] JCU: www.uu.nl/faculty/science/EN/nieuwhome/vwo/juniorcollege/Pages/default.aspx
[47] www.cnvo.nl/fileadmin/user_upload/PDF/Artikelen_po/Definitieve_versie_cao_po_2013_maart_2013.pdf
and www.duo.nl/particulieren/studiefinanciering/lerarenbeurs/lerarenbeurs_voor_scholing.asp

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10% (166 hours) is used for professional development, resting hours are used for school-tasks besides teaching. This 166 hours it is both compulsory in the way that these hours should be used for professional development, but voluntary in a way that the teacher chooses their own professional development trajectories.
In addition to the hours reserved for profession development, teachers are able to apply for scholarship for further profession development.

Professional development Secondary level
The collective agreement for secondary education[48] is similar to primary education. Secondary teacher are also obligated to work 1659 hours in fulltime basis, however profession development is not included in the collective agreement.

PART 2: EMERGING ISSUES FOR REFLECTION

Equity specific issues

[48]http://www.vo-raad.nl/userfiles/bestanden/CAO/CAO-VO-2011-2012.pdf

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The gender issue is recently analysed (for the Dutch situation) in Booy et al (2012)[49]: What the authors describe is that the situation is getting better for women in STEM, although the trends are slow[50].

VHTO, the Dutch national expert organisation on girls/women and science/technology, makes an effort in many different ways to increase the involvement of women and girls in science, technology, engineering and mathematics (STEM). Although research over the past decade has made clear that girls are no less talented than boys in STEM, girls and women are still underrepresented in these fields in education and on the labour market. This is inconvenient for both girls/women and for society. Girls/women have equal rights as boys/men to develop their STEM talents, and society would benefit from fully exploiting all available talent. VHTO participates in a great variety of international projects and networks and uses knowledge gained from working with partners abroad to bring best practice into the Netherlands as well as sharing Dutch experiences with international relations.

Addressing low achievement

In the Netherlands there is a recent discussion about dyscalculia (the less gifted students that have problems with mathematics tasks). Recently a new protocol (protocol "ERWD = Ernstige Reken/Wiskunde problemen en Dyscalculie"[51]) has been developed (on behalf of the Dutch Ministry of Education) for primary, secondary and vocational education.
Another government-policy is to implement new assessments (2014 and onward) in secondary education and vocational education that must help support the low achievers[52].

Promoting entrepreneurship

In vocational education there are 4 levels (where level 4 is more or less with the appropriate skills to become an entrepreneur). This is about 20 % of the total population of vocational education. We have no numbers of general (secondary) education.

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[49] Booy, C., Jansen, N., Joukes, G., & Van Schaik, E. (2012). Trend analysis gender in higher stem education (pp. 76). Den Haag: VHTO/Platform beta techniek.
[50] In november 2013 VHTO organizes a conference for teacher trainers on the topic 'Gender and STEM' .
[51] http://www.fisme.science.uu.nl/wiki/index.php/ERWD
[52] ('Referentiekader Rekenen' - Framework for mathematics in primary/secondary and vocational education)

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Professional Development:
When we look at what mascil will investigate in the area of the World of Work, this is an important issue (competences for students and workers to work (in groups, with own ideas, etc.).The average training (at the moment, in the Netherlands) is not dedicated to those aspects, although Primas professionalisation has made a difference in this area.

Comments by the mascil NL NAB

According to a meeting in spring 2013.
The project proposal of mascil and the first steps of the project were presented to the NAB. This is the group of experts.

Name	Occupation	Domain
Harrie Eijkelhof	Professor physics education and curriculum development / Utrecht University / chair Advisory committee of a new interdisciplinary subject for upper secondary school (Nature Life and Technology).	Research/innovation of science and mathematics education
Marcel Voorhoeve	Member of the board of St-Gregorius College Utrecht / mathematics teacher	Secondary school authority & teacher
Sebastiaan Smit	Project leader Jet-Net (connecting school & industry)	Policy, industry & education
Eveline van Hoppe	Regiegroep Chemie	Policy, chemical industry & education
Tom Goris	Fontys Hogeschool Tilburg, lerarenpleiding	Teacher education (teacher college)
Rutger van der Sande	Lectoraat Bètadidactiek, Fontys Tilburg	Experienced in connecting schools & world of work
Joke Daemen	Utrecht University	Teacher education (university)
André van Aperen	Shell Nederland	Coordinator Jet-Net

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Ton Ellermeijer	Professor, CMA	Coordinator NL Establish

Issues that were raised during this meeting:

- It is difficult to make the right connection between general secondary education and vocational education. Of course we can learn from the expertise of 'the World of Work' from vocational education, but there is no tradition in meeting each other.
- It is important to make immediate connections between the pre-service training teachers and what Mascil is going to do in the in service teacher training.
- Make use of the National and European networks of Jet-Net[53] and in Genious[54]
- When making a website with teacher materials, please make use of (national) websites already set up for this purpose.

The next meeting will be in January/February 2014.

[53]http://www.jet-net.nl/?pid=76
[54]http://www.ingenious-science.eu

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mascil
mathematics and science for life

Project Information

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Analysis of the Dutch policy context

Excerpt from the Deliverable No. 2.1 "National working papers on analysis of policy context"

Contact Information

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