

Outline of a new subject in the sciences

A vision of an interdisciplinary subject: Nature, Life and Technology



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Steering Committee Nature, Life and Technology (NLT).



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Introduction

Nature, Life and Technology (NLT) is a new, integrated science subject, which will be 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, 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 will result in an advice of the Steering Committee to the Minister of Education, Culture and Science concerning the adaptation of the national examination programme for Nature, Life and Technology.

In this document the Steering Committee presents her vision on the aims of the subject and on the manner in which those aims can be achieved. This vision document wants to address teachers, members of school management and NLT-developers in secondary and tertiary education, as well as in the business community. The draft version was discussed with the Feedback Group and with teachers from the schools involved. After its valorisation by the Steering Committee and its acceptance by the sponsors it, it will serve as a guideline for the development of NLT from 2007 to 2010. The following chapters will successively deal with the identity and structure of NLT (1 and 2), the development of materials and resources (3), the outline of an examination programme and quality assurance (4). The last few chapters describe the rules and terms for quality (5), the project team and the National Development Centre NLT (6).

1. The identity of NLT

Nature, Life and Technology is a new school subject with an identity of its own. It differs from other subjects in the sciences, but at the same time, it is linked to those subjects. In this chapter we will successively address its aims, means and contents. Besides that, we will touch on the relation with other school subjects and the significance of NLT for school development.

1.1 Aims

NLT is supplementary to the school subjects physics, chemistry, biology and mathematics. It completes the natural sciences, and can be regarded as their flagship, as it were, and as a good preparation for a study in higher education in the field of science and technology (a steppingstone towards science and technology).

The aims of NLT are the following:

- To offer both a broader and more in-depth educational programme for science and mathematics; in the current examination programmes this is hardly possible (a similar approach has proved to work well in the Utrecht Junior College, in pre-university colleges in Eindhoven and Leiden, as well as in master classes for students in various other cities)
- 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.

1.2 Means

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

- 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.

1.3 Contents

The subject NLT deals with recent research in the natural sciences and in modern technology and the significance of both for the quality of life in the living environment. Education in NLT makes students experience the following.

- Science and technology offer new possibilities to improve the quality of life in the fields of energy, housing, transport, safety, food, health, reproduction, communication, information, navigation and automation.
- On the one hand, advanced technology offers many new possibilities for the development of scientific knowledge, for instance in the form of satellites, medical conceptualisation, the use of the computer, microscopy on an atomic scale and detection techniques, and on the other hand, scientific knowledge favours the progress in the quality and the possibilities of instrumentation.
- In a lot of scientific research and technical developments the concepts and methods from various disciplines are used. In NLT many of those concepts and methods are addressed.
- In science and technology the use of concepts, algorithms and heuristics from the fields of mathematics and information technology is often necessary.

Connecting and attuning to other school subjects

Education in NLT must take into account the prior knowledge and interests of students with the subject combinations Nature and Technology (NT) and Nature and Health Care (NG) both in senior general secondary education (havo) and in pre-university education (vwo), of both girls and boys. Furthermore, at a curricular level the programme must tune in with the content and development of other school subjects. Basically, it is possible to establish links with virtually all school subjects, but we will confine ourselves to mathematics and the sciences.

Mathematics (A, B, D)

- NLT is in line with the content of the 2007 version of the Mathematics A and B curriculum.
- There is some alignment with the curriculum of Mathematics D. Perhaps some of the modules will fit in with both Mathematics D and NLT.
- The mathematical content of NLT is determined primarily by the importance of mathematics for a broad range of the sciences (for instance biostatistics, dynamic modelling, differential and integral calculus, vector calculus, analytic geometry).
- Depending on the student's examination subjects (mathematics A or B) and the necessary prior knowledge, solutions must be found within the study load of NLT.

Physics

- NLT is in line with the content of the 2007 version of the curriculum for the natural sciences. For students, who did not choose physics as an examination subject, solutions must be found within the study load of NLT.
- There is some alignment with the curriculum for New Physics (NiNa). Some of the NLT modules can fit in completely or partly with the NiNa-curriculum.

Biology

- NLT is in line with the content of the 2007 version of the biology curriculum. For students, who did not choose biology as an examination subject, solutions must be found within the study load of NLT.
- There is some alignment with the curriculum of the Committee on the Reform of Biology Education (CVBO). Some of the NLT modules can fit in completely or partly with the CVBO-curriculum.

Chemistry

- NLT is in line with the content of the 2007 version of the chemistry curriculum. The assumption is that all students follow the subject chemistry.
- There is some alignment with the curriculum of the Steering Committee on the New Chemistry. Some of the NLT modules can fit in completely or partly with the new chemistry curriculum.

Geography

- NLT is in line with the subject geography in lower secondary education (the first three years), especially with physical geography. It cannot be assumed that students follow the subject geography in upper secondary.
- More than the subject geography does, NLT pays attention to processes and models in the earth sciences.

Informatics

- It cannot be assumed that students follow the subject informatics in addition to NLT.
- In many fields of science and technology informatics plays an important role, and this becomes apparent in a number of modules.
- Perhaps some of the NLT-modules can fit in with the 2007 version of the school subject informatics or vice versa.

Science for Public Understanding (SPU)

- The assumption is that students in pre-university education have followed the subject SPU or will do so, but that this is not the case in senior general secondary education.
- The intention is to incorporate elements from the current SPU-programme into the NLT programme for senior general secondary education.
- A link with the SPU programme in pre-university education is possible by referring to aspects that have been addressed in SPU.

Research and design

- Research and design is the new examination subject in “Technasium”, a new educational concept within the sciences for senior general secondary education and pre-university education.
- Research and design assignments are based on concrete and realistic issues from the professional practice of higher educated scientists and technologists.
- In the course of 2007 the possibilities of mutual reinforcement of Research and design and NLT will be explored.

1.4 Contexts and concepts

The NLT programme is based on a context-concept approach. The interpretation of this notion is not the same in all subject areas. Sometimes contexts are regarded as tools, sometimes as targets. In the regular consultations between the reform committees for the sciences (bèta5nieuw), in which NLT takes part, the participants work on a formulation and clarification that is workable for all parties involved. In the course of 2007 there will be a publication on this issue.

1.5 The significance for school development

The subject NLT can play an important role in school development. Just think of the following aspects.

Improvement of the sciences

- NLT helps reinforce the science subject combinations.
- NLT gives students the opportunity to get a better preparation for a career in the sciences.
- NLT inspires some schools to give more attention to the sciences in lower secondary, for all or part of the students (science-stream)

Team development

- Teachers are compelled to collaborate while composing the programme, while attuning the educational activities and during the preparation of the lesson. The teachers of mathematics and geography must also be involved as much as possible.

In-service training for teachers

- A number of modules will contain content the teachers are not familiar with, which makes in-service training necessary. The intention is to involve higher education in these training courses.

The development of networks

- Through NLT the school can intensify and extend the contacts with other schools, with institutions in higher education and with the business community.

Differentiation between schools

- A number of schools will want to present themselves as a school of sciences, and will for instance want to join the ‘Universum’- programme¹ of the Sciences and Technology Platform.

¹ A stimulation programme to make the sciences more attractive in education for girls and boys

2. A vision on the structure and content of NLT

After an informal consultation of teachers in secondary and higher education, the Steering Committee selected a great number of topics eligible for incorporation in the NLT programme. Those topics are primarily geared to the objectives described in chapter 1. In order to create some coherence within those topics the Steering Committee has categorised them into a number of domains. These domains will be discussed in more detail in chapter 4 in the context of the examination programme.

2.1 Modulair structure

The Steering Committee agrees with the proposal of the Committee on Subject Combinations to give the subject NLT a modular structure. This has the advantage that schools get more freedom of choice in shaping content and teaching methodology. Therefore there will be more modules than necessary to cover the domains of the examination programme. This gives teachers and students the opportunity to choose the modules according to their interests, prior knowledge and expertise, as well as fitting in the chosen subject combination and the possibilities at school. The vicinity of educational institutions and the possibility to collaborate can also influence their choices. A modular structure also facilitates changes in parts of the subject matter, for instance as a result of current developments in technology or science. One module covers a study load of 40 hours. A module can also build on a previous one. This will be clearly indicated.

Preferably every student follows a *starting module NLT* (40 study load hours for both senior secondary and pre-university education). Besides that, each student follows a number of topics from the domains of the examination programme selected from the school's offer of *certified* modules. The examination programme describes the terms for choosing from the different domains.

2.2 Start module

The *start module* is an introduction to NLT and has the following functions:

- Getting familiar with NLT and preparation for the follow-up choices in this subject
- Offering a survey of the different subject areas in the sciences and their coherence
- Making clear that mathematics is 'the language in which the book of nature is written'.

2.3 Certified modules

The *certified modules* developed for national use constitute the principal part of NLT. Those modules belong to different domains, and thus present a picture of the diversity of topics in the world of science and technology in the 21st century. The topics are often from the interface of the different disciplines. The modules are about the integration of concepts in contexts: both the application of disciplinary concepts and the acquisition of new knowledge and skills. The modules contain a knowledge component and a skill component, integrated as much as possible. Through the context students are faced with new concepts as well as with applications of familiar concepts in new contexts. In this way the subject can also contribute to a sustained anchoring of disciplinary concepts.

In order to make true choices possible for students and/or teachers, the content of the modules is specifically developed for

- senior general secondary education (havo) or pre-university education (vwo)
- different levels (grades 4 or 5 havo, grades 4, 5 and 6 vwo)
- students with different subject combinations (Science and Health or Science and Technology, mathematics A or B, with or without biology or physics).

In a joint effort with other reform committees the Steering Committee intends to design some modules, which can be offered within NLT, as well as in other subjects with a modular structure. See also chapter 1, paragraph 1.3..

2.4 Other content

Next to the certified modules there is some room for the school to give its own interpretation to the programme, all within the framework of the examination programmes. The school can think of the following possibilities:

- Development of some modules of their own
- Participation in an Olympiad, in young researchers or other contests
- Following a *summer course* or *master class* at a university or a school for higher education
- An internship with assignment in a business company or at a university
- Developing and teaching lessons on a topic in the natural sciences in lower secondary or primary education
- Modules to fill the gap in prior knowledge
- Realisation of a technical design or carrying out a research assignment in the natural sciences, (commissioned from outside school) with a problem-oriented phrasing of the question.

At the moment institutions of higher education show some inclination to invest in this sort of activities, as can be concluded from their offer of master classes and follow-up activities. Initiatives like Jet-Net² show that business companies are also interested.

Spreading of the proposed study load hours is the following

	havo	vwo
Start module	40	40
Choice from the obligatory domains according to the examination programme	200 (5 modules)	280 (7 modules)
Remaining topics	80	120
In total	320	440

havo= senior general secondary education

vwo= pre-university education

Development of (new) modules

The objectives of the subject require a continuous development of the content. This means that modules will be adapted, updated or replaced, even after the introduction of NLT.

² Network Youth and Technology

3. The development of materials and resources

In order to stimulate the development of materials and resources along the right lines, the Steering Committee has formulated a number of requirements the materials should meet. Besides that, a procedure has been set out for the development of materials and resources in collaboration between schools and other (educational) institutions (higher education, business companies).

3.1 Characteristics of the materials

The Steering Committee thinks that materials and resources should meet the following requirements:

a. Structure and flexibility

The subject matter must reveal a balance between a systematic structure and the possibility for teacher and student to choose their own directions while working on the module. This enables the student to direct his/her own learning process. This also offers the possibility to make use of the teachers' expertise and interest and to address current developments and news.

b. An activating teaching methodology

The teaching methodology underlying the subject matter should be as stimulating and activating as possible for the students. This makes the subject matter more attractive for the student, which will probably lead to better learning outcomes. The acquisition of skills is only possible if the students participate actively in the educational process.

c. Concepts and contexts

The modules are based on the relation between concept and context. Concepts play an important role, because they offer a framework for the acquisition of knowledge. The establishment of logical links between concepts will lead to a conceptual network. A student must learn how to extract the underlying concepts from the different contexts and how to use them.

A context is taken as a meaningful situation or definition of a problem for the student. One may think of a situation or problem from the real world: the living environment, a profession or science. Contexts can be starting points for the development of concepts. The basic idea is that the use of contexts facilitates the acquisition of new knowledge and improves its anchoring in memory. Contexts give a good picture of the role the natural sciences and technology play in society. The use of contexts can easily elicit amazement, and thus make the subject matter more exciting and challenging.

d. The role of ICT and distance learning

Information and communication technology (ICT) manifests itself in many ways, for instance in communication networks, but also in various and complex information systems in business companies, in government, science and education. The role of ICT in science and technology is significant. Well-known applications are measurements for the collection of data, the design and use of models of forecasts and predictions (the weather, human behaviour) and the design of complex systems such as aircraft, cars and factories, as well as the design and technical realisation of products.

Therefore ICT and NLT go hand in hand. Besides that, ICT will play an important role in the teaching methodology. Just think of the acquisition of background knowledge, the presentation of results and distance learning, the consultation of experts, video conferencing, data processing, simulation and conducting virtual research on a site.

e. Attractive for girls and boys

In the year 2006 the choice of subject combinations of boys and girls was very different. Not only do more boys than girls choose science subject combinations, but also relatively more boys choose the science and technology combination. This gives reason for concern with respect to the shortage of students in the natural sciences and technological subjects. NLT can make a positive contribution to this problem by offering subject matter that is also attractive for girls.

f. Appealing for students in general secondary and pre-university education.

The subject must be appealing for students both in senior general secondary (havo) and pre-university (vwo) education. Therefore it is necessary to make a clear distinction between different learning styles, interests and the level of knowledge of students in senior general secondary education and pre-university education. Generally speaking one can make the following remarks: Havo students are more product-oriented, whereas vwo-students are more easily captivated by the content of the subject matter. So, challenging assignments with a clearly defined final product are helpful for havo-students, whereas vwo-students must find sufficient challenge in the subject matter itself. Havo-students are more interested in more practical and application-oriented topics that have a direct connection with their perception of the environment. Vwo-students are often more attracted by theoretical and cultural-historical topics. So the contexts for havo-students will be primarily found in everyday life, whereas for vwo-students scientific contexts are also important. As far as the assignments are concerned, havo-students want to have more activity while working on the subject matter, they want to get to it immediately. So the havo-modules must primarily make use of activating assignments. In vwo classical instruction is more often applicable. Vwo-students should get more open assignments, whereas those for havo students should be more structured. Most of the havo-students move on to colleges of higher vocational education, whereas most of the vwo-students go to university. This is why in havo-modules the emphasis will lie on professional practice and more on design, development and application than on research. In vwo research has a more prominent place.

g. Distribution over monodisciplinary and interdisciplinary contents

The topics of the modules will be mainly interdisciplinary and for a smaller part monodisciplinary.

3.2 Development procedure

On the basis of the criteria the Steering Committee developed for the modules, secondary and tertiary education as well as the business community have developed initiatives that could be used as a first step for the development of the modules. Depending on the degree to which they meet the criteria, promising initiatives will be further developed for NLT. Should there still be gaps in the topics per domain, more modules will be developed to fill those gaps.

The development work will be done by small development networks of teachers, teaching methodologists and subject experts from higher education, centres of expertise and the business community. The intention is to involve as much as possible

the already existing development networks, for instance those dealing with the transfer from secondary education to university education, the SPRINT-programme³ or Jet-Net. The development of materials and resources must leave sufficient scope for teachers to choose their own approach to teach the modules. The developed materials will then be tested in a number of schools for secondary education.

The test schools and the development schools will exchange experiences of students and teachers, on the basis of which the developed materials can be improved. During the development period from 2007 to 2010 certified modules will be freely available in digital form.

Schools:

There are different ways for schools to take part in the development activities, the implementation and the evaluation of NLT.

As a development school (from September 2006 until July 2009)

- A development school develops one or more modules for NLT, which will later be made available at a national level for all schools that want to implement the subject. The development of a module takes place in collaboration with an institution for higher education and/or a business company.
- A school can register at the National Development Centre NLT as a development school, by filling in a questionnaire. It will be to the school's credit, if it already takes part in an existing network, for instance as a Universum-school⁴.

As a test school (from January 2007 until March 2009)

- A test school tests the new module developed by the development networks and evaluates it. Test results are discussed with the development network and the National Development Centre NLT. Schools that want to become test schools fill in a questionnaire and send it to the National Development Centre NLT.

As an implementation school (from September 2007)

- An implementation school implements the subject NLT as an examination subject during the development phase (2007-2010) and registers at the National Development Centre NLT. This registration serves the purpose of evaluation of the development and implementation of NLT, in order to support the advice to the Minister of Education, Culture and Sciences.
- In order to stimulate schools to offer high-quality education in this new subject, the Steering Committee has formulated criteria that implementation schools should meet. These are summed up in chapter 5 of this document. Implementation schools, which want to implement NLT as an examination subject for the cohort 2007-2008 should register before 1 May 2007.

Besides that, schools can choose not to contribute to the development, implementation and evaluation of the subject NLT. They can still implement NLT on the terms of the examination programme. Schools that will not implement NLT as an examination subject, but still want to offer some of the nationally developed modules in the free teaching time do not need to register at the National Development Centre NLT either.

Institutions in higher education, centres of expertise and business community

³ *A stimulation programme to make education in the sciences more attractive for boys and girls in Dutch universities*

⁴ *A school taking part in the Universum-programme to make the sciences more attractive in education for both girls and boys*

There are several ways for institutions in higher education, centres of expertise and business community to take part in the development and implementation of NLT:

- By making available existing resources that can be further developed into modules
- By taking part in one or more development groups, whether or not they are composed on the basis of an existing network
- By giving support to development groups, for instance by offering content or methodological expertise
- By participating in regional networks of implementation schools
- By making a contribution to the training of teachers who are teaching or going to teach NLT.

Other partners

Next to the schools and institutions for higher education other organisations will be involved in the development of materials and resources, in linking them to other school subjects and in supporting schools with the implementation and publicity work.

These organisations will in any case be the following:

- Professional teacher associations for the natural sciences (NVON), mathematics (NvVW) and geography (KNAG)
- Reform committees of the separate subjects and the Committee on Subject Combinations
- Institutions in the educational support structure, such as the Netherlands Institute for Curriculum Development (SLO), the National Institute for Educational Measurement (CITO), and the Non-denominational Educational Advisory Centre (APS)
- The Sciences and Technology Platform
- Educational advisory centres

4. Examination programme, assessment and quality assurance

4.1 Characteristics of the examination programme

The examination programme NLT describes the requirements candidates must meet to complete NLT as an examination subject. In order to give direction to the development phase (2007-2010), an *examination programme* will be drawn up during the first few months of 2007. An advice on the examination programme, based on evaluation of the first years of development and implementation, will be presented to the Minister of Education, Culture and Science by the end of 2010. Unless stated otherwise, the description below refers to the examination programme 2007.

The examination programme reflects the identity of the subject NLT.

- The examination programme promotes the coherence between the subjects biology, physical geography, physics, chemistry and mathematics.
- The examination programme promotes depth, challenge and stimulating design of the subject.
- The examination programme leaves room for addressing items from the current news and for flexibility.
- The examination programme is based on the context-concept approach.
- The examination programme takes into account the characteristics of senior general secondary education and pre-university education, and at the same time shows the similarities in the identity of the subject in both school types.

Structure of the examination programme

The examination programme consists of two parts. In the first place a description of the domains with one general attainment target per domain. Candidates do not have to achieve all the attainment targets, because there must be room for choices. This is why the examination programme also contains criteria according to which a selection from the attainment targets must be made.

Complementary to the examination programme, SLO will publish a manual with clarifications that are not binding.

The examination programme allows *a choice from prescribed domains*. It contains one skills domain and several knowledge domains, which are different for senior general secondary education and for pre-university education. The attainment targets are formulated in a general way. For each of those domains several modules (of 40 study load hours) will be developed during the development phase of the subject. The examination programme will prescribe how a selection from the different domains must be made. The examination programme will stimulate, but not prescribe that the subject facilitates direct contacts with study or professional practice (including scientific research). This can be realised by executing parts of the modules at institutions in higher education, but also by career-based modules via the Internet, or by working with interviews and/or professional situations laid down in the media.

The programmes for senior general secondary education and pre-university education

The examination programme differentiates between students in senior general secondary education and those in pre-university education by choosing different 'outlines' for the domains.

The outline for the *programme for senior general secondary education* (havo) is that science and technology offer new possibilities to improve the quality of life, for instance in the fields of energy, living conditions, transport, safety, food, health, environment, reproduction, communication, information, navigation and automation. The subject NLT gives students a picture of those areas, where more and more educated people will be occupied.

The outline for the *pre-university programme* (vwo) is that science and technology develop rapidly. They often offer possibilities to improve the quality of life. In some of the scientific domains applications are still a distant prospect, but new perspectives are offered for the past and the future of the earth, the universe, the nature of life and matter. Scientific knowledge often leads to the development of modern instruments that offer new possibilities for science.

NLT gives the students a picture of the development of science and technology, both of the development of knowledge and of the use of knowledge in numerous fields. Many experts are necessary for this development in science and technology.

On the basis of these outlines the following domains are included in the examination programmes:

Domains examination programmes of NLT

	havo (senior general education)	vwo (pre-university education)
A	Skills	Skills
B	The language of the natural sciences	The foundations of science and technology
C	Threats to the living environment and its preservation	Earth and climate
D	Caring and curing	Stellar information and processes
E	Tracking and protecting	Biophysics, biochemistry and bioinformatics
F	Improvement of the quality of life	Biomedical technology and biotechnology
G	Breaking new grounds	(Sustainable) use of raw materials, energy and space
H	Communication and navigation	Materials, process- and production technology
I	Men leap over where the hedge is lowest (seeking convenience)	Tools, vehicles and products

4.2 Forms of assessment

The subject NLT is only examined in a school examination, and therefore there are no binding regulations in the field of assessment or an end-of course test. The manner, however, in which assessment and completion of the course take place must be laid down in a Programme for Assessment and Completion.

Given the specific character of NLT, there will be recommendations for the manners of assessment. On the one hand, the students will carry out many activities, the learning outcomes of which cannot easily be recognised by means of a written test. On the other hand, a total omission of written tests will probably not do justice to the deepening and broadening character of the subject.

Tests to go with the modules

The modules developed in collaboration with the National Development Centre NLT will contain, where possible, the following forms of assessment:

- Digital diagnostic tests (if possible to be taken in an electronic learning environment)
- A description of the products (among which reports and other forms to present research), which the students have to submit while working on the module, with *rubrics*⁵ for the assessment of the products. Peer-review (students assess themselves and each other) can also be applied as one of the possibilities.
- A final written test with model answers, which could consist of the following question types:
 - Short, closed/multiple choice questions in order to test the knowledge-related objectives
 - Short, simple calculations and questions relating to application
 - Complex and more open assignments, where the acquired knowledge and skills are placed in a new context. They can also be assignments requiring the analysis of a set of data, the design of research or the realisation of part of the design cycle.
 - One or more (choice) essay-questions, in order to test whether the candidate is able to use the learned concepts to reflect on a new situation.

4.3 Quality assurance

The subject NLT is a school examination subject. The lack of a final central exam requires extra guarantees for the quality of the subject. The Committee on Subject Combinations, too, advised to search for new manners to assure the quality of this subject in secondary education. One of the aims of the development phase is therefore to set up and test a system of quality assurance.

One could think of the following possibilities:

- Quality assurance through consultations among colleagues
- Quality assurance by conducting external visitations and assessment
- Quality assurance through regular supervision by the Education Inspectorate.

Quality assurance through consultations among colleagues

During the development phase (2007-2010), an investigation will take place to find out whether consultation among colleagues is a possible form of quality assurance.

For this purpose implementation schools will be clustered into regional NLT-networks during this phase. In each of those networks at least one institution in higher education should participate. Those networks do not have to correspond with the development networks, where development schools collaborate in the development of modules. After all, the development networks do not necessarily have to be regional and do not comprise all the implementation schools.

The teams of teachers in the participating schools and the institution in higher education organise NLT- network meetings that have the following functions:

- to inspire and to stimulate each other by discussing practical situations in their own school and to exchange educational resources and student materials
- to support each other by discussing organisational and content-based problems, which arise during the implementation of the subject

⁵ See for instance http://digimap.slo.nl/aanpakindeklas/beoordeling/Rubrics_of_Rubrieken.doc or <http://rubistar.4teachers.org>

- to exchange programmes for assessment and completion, to compare and discuss those also with respect to their compliance with the examination programme
- to evaluate the tests including assessment and standards.

Initially the network meetings will be organised frequently (3 or 4 times a year) as the new subject has to develop. Later the frequency can probably be reduced to one meeting a year with e-mail contacts in between, whenever there is the need.

The networks serve two purposes:

- to support the professional development of the teams of teachers (the first two functions of the network meetings)
- to support the quality assurance of the school examination subject (the last two functions of the network meetings)

In this way, schools in an NLT –network evaluate and assess each other’s school examinations. Schools can use this network evaluation to give account of the quality of their school exam to the Education Inspectorate.

The networks will succeed in bringing these aims closer only if the benefits for the participating teachers will be greater than their time investment. Therefore one must search for a broad scale of outcomes that those networks could produce. Next to the above-mentioned network meetings one could think of the following:

- collaboration in the field of filling the free teaching time, preferably together with the institution in higher education
- collaboration in the field of special wishes of students and the possibilities of the teams (for instance students from school A follow a module at school B and vice versa)
- collaboration in the field of modules on career-orientation (together with the institution in higher education, but perhaps also with partner schools) by letting students collaborate with students of other schools for part of their career orientation).

Quality assurance by conducting external visitations and assessment

After the first year of implementation the Steering Committee NLT will organise a number of external visitations, in which representatives of regional NLT-networks will visit and assess other networks. Every effort will be made to involve students in this process, too. On the one hand the aim of this procedure is to evaluate the quality of the subject NLT in the implementation schools, and on the other hand to gain insight into the functioning of the regional networks and the possibilities to have their work continued as a form of support of professional development and quality assurance.

Quality assurance through regular supervision by the Education Inspectorate

As NLT is a school examination subject, supervision of quality assurance should be an issue during the regular visits of the Education Inspectorate. To this effect, the Steering Committee keeps in contact with the Education Inspectorate during the development phase, in order to exchange information about the subject and to use the findings of the inspectorate in the evaluation of the development phase.

5. Rules and quality terms

Nature, Life and Technology (NLT) is an examination subject in upper secondary education. It has the size of a normal examination subject (320/440 study loadhours), and it is an optional subject in science subject combinations, to be completed with a school exam.

What makes the subject special is its highly interdisciplinary character, the modular structure and the fairly great freedom schools have to fill it with content. After a minimum of one complete examination cycle (three years), advice on the examination programme and the curriculum will be offered to the Minister of Education, Culture and Science.

These characteristics make it necessary to formulate a number of terms for implementation schools (see chapter 3).

For the sake of completeness we distinguish terms arising from the regulations of the Ministry of Education, Culture and Science, and those that are necessary to guarantee the quality of education in NLT.

5.1 Terms arising from the regulations

Size	320 study load periods for havo, 440 for vwo.
Decisions	The school authorities decide whether NLT is part of the educational programme, and if so, for which groups of students. Examples of possibilities are: havo and/or vwo students, compulsory for a certain group or optional for all students, optional subject within subject combinations and/or free examination subject, for students in the subject combination Science and Health and/or the subject combination Science and Technology, only for students with mathematics B or also for students with mathematics A.
Examination	NLT is completed with a school examination.
Competence	The teacher must meet the competence requirement as laid down in the Decree Competence Requirements for Educational Staff (Stbl.2005,460). These are teachers competent to teach in upper secondary education in the fields of mathematics, physics, chemistry, biology and/or geography with a specialisation in physical geography.

5.2 Quality of education in NLT

Registration	Implementation schools (see chapter 3) register at the National Development Centre NLT.
Content	At least 75% of the study load hours are spent on certified modules including a start module NLT.
Quality assurance	Implementation schools take part in quality assurance and the evaluation cycle of the new subject.
Team of teachers	In implementation schools NLT is taught by a team of teachers with a minimum of three members who have a grade one teaching qualification for at least three of the

mentioned disciplines.

The proper authorities give the team of teachers of NLT the opportunity to follow in-service training in the fields of subject content and teaching methodology, for instance team work, or the development of school examinations and specific modules.

The school authorities give the team of teachers of NLT the opportunity to take part in internal consultations and to establish and maintain external contacts.

School Management The school management supports the implementation of NLT, for instance by allowing a fair number of clock hours a year for development tasks.

Timetable A subdivision in three to six periods in a year is desirable, within that period a schedule of weekly (part of) afternoons with a possible extension for extracurricular activities. NLT can best be taught from November onwards in year 4 of senior general secondary education (havo) and from the start of year 5 in pre-university education (vwo).

5.3 Clarification of the terms for quality of education

Registration is necessary in order to make the adaptation of the curriculum in development possible, including the examination programme. Furthermore, implementation schools will participate in a network together with institutions for higher education.

Implementation schools offer their students a certified start module, if relevant, and spend at least 75% of the study load on certified modules. This means 6 modules for havo and 8 modules for vwo (including the start module). See also chapter 2.

Completion with a *school examination* makes it necessary to give extra attention to *quality assurance*. Together with schools methods will be developed, which assure the quality of school examinations and at the same time give teachers insight in the results of their own students as compared to those of other schools.

A *team of teachers* is responsible for education in NLT, which means that the qualification of the individual members contributes to the quality of the team. In the ideal case, a team consists of five teachers with a grade one teaching qualification, with at least one grade one teacher for each of the mentioned disciplines. This will not be possible for all schools. The Steering Committee has stated that a minimum of three teachers with different grade one qualifications is required. A geography teacher must be specialised in physical geography or must follow in-service training in this discipline.

Being qualified is not the same as being competent. Taking the interdisciplinary character of the subject content into account, and also the emphasis on new developments, teachers will feel the necessity to follow *in-service training* at least for part of the content. The school management must enable the teachers to follow in-service training. Furthermore, the requirement of close collaboration in a team can make training necessary. Schools must also be aware that collaboration in a team has many advantages, but also demands time for consultation. Teachers must be given the opportunity to *discuss their work with each other*. The support of the *school management* is important. One important way to show support is to facilitate the teachers' work by giving them time for workmeetings.

Schools collaborate in *networks* to develop NLT, to exchange experiences and information, to evaluate, to assess tests, etc. There must also be time available for all these activities. NLT is not a traditional subject. The nature of the materials and resources and the necessity for students to have meaningful contacts with universities,

colleges and other institutions or business companies make the availability of larger periods –mornings or afternoons- for NLT in the *timetable* desirable.

The advice is to start with NLT in havo halfway the fourth school year, in vwo at the end of the fourth school year or at the beginning of the fifth, so that knowledge acquired in the other science subjects and mathematics can be used.

6. Project team and the National Development Centre NLT

In this chapter we will deal with the organisation of the project team and the National Development Centre NLT, as well as planning and communication. At the end of the chapter we will list the contact addresses.

6.1 Organisation and activities

The organisation of development and implementation of the new programme is complex. Some of the reasons for this are: the aim to create an interdisciplinary subject area, the necessity to produce completely new subject content and examination programmes, to determine the boundaries with other similar subjects and the interactive manner of development in a very short time. Particularly the development and testing of subject content together with networks consisting of schools, institutions in higher education and possibly other partners make great demands on the organisation and coordination.

The project team established by the Steering Committee NLT is in charge of the realisation. The project management and the administrative support are in the hands of the Netherlands Institute for Curriculum Development, SLO. The project manager is part of the project team, and is in charge of financial accountability, coordination and consultation with the Steering Committee and the Sciences and Technology Platform. An important part of the activities of the project team consists of making an inventory and collecting suitable materials for modules, communication with teachers, school managers, students and other parties involved, the formation and coaching of the networks for the development and testing of modules, the registration of schools that want to implement NLT, the formation and coaching of networks of implementation schools, and the quality assurance of the implemented curriculum. For those activities the National Development Centre NLT has been established as a part of the project team. The National Development Centre NLT consists of four or five members with a part time appointment. In the project team, especially in the National Development Centre NLT, expertise is represented in the following areas: curriculum development (at macro-, meso- and micro level), teaching methodology in the sciences and mathematics (the subjects involved in the development of the integrated science subject), communication, as well as in the field of ICT and educational practice.

The Steering Committee gets advice from the Feedback Group, which in this way contributes to the creation of sufficient support. The Feedback Group meets twice a year. It consists of representatives of teachers associations, informatics experts, the Netherlands Organisation for Applied Scientific Research (TNO), The Royal Netherlands Academy of Arts and Sciences (KNAW), institutions of higher education, management of secondary education, students in higher education, the National Secondary School Students' Action Committee (LAKS) and the Network Youth and Technology (Jet-Net).

The project team has the task to coordinate and organise the execution of the work of the Steering Committee under the authority of the chairperson:

1. to translate the vision of the Steering Committee into an examination programme
2. to elaborate the vision and the examination programme in terms of course content (modules) and model examinations, to draw up a curriculum in collaboration with schools, authors, (teams of) teachers and institutions in higher education

3. to coach development schools and teachers
4. to register and support implementation schools
5. to supervise the organisation of quality assurance of NLT in implementation schools
6. to organise network meetings of implementation schools and conferences for interested parties
7. to take care of communication and information
8. to organise consultations
9. to validate the draft examination programme
10. to make an inventory of problems with the implementation of NLT in schools from 2007 onwards and report on those
11. to control the finances
12. to undertake a limited research of relevant literature.

The elaboration into course content (see 2) implies among other things the further development of existing materials into modules that can be used at a national level, the development of new materials together with schools, the evaluation and final editing. The specific tasks of the National Development Centre NLT are the items 2 to 5 and 10 of the survey above. As far as the remaining items are concerned, the National Development Centre NLT makes a contribution.

6.2 Planning and communication

The project team communicates with the target groups on developments via the website www.betavak-nlt.nl and via an electronic newsletter (please register for the newsletter via the website). Once or twice a year a conference is organised for teachers (up to now November 2005, March 2006, February 2007, February 2008). For development schools and –institutions periodical meetings will be organised. There will also be presentations and working groups dealing with NLT. There will be regular publications of articles in periodicals and professional journals. In 2006 some brochures were published for students, teachers, school managers and deans.

It is important to make a clear and strict planning. After all, schools that want to offer NLT must be sure of the availability of sufficient resources including an examination programme from August 2007 onwards. The Steering Committee works in three phases. In each phase there is much attention for communication with the target groups. Below you can read about the outlines of what was and still is planned for each phase.

The preparation phase, until halfway 2006

The Steering Committee formulated an advice for the organisation of the preparation- and the implementation phase of NLT. Communication with existing networks, institutions in higher education and other interested parties was an important aspect in this phase.

One started out with an inventory and analysis of relevant literature for the examination programme and other parts of the curriculum. An outline of the examination programme was drawn up and adopted.

As for development of content, an inventory and description of existing pilots in (network) of schools took place and the formulation of criteria for modules in NLT.

As far as implementation is concerned one of the first activities was setting up an inventory and registration of existing and new development- and test schools, as well as implementation schools. Requirements were formulated, which the implementation schools had to meet.

Communication activities started with the construction of a website. Furthermore presentations and workshops were given at conferences and other meetings for the benefit of education.

The development phase, from halfway 2006 to 2009

The implementation period will be evaluated and revised. In this phase, too, communication with the schools and institutions of higher education is of utmost importance.

The development of the examination programme was completed in the autumn of 2006. After that, a consultation of teachers, students and other interested parties took place. The draft version of the examination programme and the outline of the new curriculum became available for schools in the spring of 2007. The development of model examinations started. A procedure was set up for quality assurance of the (school) examination in implementation schools.

As far as the subject content is concerned existing modules will be further developed and adapted to meet the requirements of national use, and the development of new modules will be taken up. There will be national development networks consisting of some schools, one institution in higher education and/or a centre of expertise or a business company. A coach and a member of the National Development Centre NLT will methodologically supervise the work process of those networks. University, higher education or centre of expertise will monitor the quality of the content of the modules. Methodologically schooled authors take care, where necessary, of the writing of parts of the materials and do the final editing.

Development takes place according to the so-called wave model: twice a year the development of a new series of modules starts under the supervision of the National Development Centre NLT. Besides that, existing and new networks will develop modules according to the guidelines of the Steering Committee NLT and with the advice of the National Development Centre NLT. The first modules to be developed will be for senior general secondary education (havo), because havo departments must start the programme earlier. In July 2007 sufficient modules will be available, so that schools, if they want to, can introduce the subject NLT on 1 August 2007.

As far as the implementation phase is concerned, the registration of implementation schools will continue. From the beginning of 2007 regional networks of implementation schools will come into existence, preferably linked to an institution in higher education. At the same time recommendations will be drawn up for the development of professional expertise of teams of teachers, who will teach the new subject from 2007 onwards.

The implementation phase, August 2007 to December 2010

The new examination programme will be implemented and evaluated during this period of time. There will be special attention for quality assurance of the examinations. The development and implementation of new modules aimed at a large offer within the domains of the examination programmes for havo and vwo will continue to 2009. At the same time evaluation and further curriculum development will take place, especially the testing phase.

During the implementation phase implementation schools will participate in networks of colleagues established by the National Development Centre NLT. These networks will play a role in the evaluation and adaptation of the curriculum. The procedures for quality assurance and the implementation process will be evaluated and adapted, if necessary.

The Steering Committee will formulate an advice for the follow-up, especially the professional development of the teams of teachers, the quality assurance of the examination and the continuation of development in view of the topicality of the subject. In 2010 all those activities will result in an advice on the examination programme for NLT, which the Steering Committee NLT will offer to the Minister of Education, Culture and Science.

6.3 Contact

Visitors address National Development Centre NLT

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Postal address of the supporting secretariat of the project team including the National Development Centre NLT

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Appendix:

Steering Group NLT

Chairman:

Professor Dr. H.M.C. Eijkelhof
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Executive secretary:

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Netherlands Institute for Curriculum Development (SLO)

Members:

Mr. J.A.C.M. Andriessen, MSc
Catholic School Cluster at Etten-Leur, on behalf of NVvW (professional association of teachers of mathematics)

Mr. P.C. Beukenkamp, MSc
On behalf of KNAG (professional association for teachers of geography)

Professor Dr. K. Th. Boersma
University of Utrecht, on behalf of the Reform Committee of Education in Biology

Professor Dr. H.W. Broer
University of Groningen, on behalf of the Committee on the Future of Mathematics in Education

Mr. F.G.M. Coenders, MSc
University of Twente, on behalf of the Steering Group New Chemistry from 1 September 2006

Ms. H.P.W. Driessen, MSc
Netherlands Institute for Curriculum Development (SLO), on behalf of the Steering Group New Chemistry, until 1 September 2006

Mr.T.R. Eyckenschild, MSc
Shell International, on behalf of Jet-Net (Network Youth and Technology)

Mr. E.J. Hendriks, MSc
On behalf of NVON (professional association for the sciences)

Mr. J. Ouwehand, MSc
Saxion High Schools, on behalf of Higher Professional Education

Mr. J. Wagemakers, MSc
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Appendix:

Feedback Group NLT

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Mr. H.J.M. van Bergen
NVON (professional association for the sciences)

Mr. M. van Brakel
LAKS (National Secondary Schools Students' Action Committee)

Professor. Dr. W. Buijs
DSM (creates innovative products and services that help improve the quality of life).

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Mr. R.M.J.A. Franquinet, MSc
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Mr H. van der Kooij, MSc
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Mr. A.J. van Lange
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Appendix:

Projectteam and National Development Centre NLT

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