First International Congress on Tools for Teaching Logic
The Dissemination of Logic in Dutch Secondary Schools

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Abstract

New Dutch school curricula are ready for accommodation of the teaching of formal logic. Our dissemination project develops teaching material, textbooks and educative software, to make this possible. We support the integration of logic within the subjects of the new curricula rather than stand-alone logic courses. As a …rst example we give an overview of our program for logic based teaching of elementary computer science.

1 Intro

Dutch education reform: the 'studiehuis' Pre-academic education in Holland has recently been subject to drastic reforms. A new schooling program, the so-called 'studiehuis' (= study home), is primarily meant to guide the changeover of students to university. The major structural implication is that independent project-oriented study replaces much of the ordinary class teaching. As for the content this program o¤ers individuals schools more freedom to incorporate interdisciplinary studies and acquisition of up-to-date information technological skills.

The dissemination of logic The Spinoza project[1] "dissemination of logic" (DoL) aims at the integration of formal logic in Dutch secondary school curricula. The new 'studiehuis'-structure makes such an adaptation of logic possible.

[1] The Spinoza project was initiated by Johan van Benthem who have been awarded the Dutch Spinoza prize in 1996.

But more important, DoL foresees that in the end the accommodation of interdisciplinary and technological content within school curricula demands for more coherent structure and requires a substantial contribution of formal logic on a secondary school level.

Dissemination strategy DoL believes that an adaptation of academic logic courses is not the right way to anticipate on this situation. In line with the 'studiehuis' paradigm, our didactic philosophy is purely functional: we propagate acquisition of formal logic by demonstrating its use as the appropriate mathematical equipment for application in interdisciplinary studies and digital technology. In the current situation in Holland the most obvious …rst subject for dissemination of logic is computer science. At a later stage DoL thinks of natural deduction as a format for guiding students to learn proof techniques in mathematics, a subject which has recently been put on the curriculum for mathematics. Formal linguistics is an interdisciplinary topic for dissemination that DoL wants to put on the agenda as well.[2]

2 Logic and computer science

In this abstract an outline is given of our current work on disseminating logic teaching material for the introduction of elementary computer science. In the current situation computer science curricula at secondary schools is completely opportunistic: teachers are mostly volunteers who do not have a computer science background and the teaching material focuses merely on the use of today's popular software. DoL works on teaching material which aims at the acquisition of more persistent knowledge about mechanic computation: elementary models of computing machinery, digital techniques and algorithmics (programming). This material, consisting of a textbook and accompanying software. A board of teachers[3] has been installed to judge the accessibility of the material. Below we give short outlines of the four di¤erent sections which are to be incorporated.

1 Historical development of computing equipment The introduction part consists mainly of early inventions of computing machinery. These machines such as Pascal's 'Pascaline', Leibniz' 'lebendige Rechenbank' and Babbage's di¤erence engine are used as simple models to o¤er students a perspective on how computation can be mechanized. Logic comes on the stage with the switch of decimal to binary computation. A parallel development of logical machines accompanies this text which happily ends with the marriage of computation and formal reasoning at the time that electronic machines are introduced. This introductory section ends with a bit of future speculation about bio- and quantumbits.

[2] It is not a subject that has been put on the general 'studiehuis'-program, but DoL works on teaching material which schools may use for free interdisciplinary projects.

[3] In collaboration with the Amsterdam University Press.

2 Elementary machine models In this part we illustrate mathematical models of machines. We illustrate autonomic processes as …nite automata, which can be seen as computation without memory. We show how memory is really needed for computation of standard arithmetical functions such as addition and multiplication. Turingmachines are the natural follow up as automata with memory on tape. Several illustrations of Turing machines show how they compute simple arithmetic operations. The Turing thesis is explained with a sketch of undecidability proof of several undecidable problems The last class of models we introduce in this section are registermachines. An ultimately simple programming language is introduced to write programs for these machines.

3 Computation and reasoning In this section Boolean algebra is introduced as the mathematics of binary computation. Boolean circuits are presented as the hardware implementation of binary computation. Propositional logic comes on the stage with an explanation Boole's theorem of functional completeness of the standard logical functions.

4 Programming Within the last section a simple imperative programming language is introduced for programming registermachines. Much of the attention in this section goes to the relation between inductive de…nitions and `while`-loops in programs. Analogous to this connection we illustrate how inductive proofs and deriving correctness on the basis of loop invariants are related. This relation will be accompanied with illustrative development of algorithms on the basis of picking proper loop invariants.

3 Software development

As said earlier, at this stage DoL propagates the teaching of logic on a purely functional level. The obvious di¤erence with academic teaching as far as the text is concerned is that de…nitions, theorems and proofs are replaced by a scenario of examples, illustration and exercises. In addition DoL works on an extensive set of software applications for visualization and training. Because our functional perspective on teaching logic and the focus of independent learning in the 'studiehuis' curriculum this software will be of major importance. Independent training has motivated DoL to implement Java applets and JavaScripts so that the applications can be used over the net.[4] Below we present a sample of such applications chronological to the successive sections of the textbook.

1 History The …rst computing device on paper, Schickard's mechanization of Napier's bones for multiplication, plays an important role in the historical introduction, because this machine reveals the straightforward didactics of primary

[4] DoL has been working on software development for elementary logic courses at the university. Some of those applications can be used within this subproject. This collection can be found on the web at `http://turing.wins.uva.nl/»jaspars/animations/`.

school arithmetic: learn the elementary multiplication tables by heart and then perform the rules of algorithms like long divisions and multiplications. A virtual interactive remake of Schickard's machine is under development. Moreover, we also work on such simpli…ed remakes of Leibniz' Rechenbank and Babbage's di¤erence engine. They illustrate how more complex computing functions such as multiplication and polynomes can be mechanized as extensions of simple addition devices.[5]

2 Machine models For this section we aim at the implementation of a set of running automata and Turingmachines.[6] For the part on registermachines an editor is to be implemented for programming such machines with the simple language as presented in the textbook. In order to visualize the working of such programs the computational performance is illustrated by an animation window in which the changing content of the registers is depicted.

3 Binary computation and propositional logic In this section we proceed with a bitregister variant of the registermachines of the previous section. Here we illustrate that binary instead of unary representation causes exponential reduction of computational space. The di¤erence between decimal and binary representation is a simple linear reduction.

Another important application which is going to be developed concerns the construction of logical circuits. We illustrate how arithmetical operations can be encoded in hardware of bits and logical ports. The application that we have in mind makes it possible for students to build circuits themselves. Moreover, we show that circuit encoding of more complex operations may be much more time-e¢cient than by implementing addition and subtracting operations on bi-tregistermachines.

For additional logical training a simple applet for computing truth tables has been developed.[7]

4 Programming The main application which we have in mind for this section is an editor for writing programs in the language as presented in the textbook. Again the run of the program will be visualized by means of changing contents of registers. This application is meant for the students to check their work on the exercises concerning the development of algorithms.

[5] Babbage's di¤erence engine is in fact a good illustration of the use of loop invariants to encode polynomes as repetitive additions.

[6] See also the section Turingmachines at http://turing.wins.uva.nl/»jaspars/animations/.

[7] See also the section on propositional logic at http://turing.wins.uva.nl/»jaspars/animations/.

4 Conclusive remarks

The new Dutch system 'studiehuis' for secondary schools opens the door for dissemination of logic on a pre-academic level. DoL thinks that the introduction of logic within this program will bring mathematical support for the interdisciplinary studies and technological practice that the 'studiehuis' aims at. The best way to operate is to present logic on a practical level and therefore dissemination requires integration of logic teaching material within the context of those interdisciplinary studies and new technologies. In this abstract we have illustrated this strategy with our …rst initiative to work on teaching material for elementary computer science on a logical basis. Moreover, we strongly focus on the development of supporting software in order to present the material as functional and accessible as possible.

In the future DoL will initiate similar development of teaching material for formal semantics and syntax of natural language and proof techniques in mathematics.

In the talk we present some of the software which has yet been developed for the elementary computer science course material.