

Biobased education in The Netherlands

Inventory of present and required courses of modules

BE-Basic Foundation

BE-Basic Foundation (1)
Delft University of Technology (2)
University of Groningen, BioBrug (3)

Frans van Dam^{1,2} / Isabel Arends^{1,2} / Patricia Osseweijer^{1,2} / Janneke Krooneman³

COLOPHON

Text

Dr. Frans van Dam, Dept. of Biotechnology, Delft University of Technology
Prof. dr. Isabel Arends, Dept. of Biotechnology, Delft University of Technology
Prof. dr. Patricia Osseweijer, Dept. of Biotechnology, Delft University of Technology
Dr. Janneke Krooneman, Mathematics and Natural Science, University of Groningen

Graphic Design

Nicoline Design (info@nicoline-design.nl)

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Preamble

For a transition to a sustainable biobased economy (BBE) where products are based on biorenewable materials, communication with and participation of citizens are of key importance to raise awareness and create an understanding and support for novel forms of industry and changed roles of citizens. The complete utilization of agricultural crops will allow us to transform the carbon from the atmosphere not only into food, but also into feeds, fibres and fuels. In order to realise this, we need to prepare our future work force for jobs in the biobased economy. This requires a critical evaluation of present education tracks and actions to create interest in developing adapted or even new curricula.

Such aims, especially regarding the education of highly skilled employees are no longer national. BE-Basic has already a large strategic international program in recognition of the important roles of biomass producing countries and strong knowledge based centres.

A majority of BE-Basic's industrial partners are already active in these international contexts and in several cases extending their international activities. The joint research projects underline the importance of this collaboration. In this context education is a major challenge, as a substantial increase in jobs in this field is expected (actually already now, companies face difficulties in fulfilling their vacancies).

For developing a robust and coherent education plan, BE-Basic has inventoried existing BBE education materials in The Netherlands as well as the demands and knowledge of the various stakeholders in the field: industries (large and SME), educational institutions, BE-Basic flagships and BE-Basic international office. A summary of the results can be found in this report. The full inventories are available via www.be-basic.org.

Built on the inventory, BE-Basic will implement an ambitious education program from secondary to post tertiary education. A short summary of this program is enclosed in this report.



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(The annexes 2-5 can be downloaded via www.be-basic.org)



Chapter 1. Approach

In the period January-May 2013, BE-Basic commissioned a number of inventories of available teaching materials in The Netherlands.¹

Primary and secondary education

Stichting C3, a national initiative that promotes chemistry education, inventoried available primary and secondary education materials, via an extensive internet search (spring 2013)². C3 found a total of 28 BBE-related modules for primary and 25 for secondary education (C3's search included topics such as sustainability, recycling and energy saving). For all modules, characteristics, such as age group, content, learning aim and educational approach were scored. In addition, C3 made a survey of terms for quality of education that relate to BBE-content, both for primary and secondary education.

Mbo (vocational education)

Available and planned courses at mbo were inventoried via telephonic interviews. This survey was carried out by De Praktijk, consultancy for education and science communication³. From a total of 13 Dutch agricultural mbo schools (aoc's), 7 have been interviewed. From a total of 43 roc schools, 13 representatives from 8 schools were interviewed. The schools in the survey were selected based on the relevancy of their curriculum and geographical distribution. Respondents had various positions: directors, education managers, innovation managers, project leaders and teachers. The schools/courses found were scored on characteristics such as BBE-content, level and bio-based cooperation.

Hbo

In Spring of 2013, relevant hbo schools were surveyed by DAS (Domain Applied Sciences). In DAS, education directors of hbo schools that offer science courses cooperate. DAS inventoried all available biobased related courses, minors and majors at 'grey' hbo schools⁴. The courses were scored on characteristics such as type of education, BBE-content, target group and educational approach.

Universities NL

Existing BBE bachelors and masters at Dutch BE-Basic partner universities have been inventoried by the University of Groningen and BioBrug. A total of 518 bachelor and master courses were uncovered and assessed - using the Boston Consultancy Group Matrix and Criteria - according to level (basic/advanced) and BBE content (high/low). Courses with high BBE content either focus specifically on BBE, like 'Biocatalysis' or Bio-based products' or contain one or several pre-selected BBE-elements such as 'biomass' and 'fermentation'. A 'low BBE course' is a course which do not have specific BBE-elements or focus, but is applicable both within and beyond BBE, e.g. courses on 'Microbiology' and 'Organic Chemistry'

Universities in Brazil and China

In the Brazilian State of Sao Paulo, BE-Basic has set up research and education initiatives with three partner universities, UniCamp, USP and Unesp. BE-Basic management and representatives have compiled a listing of existing Dutch advanced courses and discussed the interest for offering joint courses on the basis of these existing modules for Brazilian curriculum. In addition, BE-Basic and the Chinese university ECUST have articulated the demand for advanced courses to be taught at ECUST.

Demand for trained personnel

For better understanding of the demand of trained personnel by bio-based companies, a short survey among ten companies has been carried out. Representatives (agro, chemistry, etc) from five major enterprises, including members of the BE-Basic Consortium were questioned via face-to-face and by telephone by De Praktijk. A similar survey was carried out by the University of Groningen among SMEs. The survey included items on required knowledge and competencies for both new and present personnel at mbo-, hbo- and university level.

Workshop

The results from all inventories and questionnaires served as input for a workshop in which representatives from BE-Basic (Delft University of Technology and the University of Groningen) as well as researchers from De Praktijk took part. The conclusions served as input for the proposed BE-Basic education programme (see chapter 4).

¹ This inventory was coordinated by Eveline van Hoppe, project coordinator of the Human Capital Chemistry (Top Sector Chemistry).

² www.c3.nl

³ www.praktijk.nu

⁴ At hbo, a 'major' is the main discipline to which a bachelor student formally commits, approx. 75% of education. 'Minors' are additional courses selected by the students.



Chapter 2. Results

Part 1 - Inventory of bio-based education

1.1 Primary education (age 4-12)

The inventory of available primary education modules that may relate to BBE shows that most activities and modules focus on:

- recycling of waste
- economical consumption of water and energy
- renewable energy (sun, wind, hydroelectric)
- sustainability

There was seldom or not a direct link to BBE in the sense of 'production of materials based on renewable resources'.

The topics of materials found on the internet, are almost identical to the topics in frequently used textbooks. In the latter, neither the use of biomass nor biobased production is described. Therefore, Stichting C3 recommends to:

- develop new materials on BBE;
- connect to the new school subject 'Science & Technology';
- integrate and visualize biobased in existing modules.

More information: annex 2

1.2 Secondary education (age 12-16/18)

BE-Basic and its partner universities already offer three different BBE activities for secondary education:

- The DNA-Lab on the Road 'Racing on Toilet Paper' is a module for upper secondary education offered by Delft University of Technology and the Kluyver Centre. This DNA-lab is brought to 60 schools annually by Life Sciences and Technology master students from Delft and Leiden. In addition to the DNA-lab, the University of Groningen coordinates the Discovery Truck, a travelling laboratory, designed to fascinate and interest secondary school students for Science and Technology.
- The annual Imagine project is a proven concept in which a school competition (age 17-18) involves pupils and scientists to develop plans for implementing biotech solutions in developing countries. Biobased solutions are part of this project.

- The educative website allesoverDNA.nl provides secondary school students with the basics of life sciences. The website is an initiative of CSG Centre for Society and the Life Sciences. Information is often used by school students for their compulsory independent final assignment. CSG has strong ties with BE-Basic.

In addition to these activities, many related modules can be found on sustainable energy topics, including bio-fuels, sun, wind and hydraulic energy. There is less attention for waste recycling. Most modules have no direct link to biobased production, according to the inventory by Stichting C3 (annex 2).

Textbooks have to comply with recently introduced terms for quality of education. Especially the subject 'chemistry' contains bio-based terms, such as sustainable chemical technology, green chemistry and sustainable production processes. In the subject 'nlt' (nature, life & technology) already several bio-based modules have been developed, including sustainable use of raw materials, energy and space.

Stichting C3 concludes that especially the nlt subject is suitable for involving secondary school students in BBE. C3 recommends to develop materials and modules on BBE that can inform teachers as well as students about the possibilities of bio-based materials.

In addition, C3 has reported on the possibilities for integrating Imagine projects in secondary education, in particular in Technasia.

1.3 Mbo / vocational education and training (age 16-)

In the agricultural (or 'green') mbo schools, also called aoc's, BBE is high on the priority list. One of the aoc's already has a BBE curriculum 'Green engineering'. Most of the other interviewed aoc's are in the process of developing BBE courses. Three of the aoc's indicated that they planned to start a bio-based oriented course related to horticulture in 2014-2015. In addition, the Centre for Innovative Craftmanship (CIV) for Horticulture in which five aoc's participate, as well as an Expert Team develop optional modules on bio-based education.

Regular (non agricultural) mbo schools or roc's, that took part in the questionnaire, indicated that they did not teach BBE modules at present. Only one intended to develop a bio-based module, aimed at process operators and laboratory technicians. There is one CIV called 'Passion for bio-based'. In general, most mbo's of the roc-type are not active in BBE teaching, many of which indicated that they are interested. More information: annex 3

1.4 Hbo / University of Applied Sciences (age 17-)

The inventory of BBE courses by the Domain Applied Science (DAS, an initiative in which 15 hbo schools cooperate), identified a number of BBE-related courses⁵. Avans offers minors on biotechnology and biopolymers, HAN has a master, 'Production of Biomolecules', contract courses for companies on fermentation and downstream processing. Van Hall Larenstein offers contract courses on sustainable energy and minors on fermentation, bioengineering and organic chemistry & biobased materials. Other hbo's such as Hogeschool Rotterdam have included BBE-topics in broader courses in chemistry and biology.

1.5 Bachelor and master education

Dutch universities provide a large number of courses, both bachelor and master courses, that have high BBE content. As shown in figure 1 compiled by the University of Groningen, a total of 82 courses offer basic subjects of BBE and 84 courses offer advanced topics, including advanced biorefinery, bioprocess integration, biocatalysis and green chemistry. In addition, over 350 courses were identified that are less focussed on BBE, but still relevant, as these make up the cornerstone for BBE education. Especially the universities of Delft, Wageningen and Groningen offer BBE education (but it should be noted that, these universities may be overrepresented, as most effort was spent in inventorying these).

The inventory shows that many of the courses with low BBE content, e.g. organic chemistry, tend to concentrate on the fossil-based industry. These courses are still relevant for BBE as they provide general knowledge for specialized BBE courses. In addition, they can be made more bio-based by integrating additional BBE elements, such as biocatalysis and biosynthesis.

More information: annex 4

1.6 Post-graduate courses

Most post-graduate or advanced courses on BBE are offered by joint university initiatives.

- The Institute Biotechnology Science Delft Leiden (BSDL-EDU) offers a total of 7 BBE-related courses: biocatalysis, bioprocess design, fermentation technology, downstream processing, genomics in industrial fermentation, metabolomics and environmental biotechnology.
- Research school SENSE, in which 10 Dutch universities are represented, offers courses on topics such as the principles of ecological genomics, biological processes for resource recovery and a masterclass biobased innovation.
- VLAG Graduate school offers, amongst others, courses on microalgae process design and applied biocatalysis (together with Groningen GBB).

- The Groningen Biomolecular Sciences and Biotechnology Institute (GBB) is a research school within the Graduate School of Science and provides integrated upper-level undergraduate, graduate, and post-doctoral training, consisting of practical research training, courses, workshops, and multidisciplinary research projects on biomolecular sciences and biotechnology.

At present there are no transdisciplinary courses available that focus on societal issues concerning BBE – e.g. environmental and social sustainability, stakeholder and public communication).

Degree of BB	High	<u>Total:82</u> TU Delft: 26 WUR: 21 RUG: 13 VU & UvA: 10 RU: 5 UT: 5 UU:2	<u>Total:84</u> WUR: 31 TU Delft: 20 VU & UvA: 14 RUG: 10 UU: 3 RU: 3 UT:3
	Low	<u>Total:207</u> RUG: 58 TU Delft: 50 WUR: 42 UU: 19 VU & UvA: 15 RU: 13 UT:10	<u>Total:145</u> TU Delft: 43 RUG: 43 WUR: 20 UU: 17 RU: 12 VU & UvA: 6 UT:4
		Basic	Advanced
		Level of course	

Figure 1: Number of courses with a BBE content at Dutch Universities.

⁵ This inventory was limited to 'grey' hbo schools, as 'green' hbo schools (agricultural hbo) are well organized in Centre for Biobased Economy (CBBE). CBBE coordinates the transition towards bio-based education at/between 'green' hbo's and industry in The Netherlands. Partners are Wageningen University and 6 green hbo's (HAN, Avans, CAH Dronten, HAS, Inholland, Van Hall Larenstein)

Part 2 – Consultation of industry

Representatives of five major companies in the sectors, agro, chemistry, chemistry/biochemistry, energy and pharma, were interviewed by De Praktijk. Main conclusions:

- employees should be more sensitive to the broad context of BBE;
- employees need to be able to cooperate in a trans-disciplinary fashion;
- there is a need for personnel trained in a specific, existing discipline AND able to deal with the challenges of BBE simultaneously.

More information: annex 5

The main conclusions drawn from interviews with SMEs were that SMEs are in need of (future) professionals that:

- Link competencies such as professionalism, commercial institution, enterprising, creativity and passion with knowledge.
- Have a broad knowledge on the BBE and its context, such as value chains, and see connections with other sectors.
- Have a strong technical knowledge on mbo (operational), hbo (operational + design) and university (design) level.
- Have knowledge on legal aspects.

In terms of training courses for current and future personnel the SMEs are in need of custom-made post-tertiary education courses instead of generic courses.

More information: annex 4

Part 3 – Courses for Brazil and China

Via its Brazil Office, the BE-Basic management and its Brazilian partner universities have developed a list of course topics of mutual interest for BE-Basic and Brazilian partners. These courses will be based on existing Dutch advanced courses. By using modern on-line didactic facilities BE-Basic will ensure the efficiency of the activities and applicability to other international settings, while at the same time providing an opportunity to involve high level experts from our different international partners. The following courses are under development:

Course title	Course leader	Level
IP & Tech transfer	BE-BIC	Post graduate
Nutrient recycling	NIOO	Post graduate
Biorefinery	WUR	Post graduate
Biocatalysis	TUD/RUG	Post graduate
Multicomponent mass transfer	TUD	MSc/post graduate
Biothermodynamics	TUD/EPFL	Post graduate
Process design	WUR/TUD	Post graduate
Metabolic Engineering	TUD	Post graduate
Down stream processing	TUD	Post graduate
Perception, policy & communication	TUD/VU	Post graduate
Bioprocess Engineering	TUD/DSM	Post graduate
Enzymatic Engineering	RUG	Post graduate
Cell Engineering	RUG	Post graduate
Entrepreneurship	TUD	Post graduate

The course programs will consist of a mixture of distance learning, contact hours and practicals (so-called blended learning), depending on the topic of the course. In addition the Delft University of Technology will teach the advanced course 'Bioprocess engineering' at ECUST in Shanghai.



Chapter 3. Conclusions

Primary education

Based on the results from phase one and the available resources, we concluded that, for now, BE-Basic should not focus on primary education. In the years to come, the new science terms for primary schools will be developed and integrated in the educational system for teachers. That may offer an opportunity for future BBE activities for primary education.

Secondary education

In secondary education, BE-Basic will continue and develop existing, successful activities: the DNA-lab on the Road, 'Racing with toilet paper', will be complemented by the Discovery Truck in Groningen, the Imagine school competition will be internationalised, and, if possible, introduced in international collaboration.

Vocational education (mbo) and University of applied science (hbo)

Many mbo and hbo schools have indicated that they have recently developed biobased courses or modules or are in the process of doing so. For that purpose, coordination and exchange of information and modules is very helpful. As only part of the mbo schools (aoc's and roc's) and hbo schools have been inventoried, there is a need to complete this inventory. For this purpose, the website www.biobasedeconomy.nl, initiated by the government, will use the BE-Basic inventory as starting point. Companies have indicated that schools abroad offer suitable training courses on BBE for staff. These courses (Germany and Belgium) need to be inventoried as well.

BE-Basic partners can assist in the development of training courses on BBE for mbo and hbo teachers. In addition, BE-Basic will provide means for visits and education modules located at the Bioprocess Pilot Facility (BPF) in Delft.

On a regular basis BE-Basic will meet with BBE-related CiV's and CoE's, for coordination purposes and for support of these initiatives.

University education

For bachelor level, BE-Basic academic partners are well-equipped to set up a Massive Open Online Course (MOOC). Two MOOC modules can be foreseen in which a) the technological needs for biobased products and b) the societal issues around transition towards BBE are taught. A MOOC offers an opportunity to reach many thousands of bachelor students, upper-level secondary school students and others who are interested (company staff). Moreover, a MOOC is an appropriate instrument for increased student (BSc and MSc) enrolment at BE-Basic university partners⁶.

Early 2013, BE-Basic partner Delft University of Technology agreed with its Brazilian partner UNICAMP to initiate two courses for masters and PhD's 'Biobased-economy Beyond Bioethanol' and 'Fermentation technology'. In addition, BE-Basic and its Brazilian partners have identified an impressive program of advanced courses, covering all relevant BBE topics for which they will develop joint programs. These courses will facilitate education of PDEng and Double Degree PhDs that will be trained in joint research programs between BE-Basic partners and their Brazilian colleagues.

BBE enterprises

Respondents from industry stressed the need to align BBE courses at mbo/hbo and university with the needs of industry. Especially SME's were interested in staff training, both on the legal aspects of BBE and in the area of entrepreneurship.

As the planned MOOCs on the basics of BBE will provide the broader scientific and social context of BBE, these can serve as an introductory course for companies. In addition, companies would welcome participation of staff in advanced courses on BBE offered by BE-basic partners.

In particular SME's require high educational levels of the personnel involved and an intense exchange of dedicated knowledge and skills. The SME survey indicated that companies feel an urgent need to improve BBE-related skills and competencies at the academic level. Both for specific skills and for more general BBE-related aspects, the broader BBE-perspective and context are relevant (e.g. value chains, from regional to global impact, logistic aspects). Therefore, BE-Basic will invest in a 'lifelong learning trajectory' for SME's.

⁶ Delft University of Technology recently initiated MOOCs on Water Management and Solar Energy in which over 20.000 resp. over 40.000 persons participated: www.edx.org/school/delftx/allcourses. In Spring 2014, three additional MOOCs are scheduled.



Chapter 4.

BE-Basic education program 2013-2016

This BE-basic education program has a twofold objective:

- to raise awareness; to develop and to embed education and training for identified needs in several levels of the Dutch education domain; and
- to develop and to embed an international (joint) program of tertiary and post-tertiary education.

Raising awareness among citizens for innovation for a Biobased Society:

Current public debate and the media tend to focus on energy from biomass and the tensions between land use for food or fuel. Recent public research shows that people tend to respond negatively to bio-energy but regard bio-resources in a more positive way. People have a hard time to define and understand 'Biobased Economy'. This is a potential issue for embedding innovation in the development of a Biobased Economy, i.e. bio-based products: materials, plastics, fuels and feeds

Approach: Raising awareness early in life. We propose to focus these activities on formal secondary education. Criteria used for selection of dedicated activities are (1) substantial outreach and accessibility (2) education activities with proven track-record (3) activities that last for a number of years. A mobile DNA-lab and Discovery Bus provides 16-18 year olds with the basics of fermenting waste. Imagine is a proven concept in which a school competition (age 17-18) involves children in implementing biotech solutions in developing countries.

Education for innovation and internationalization: on the global level, the need for higher level education is growing rapidly. For facilitating this we would need to build five universities a week (with an average size of Delft University of Technology) for the coming 15 years. The Dutch TKI-BBE Board has recently stated that the realisation of a BBE in terms of pioneering and innovative solutions requires the ability to think 'out of the box' (TKI BBE, May 2013). We need to educate young people for future jobs in BBE and, at the same time, offer training to employees in BBE (-related) companies and institutes.

In Spring 2013, existing and planned BBE courses in The Netherlands, from vocational to post graduate level, have been inventoried, as well as the needs from industry concerning biobased education. Also, academic staff in Brazil indicated their interest for joint education. Industry has expressed the need for well-educated personnel from vocational education (mbo) and applied science universities (hbo). Mbo and hbo institutes have already initiated the development of new programs. In Brazil, BE-Basic's partners have expressed a great interest for extending their tertiary and post-tertiary programs.

Approach for international outreach: For a worldwide audience of high school and bachelor students and other interested people, Online Course modules on BBE will be organised, bringing in the best teachers of BE-Basic partners and resulting in worldwide attention for Dutch BBE education

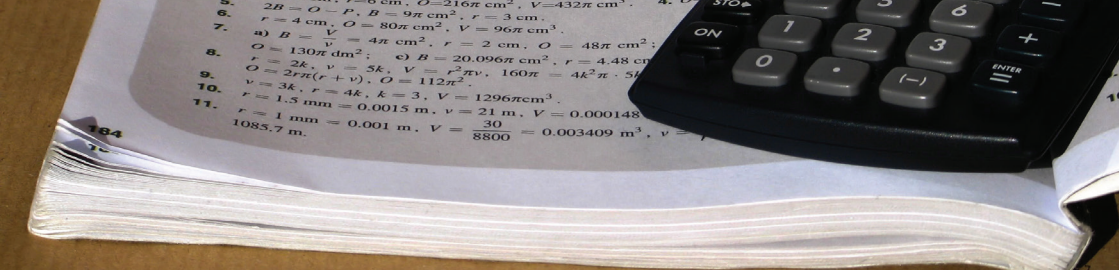
A double degree PhD program will be set-up allowing for joint supervision by Dutch and Brazilian supervisors, within the important area of Bioenergy. In addition, BE-Basic will stimulate activities for PDEng students participating in bi-lateral research projects⁷.

Existing and novel master and advanced courses will be tailored to / developed for the Brazil situation and embedded in local universities. By using up-to-date online technology, this collaboration with Brazil can be used as a stepping stone for other international collaborations in e.g. China, Vietnam and with neighbouring European partners.

Approach for innovation: For Dutch BE-basic PhDs, a special course on entrepreneurship will be developed. This course will be run in an international edition.

In a lifelong learning trajectory industrial needs for staff training will be specified in more detail, tailor-made training programs and master classes will be developed. After evaluation of the training programs, the results will be fed back to master courses of BE-Basic academic partners.

⁷ PDEng program: the Professional Doctor in Engineering program is a two year post MSc program, that includes an industrial design project for industry (www.pdeng.tudelft.nl)



Annex 1. The Dutch educational system

In The Netherlands children first visit primary school (8 grades, age 4-12). These schools do provide science lessons, but the science content is, in general, very limited compared to other countries. For that reason, the government has initiated the development of a new science curriculum, to be implemented in the coming years.

After having visited primary school a limited number of children will ensue practical education (mainly technical, professional gardening, cleaning etc). Most Dutch children will enter:

- one of the pre-vocational school types (vmbo, age 12-16),
- higher general continued education (havo, age 12-17) or
- pre-university secondary education (vwo, age 12-18).

In upper-level havo and vwo, students chose one of four tracks, two of which focus on science: nature & technology and nature & health.

A limited number of havo and vwo schools offer the Technasium track, in which science education has a more prominent position. Technasiums have one special subject: 'Research and Designing (Onderzoeken en Ontwerpen)'. The track can start in either the first or fourth grade.

After secondary education, most students will proceed to:

- Vocational education (mbo)
Roughly, there are two types of mbo institutes, roc, regional education centres and aoc, agricultural education centres.
- University of applied science (hbo)
- University

At hbo, students receive a bachelor-degree after 4 years, occasionally followed by a master (1-2 additional years).

Mbo schools have organised thematic networks in which several mbo schools (roc's or aoc's) as well as local companies participate. A number of these networks, CiV's (Centres for Innovative Craftsmanship), focus on BBE. A recently initiated CiV is 'Passion for Biobased' in western Brabant, in which 3 roc's, 1 hbo school and 3 companies participate.

In a similar way, hbo schools are organised in CoE's (Centres of Expertise).

One CoE is the national CBBE (Centre for Biobased Economy), in which 6 'green' hbo schools and Wageningen University participate. Hbo schools Avans (Breda) and Hogeschool Zeeland have started the Centre of Expertise BioBased Economy.

At university, students start a 3 year bachelor, followed by master tracks of 1, 2 or 3 years. Several universities, including Delft and Wageningen, offer double degrees for master students. It is sometimes also possible to complete a curriculum at two universities, one in The Netherlands and one abroad, in those cases students will receive 2 diplomas. The Delft University of Technology offers a two year Professional Doctorate in Engineering-degree (PDEng) for graduated excellent master students as an alternative for a further PhD track, offered at all academic universities.

For PhD students, researchers and industry personnel, universities offer post-tertiary education (advanced or post-graduate courses). Most advanced courses are provided by graduate or research schools in which a number of universities participate.

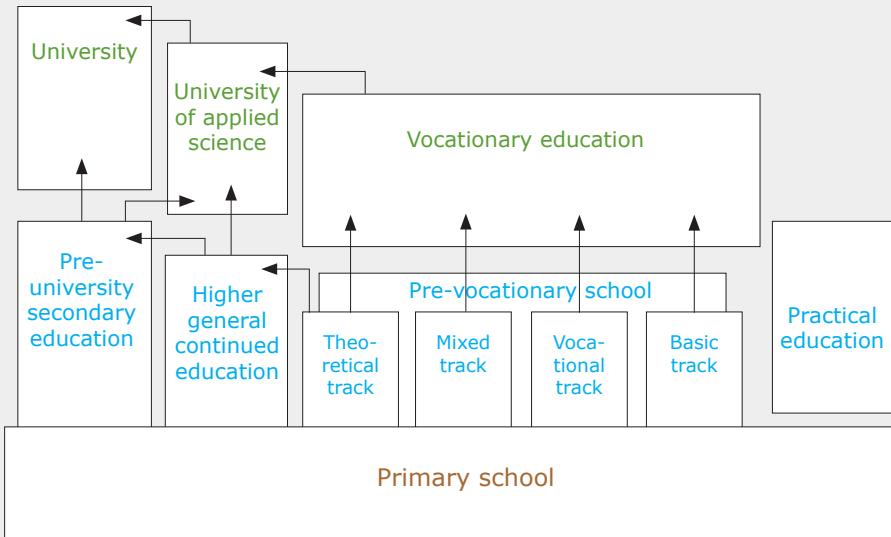


Figure 2: Schematic overview of the Dutch educational system.

