Technology for 15+ – Integration of Technology in the Science Curriculum of Upper Level Secondary Education in The Netherlands

Cor de Beurs, AMSTEL Institute, University of Amsterdam, The Netherlands

Abstract
In The Netherlands, as in other countries, there is a growing interest in technological education as a part of general secondary education (for students aged 12 to 18 years). We have an obligatory subject called ‘technology’ for students aged 12 to 15 in the lower level of secondary education, but no continuation in the upper level (for 15 to 18-year-olds).

In 1997 the Dutch government decided to integrate aspects of technology into the science subjects of upper level secondary education. Under the authority of the Ministry of Education, the project group ‘Technology 15+’ developed a didactic framework and curriculum materials for the integration of technology and design activities into science subjects. The project group Technology 15+ is a co-operation between educational institutes, teacher training centres and the national institute for curriculum development. Where initially the attention was directed towards teaching content and curriculum development, now the focus is on a wide and durable implementation in all secondary schools. In co-operation with technical colleges, universities, local industry and secondary schools, we organise regional networks for supporting design activities in (and outside) schools. This support can have different dimensions, for example in-service training for science teachers, technical students coaching pupils working on design activities, pupils from secondary schools doing their practical work at the institutes, internet support, and visits to industry. In this paper I will report on this project.

Introduction
In The Netherlands, technology in general education was introduced in 1993 as a compulsory subject for all pupils in lower secondary education (aged 12 to 14). Recently the curriculum has been revised to target a stronger development of general skills in a design-focused approach and to address more attention to information technology.

In primary schools, technology is integrated with existing subjects like craft and science, with a focus on designing, making and investigating products of technology. Recently curriculum materials were developed and distributed within the framework of a national project.

In the upper level curriculum of general education (for students aged 15 to 18) a technology component is still missing: technology for 15+.

Technology 15+
The Technology 15+ (T15+) group was set up in 1993. Among the founders were the late Professor Jan Raat from the Technon Foundation and Professor Dietrich Blandeau from the Department of Technology Education at the University of

Eindhoven. We remember and appreciate them for their inspiring contribution to the work of T15+.

T15+ is a co-operation between several institutes:

- AMSTEL Institute, University of Amsterdam
- Faculty of Teachers Education, Utrecht
- Educational Centre, University of Twente
- National Institute for Curriculum Development (SLO)
- Technical Colleges and Universities.

The aim of the project is the development and implementation of a technology curriculum in the upper level of secondary education. From an educational point of view, this is necessary to create an uninterrupted curriculum for pupils aged 12 to 18, in which a depth of understanding and capability can be built systematically. This is important from a social and economic point of view because Holland – like a lot of other countries – faces serious problems with the input, throughput and output of students in technical colleges and universities (de Beurs and Mulder, 1993). A substantial number of pupils in secondary schools who show talent in technological subjects are choosing non-technical studies like medicine and law (Tinbergen Institute, 1996). Therefore the shortage of technically educated graduates for an increasing amount of technical professions is growing steadily. And this shortage seems to be structural!

One problem is the general attitude towards technology and the unfamiliarity of most pupils with technology and technological problem solving. Therefore pupils have to find out their motivation and capabilities in this field by means of concrete experiences in challenging projects. Orientation on technological studies (in colleges and universities) can be improved by connecting to these kind of activities.

A concrete proposal for the project Technology 15+ (Project Technology 15+, 1993) was offered to the Ministry of Education in February 1993. At this time the complete curriculum for upper level secondary education was under revision. The Steering Committee for this revision decided in October 1994 – referring to the ideas of T15+ – that technology should be part of the upper level curriculum.

It was decided to integrate technology with the existing science subjects. The option for a separate subject was rejected on the grounds that fragmentation of the curriculum into too many subjects should be avoided.

In the next two years the examination programmes for all subjects in the upper level curriculum were adapted. Technology was integrated into the programmes for science subjects by defining a few technology domains for the subjects and by admitting design skills to the general list of acquirable skills. As part of the obligatory practical work in the last two years of science education (40 to 80 hours), pupils choose a research project or a design project.

The new examination programmes came into practice from August 1998 for about 30% of schools, and from August 1999 for all schools.

Design modules in the science curriculum

On an assignment in March 1997 for the Ministry of Education, T15+ developed design modules for use in biology and physics. A contribution from the University of Twente made it possible to develop a module for chemistry at the same time.

In three different author teams, design modules were developed for each subject. Preconditions for the modules were the existing facilities of the traditional science laboratory for design activities, and the demand for a substantial link with the subject content. Furthermore, each module had to provide about 30 hours of pupil activity.

In preparation for developing the modules, a didactic framework had to be worked out. In discussion with educators from the design departments of technical colleges and universities many different questions arose, such as:

- What do pupils need to know about ‘design methodology’ to become better problem solvers?
- Which phases in the design process do we have to highlight to give a realistic impression of good engineering practice?
- How do we avoid the focus on methodological aspects forming a restriction for creative problem solving?
- How can we encourage pupils to finish their projects successfully, given the limitations on time, materials and facilities?

From earlier experiences with design projects at upper level (Frederik and Huijs, 1997), we learned that pupils as novice designers primarily focus on making. There is hardly any reflection on the background of the problem and possible reasons for the design task. Consequently pupils do not tend to collect information about the problem, express requirements for the products they design, search for alternative solutions, or do solid testing based on predefined requirements. These experiences correspond with similar experiences in the design departments of technical colleges and universities. Novice designers tend to pay little attention to problem analysis and the process of generating ideas for solutions.

It was therefore decided to focus on the first stages of the design process: problem analysis, problem definition and the search for alternative solutions. To emphasise these aspects not only reflects good engineering practice and leads to better designs, but also strengthens the image of technology as a human activity. In this approach, doing technology is highlighted as the search for and the realisation of concrete solutions for recognisable human needs. These activities demand creative pupils with empathy, communication skills, multi-disciplinary interests and a practical mind, rather than smart and possibly narrow-minded whiz-kids.

The following attainment targets were specified for different stages in the design process.

Problem analysis
Pupils must be able to identify with the content of the design task and find answers to questions like ‘What is the problem?’, ‘Who has the problem?’, ‘Why is it a problem?’ and ‘What do we want to obtain with a possible solution?’. The starting point for each design project is always *a recognisable owner of the problem*. This is important for the conceptualisation of technology as a human enterprise and for the motivation of pupils (especially girls).

Design specification
Pupils must be able to gather the design requirements from a given context and reformulate general described requirements as *testable* requirements. To strengthen the identification one can work with a real or fictive (e.g. teacher) owner of the problem for further analysis.

Alternative solutions
Pupils must be able to suggest at least two alternative solutions for the design problem.

Design problems don't have unique solutions and you never know if you have overlooked a promising one. Therefore generating alternative solutions is an important part of the design process that requires divergent thinking. To stimulate this kind of thinking pupils are asked to identify sub-problems and generate solutions for each sub-problem. The results are presented in a so-called 'table for ideas', which serves as a starting point for formulating a design proposal.

Design proposal
Pupils must be able to generate a design proposal from the alternative solutions, taking into account the list of requirements and the available materials and facilities at school.

Realisation
Pupils must be able to elaborate the design proposal in a working prototype, examine to what extent the requirements are met, and suggest improvements and modifications. It is not expected that pupils redesign their prototype.

Presentation and reporting
Pupils must be able to present their results in a brief and to-the-point way to their teacher and their fellow pupils. A portfolio document is used for reporting and process control.

These targets are applicable for all design modules in the different subjects.

A design manual and portfolio document for pupils have also been developed for common use in all modules. The design manual is a reference book with general instructions (methodology) for each stage of the design process. The portfolio document enables pupils to report the results (outcomes, arguments, decisions) of different stages in the design process, and supports supervision by the teacher.

From August 1997 until August 1998 design modules were developed for biology, chemistry and physics.

- The module for biology involves pupils designing and making alcohol-free beers. This biotechnology module was developed in co-operation with the University of Agriculture in Wageningen.
- The module for chemistry involves pupils designing and making paints (for example masonry paint and skin paint). This module about chemical technology was developed in co-operation with the Technical University of Twente and the Technical College of Enschede.

- The module for physics involves pupils designing and making automatic systems (for example a pathfinder system for blind people, a waste separation system, a solar energy system, or an automatic bridge). This module about information technology was developed in co-operation with the departments of Electrical Engineering at three Technical Universities in The Netherlands.

At the same time, the design manual and the portfolio document were slightly altered for each module, to meet the demands of the concrete projects.

As mentioned before, the design modules developed in the project Technology 15+ are preparatory for the independent design activities as part of the obligatory practical work.

With reference to the T15+-modules, the National Institute for Curriculum Development worked out general guidelines and related documents for pupils and teachers to support these independent design activities. One of the products is a design manual (reference book) for pupils.

The implementation problem

The integration of technology with science subjects is far from easy. We distinguish at least three problems. Firstly most science teachers are unfamiliar with technology. Secondly the science laboratory is generally insufficiently equipped for design activities. Thirdly there is a shortage of well thought-out and motivating teaching materials to support design activities in the classroom.

To solve these problems, the project group Technology 15+ has worked out an additional project in co-operation with industry, technical colleges and universities. Elements of this project are:

- the development of additional modules
- the development and implementation of teacher training courses
- the development and distribution of material packages and equipment for classroom use, in co-operation with industry
- the development and implementation of a support structure by means of regional networks between secondary schools and technical colleges/universities.

We feel that the network support in particular can have an important impact on the implementation process. In The Netherlands we have 22 Technical Colleges and 4 Technical Universities. As a result of the dropping intake of students, these institutes are increasingly willing to get in touch with secondary schools. However, lasting relations are only built up in situations of mutual interest. Network relations aimed at the support of concrete design activities in the classroom satisfy this condition. Regional co-operation offers fruitful starting points for pupils' orientation on future study and profession, which is important for the higher education institutes. Secondary schools take advantage of the available expertise in design education and facilities at these institutes.

This support can have different dimensions, for example in-service training for science teachers at the institutes, technical students coaching pupils working on design activities, pupils from secondary schools doing their practical work at the institutes, and internet support.

At the moment a Technology 15+ internet-site is under development, where pupils can find not only general information about design and their design projects, but also have the opportunity to ask experts from higher education questions about their design project.

With this new project, Technology 15+ is moving on to a new stage. Where initially the attention was directed towards teaching contents and curriculum development, now the focus is on implementation on a national scale.

From January 2000 we start a development and implementation project in three phases:

1 January 2000 to September 2000 – use and evaluation
2 September 2000 to January 2001 – development
3 January 2001 to September 2002 – revision, distribution and transfer

In the first project phase, existing materials will be used and evaluated in the first school networks. The project starts with three regional networks, in which some 50 schools, 3 Technical Universities, 4 colleges and local industry co-operate. In addition, an evaluation of different types of network support will be performed.

The results of the evaluations will be used to design manuals and formats for the development of new teaching materials and teacher training materials in the second phase. The results of both phases will be communicated to schools, teachers, teacher organisations and (new) network partners from colleges, universities and industry.

In the third phase, the revision and distribution of insights and materials is the central issue.

Besides this, efforts are to be directed at extending existing school networks and creating new networks.

The final goal is a nationwide and durable implementation of a technology component in all schools for upper level secondary education.

References

Beurs, C. de and Mulder, C.T.H. (1993) ‘Technology in the Upper Level of General Secondary Education’, proceeding Patt-6 conference, Breukelen, The Netherlands
Frederik, I. and Huijs, H. (1997) *Pupils’ Experiences with Design Projects*, Enschede: publication SLO (in Dutch)
Project Technology 15+, *Technology 15+, Technology in Upper Level Havo/Vwo*, Amsterdam: AMSTEL Institute (In Dutch)
Tinbergen Institute (1996) *Is There a Hidden Technical Potential?,* Amsterdam