Which way with informatics in high schools in the Netherlands? The Dutch dilemma

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Which Way with Informatics in High Schools in the Netherlands? The Dutch Dilemma

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Abstract. Informatics is currently being taught in high schools all over the world. In the Dutch curriculum, computer literacy is taught in the lower grades as a compulsory subject, Informatics is taught as an elective in the higher grades of some schools. As a follow-up to the outline of Grgurina and Tolboom (2008), the discussion about the future of Informatics education in the Netherlands is investigated and elaborated in this paper. Our research brings forward four positions of the stakeholders in the field: the negative-critical view, the positive-realistic view, the no-nonsense view and the innovative view. Extreme positions are either 'to terminate the school subject, because teachers are not qualified and there is little relation with Informatics as a scientific discipline', or 'to strengthen the school subject because of its social relevance'. The latter position will be substantiated by a discussion of the novice-expert approach for teaching and the importance of enculturation and situated learning. As a way to strengthen secondary Informatics teaching, especially in the Netherlands, Schoenfeld's framework is advised (Schoenfeld, 2010).

Keywords: Dutch informatics curriculum, informatics in high schools, teacher's perspective.

Introduction

As a country, the Netherlands remain among the top nations in Informatics research, and in the absolute top of research in a number of sub areas, see Leiden University, *et al.* (2010). However, in contrast, Dutch secondary Informatics education is at risk. We believe that it is at a crossroads. The main criticism is that its content is not sufficiently up to date and that the quality of the teaching is too low. To bluntly summarise, it is either going to disappear or to enter a position comparable to secondary school disciplines such as Mathematics and Dutch and English language. In order to get the different opinions about Dutch secondary Informatics education substantiated we performed a study among several stakeholders about questions related to its future development. We have to admit that we expected beforehand a great diversity in the opinions. In this article we report about this study.

However, we start with a very global sketch of the situation of secondary Informatics education worldwide, followed by a more detailed description of the Dutch situation. Secondly, we will present the mentioned research and as a result we conclude that there are four positions. Finally, we give what we call 'the Dutch dilemma' and our answer to it. This answer is mainly based on the novice-expert approach, on enculturation, and on situated learning. We advise to use Schoenfeld's framework (Schoenfeld, 2010) about how people address complex tasks in order to strengthen secondary Informatics education.

Informatics Education Worldwide

The information about the situation of Informatics education in secondary education worldwide is not readily accessible, on the Internet, for example. Since it is not our aim to give a full overview, but to focus on the Dutch situation and on how we think it should develop, we only give a very brief and global impression.

In the USA, the National Science Foundation (NSF) reported at the end of 2009, that in the United States of America the situation is poor as well. Only a bit more than 16.000 high school students entering college took the Advanced Placement computer science exam, whilst for Calculus AB this number is 230.000 and for History over 360.000. For the NSF, this was a reason to stimulate the development and implementation of a comprehensive Informatics curriculum for grades K-12. The NSF supports this by creating a new research grant programme (National Science Foundation, 2009).

In Blumrich (2007) a synopsis and comparison are given about Informatics education in thirteen countries, including three non-European countries, Japan, New Zealand, and the Philippines. The study clearly illustrates how diverse the situation of Informatics education is in the world. It shows the different national strategies used to implement ICT/Informatics in secondary education. It turns out that that there is no common idea about the content of ICT/Informatics education. Sometimes it is about the teaching of how to use the most common computer programs like word processing, using a spreadsheet program, making presentations by use of a presentation program, browsing on the Internet or searching for information. Sometimes it is about the concepts behind the usage of a computer, like databases, information systems, et cetera; sometimes it is (also) about programming, and sometimes it is about solving problems using ICT/Informatics. Secondly, there is not a common idea about the age group this education is meant for either. Sometimes it is for students in primary, sometimes in lower secondary, sometimes in upper secondary education. Of course there exists a relationship between the content and the age group. Sometimes the situation of Informatics education is very well organised top down, mostly by the ministry of education. But even then great differences can be observed: in some countries Informatics is an obligatory discipline, and in other countries, such as in the Netherlands, schools are free in designing their policy: they can offer it as an elective. But we know, based on private communications, that there are still countries without any form of information/ICT/Informatics education[1].

[1] Ireland is such a country; oral communication on 27th of July 2009, Bento Goncalves, Brasil.

Informatics Education from the Student's Point of View

Besides this more or less chaotic situation from a policy point of view, there is at least one other aspect that plays an important role: the confusion of students (and of the general audience as well, including parents, study advisors, deans, and non-informatics teachers) concerning what Informatics is about. Hadjerrouit (2009) mentions in regard to this confusion, that students do not possess a conceptual and consistent picture of what is going on in the computer. As a consequence, their activities rely on what is visible on the screen. When students are confronted with unexpected results, they do not know what they can do to deal with the information the computer shows on the screen (Bruillard, 2004). Hadjerrouit (2009) mentions several reasons to explain this 'poor' situation of students' confusion about Informatics, based on many research papers (Belland 2009; Minaidi and Hlapanis, 2005; Bruillard, 2004; Micheuz, 2008; Webb, 2002; Hammond, 2004; Hromkovic, 2006; Freischlad and Stechert, 2008; McDougall and Boyle, 2004): the slow adaptations of schools and teachers to technological and pedagogical changes; the rather weak competencies and qualifications of Informatics teachers in secondary education; the impossibility for teachers to know the functionality of the software used in the schools; the underdevelopment of teaching materials; little published research work on school Informatics regarding content, modalities of teaching and learning, and didactical and pedagogical issues; the fact that students nowadays are focused on visual representations, such as what they see on the screen, and that as a consequence they do not make conceptualisations of what is happening with respect to the information processing behind the screen; the difficulty of teaching certain topics from Informatics which require a great range of professional and pedagogical skills.

Informatics Education in the Netherlands

Grgurina and Tolboom (2008) describe the first decade of Informatics in Dutch high schools. After a description of the Dutch educational system with a focus on the secondary schools, they mention the birth of Informatics in 1998 in the upper part of secondary schools which (in case of VWO) prepare their students for university or (in case of HAVO) for higher professional education. See Appendix 1 for a description of the Dutch school system with its three levels and four profiles. Universally speaking, the objectives were 'to provide students with an understanding of IT concepts, and to give them a sense of the potential and limitations of their use in the community as a whole, and, more specifically, of their use in their future careers' (Hacquebard *et al.*, 2005). The course was designed to be well within the capabilities of all students, regardless of whether the rest of their curriculum followed the social or the scientific profile. The result was a course of multidisciplinary nature, which exemplified how this characteristic could be applied to complex problems and structures. Furthermore, since Informatics was not a prerequisite for any subsequent study at the university/college level, there was no need for a national exam; all assessments had to take place at the high school level. The original curriculum consisted of the following four themes:

- Informatics in perspective.
- Terminology and skills.
- Systems and their structures.
- Contextual usage.

In Appendix 2 the subdivision into a total of 15 sub-themes is described. In 2006, some minor adaptations were implemented (Schmidt, 2006). After a comparison of this curriculum with the UNESCO/IFIP curriculum (Van Weert and Tinsley, 2000), Grgurina and Tolboom (2008, p. 76) conclude that 'The curriculum makes clear that the objectives of the Dutch Informatics course are primarily the study of Informatics in the broadest sense of the scientific discipline. Computer literacy is assumed to have been achieved earlier on, and the use of computers as teaching aids in other courses falls beyond the scope of Informatics. In other countries, Israel, for example, curriculum developers chose to design a secondary education programme that, although fundamental in character, focused on programming: 'algorithmics is the central subject of study' (Gal-Ezer, 1995)'.

The teaching and the assessment of the learning results were supported by several documents (Hartsuijker, 1999; Hartsuijker *et al.*, 2000; Schmidt, 2006) and by three textbooks of which two (Bergervoet *et al.*, 2001; Meijer *et al.*, 2001) are now only available on-line and of which one does not exist anymore. There is also a website, www.informaticavo.nl, which is updated weekly in order to support the Informatics teachers.

Grgurina and Tolboom (2008) also give much attention to the *quality* of the Dutch Informatics teachers. Most of them became an Informatics teacher through a specially organised two-year course of about 900 hours of study load. This course was organised and executed by a Consortium of universities (of applied sciences), named CODI. They were already a teacher in some other discipline, and not always in Science or Mathematics. The participating universities delivered the learning materials, all for usage in a distant learning mode. The participants worked in four groups of about twenty people with meetings for tutoring in one of the four designated places in the Netherlands. In the course they learned the basic Informatics principles. They also had to conduct a full track of the two years Informatics curriculum in their classrooms, including the final school examination, as certification requirement. CODI certified about 330 Informatics teachers, while there are about five hundred schools for VWO and HAVO.

Since 2008, it is possible for students with a bachelor degree in Informatics to become a teacher in Informatics after a two year university study, comparable to the teacher education in other disciplines such as Mathematics. This creates the opportunity that more or less experienced computer scientists, professionally trained in education, teach an Informatics class. But there are still only very few teachers with that scientific background.

With respect to the *quantity* of Dutch secondary Informatics teachers, we can mention the following. In the beginning of secondary Informatics education in the Netherlands (1998–2006) about 60% of the schools offered Informatics. So, the 330 CODI-trained teachers had about 13500 students who completed the course. In 2009, about only 9000 students completed it (Dienst Uitvoering Onderwijs[2], 2010). This means a decrease of about one third in the number of students. There was also a proportional fall in the number of Informatics teachers. A number of the Informatics teachers who are only trained in the basic Informatics principles by CODI has retired in the meantime or will soon retire. On an online questionnaire among the members of the association of Informatics teachers (i&i) almost 40% responded. It turned out that almost 20% of the respondents expect to retire within five years (Archief Informatica in het voortgezet onderwijs, 2010). The management of schools is considering to do away with Informatics, not only because there are no longer any Informatics teachers, but also because there are other electives which attract (more) students, such as NLT (Nature, Life and Technology)[3] and Mathematics D[4]. But the main reason seems to be that the management, and also the other teachers, have false ideas concerning what Informatics is really doing. Some think that Informatics means 'to push the keys and that all young people are very competent in doing so'. This leads us to the question: how can this decrease of secondary Informatics education teachers in the Netherlands be stopped?

Although there are now university Informatics teacher training institutes in the Netherlands, only very few students choose a career as Informatics teacher. (Obviously for students careers in ICT seem to be much more appealing). But it seems that there is a rise in the number of students for the Informatics teacher training track. And also there are people working in ICT who make a career switch to education. We can only speculate about their reasons: less jobs in ICT?, no longer retirement at age 65 but at 67?, is working in education no longer considered as inferior?

Besides the concerns about the number of Informatics teachers, the more serious concern exists that the quality of teaching is insufficient. This has, of course, also to do with the modest Informatics training of most of these teachers. They are not very well able to judge the quality of the learning materials and they are not very well informed about the new developments in Informatics which are relevant for their teaching. One can also wonder if the way in which they assess the learning results of their students is sufficient.

From the very beginning, the introduction of Informatics in secondary education has been monitored (Hartsuijker, 2001, 2002, 2003, 2004). In 2008, the most recent monitoring survey was published (Schmidt, 2008) in which a number of fundamental questions about Dutch secondary Informatics education was raised:

- Should there be a central examination?, Should it be a compulsory course?
- Should the curriculum not include a part for students who intend to study Informatics in university?

[2]The Dienst Uitvoering Onderwijs (DUO) is responsible for the execution of several acts and regulations, such as student grants and information management. These acts are commissioned by the Ministry of Education, Culture, and Science.

[3]In NLT students get modules based on (an integration of) Physics, Chemistry, Biology, Mathematics and some Informatics. Although some Informatics is involved, Informatics teachers do not have a license to teach NLT.

[4]Mathematics D is a course with special mathematics subjects like complex numbers, dynamic systems, analytics geometry, which are not in the central mathematics examination.

- Should there be a committee of teachers, teacher educators, informatics education researchers and computer scientists, in order to give impulses to the further development and quality of Informatics?

Until now it turns out that the Dutch Ministry of Education which has to decide about this question has no intention to make any move. Nevertheless, we can mention some initiatives with respect to these questions. There is, for instance, some co-operation between teachers and computer scientists to develop new learning materials. Also, two professors in the didactics of Informatics (one is the third author of this article) are yet trying with the support of the Dutch Royal Academy of Sciences to convince the Dutch Ministry of Education to set up a committee that will be responsible for a substantial improvement of the secondary Informatics education: quality assurance (including a central examination), innovation of the curriculum, pilots in classrooms with new topics/learning materials, refresher courses, et cetera.

We may conclude that the discussion about Dutch Informatics education has not yet reached a clear outcome. As a follow-up to and a broadening of Schmidt's survey (Schmidt, 2008) mentioned above, we present the methodology and results of our investigation into the opinions about secondary Informatics education among stakeholders of the field.

The Stakeholders' Opinion: A Fourfold Fragmentation

To map the many different opinions on the subject of Informatics in secondary education, an investigation has taken place in 2008. The research question of this investigation was the following: *Which opinions exist about the future of secondary Informatics education in the Netherlands among its stakeholders?*

In order to be able to analyse and interpret subjective matters such as personal points of view, opinions, attitudes, feelings and the like, the Q-methodology (Schmolck, 2010) has proven to be a powerful tool. Therefore, this research has used this methodology. As a first step, the Q-methodology requires the construction of a set of theses related to the content of the opinions to be investigated, that is the future of Informatics in (Dutch) secondary education. To construct a set of theses, three experts were interviewed: an Informatics teacher, a Informatics teacher trainer, and an educational manager of a university Informatics programme. Also, national literature was studied (Automatiseringsgids, the leading professional journal on ICT in the Netherlands) and national conferences were attended (NIOC, Nationaal Informatica Onderwijs Conferentie, the Dutch conference on Informatics education, organised every two years and i&i, the professional association of Informatics teachers). After selection on usability, recognisability and relevance, this resulted in a set of 37 theses related to the content of the subject, the position of the subject at schools and the role of the teacher. See Table 1. The theses have been translated from Dutch, see Van Diepen (2009) for the original. The theses have been presented to the participants from the field of Informatics by a web-based tool, with the assignment to sort the theses into seven categories, ranging from 'least agreed upon' (−3), through

Table 1

List of theses related to the opinion on Dutch Informatics education

No.	Thesis
1	In the exam programme the distinction between the HAVO level and the VWO level is insufficient.[5]
2	The actual contents of the subject of Informatics is too teacher-dependent.
3	The final level of the subject of Informatics is formulated into too global terms.
4	A centralised (written or practical) final exam in Informatics is desirable.
5	Working-in-a-project is a didactical method and should therefore not be part of the exam programme of Informatics.
6	The programme for Informatics is lacking a fundamental theoretical module, containing, for instance, logic and automat theory.
7	The best choice for information modelling for the HAVO level is ERM[6].
8	The concepts of object orientation are too complex for high school students.
9	The current available methods for Informatics are satisfactory.
10	The width of the subject is the power of the subject.
11	The subject of Informatics has not been developed sufficiently.
12	Students of all optional profiles[7] should be offered the same Informatics programme.
13	The website www.informaticavo.nl is indispensable for Informatics teachers in secondary education.
14	The subject of Informatics can be well examined without a written test, namely only with a practical component and a project component.
15	More attention should be spent to the role of ICT in society, in particular to ethical and legal aspects.
16	A centralised (written or practical) final exam is necessary for securing the level and quality of the examination.
17	The best choice for information modelling for the VWO level is FCO-IM [8].
18	A module on Artificial Intelligence should be a component of the compulsory subject matters of Informatics.
19	The distinction between the HAVO and VWO level does not exist within the domains, but in the educational style.
20	The main reason why teachers choose for the topics robotics and gaming is because the students like it.
21	More attention should be spent on the role of ICT in the personal life environment, in particular communication, information overload and privacy.
22	If students use a lot of HTML coding in building a website, they fulfil the requirements of the ‘programming’ component of the exam programme.
23	An Informatics teacher who has no subject colleagues in his own school, should cooperate with a colleague from another school.
24	Teachers, licensed to teach Informatics, should be licensed to teach NLT, too.
25	It is a duty for Informatics teachers to teach the subject as appealing to girls as possible.
26	Informatics should be a compulsory subject for all optional profiles.
27	i&i, the professional association of Informatics teachers, should set up a certification system.
28	Informatics should profile itself as a science subject.
29	Modules aimed at the profile Economics and Society should be developed.
30	The professional knowledge of CODI-educated teachers is sufficient.
31	Information security should be a compulsory part of the subject.
32	School leaders and school counsellors know too little of the content of the subject of Informatics.
33	Every HAVO/VWO school should offer Informatics as an optional subject.
34	There should be an Informatics module for middle school to prepare students in choosing it as a subject in high school.
35	There is a need for differentiation inside the classroom for students from the various profiles.
36	The job combination of teacher of Informatics – System manager/ICT co-ordinator is giving a wrong signal of the subject.
37	The Informatics teacher must be an example for his colleagues with respect to the use of ICT in education.

[5] For the difference between HAVO and VWO see Appendix 1.
[6] ERM: Entity-relationship model.
[7] See Appendix 2.
[8] FCO-IM: Fully Communication Oriented Information Modeling.

'neutral' (0) to 'most agreed upon' (+3). According to the Q-method, the participant has to sort the theses according to a prescribed semi-normal division: in this case two theses in the category -3, four in -2, seven in 1, eleven in 0, seven in $+1$, four in $+2$ and two in $+3$.

From the set of stakeholders a purposive sample of 89 potential respondents have been invited, a selection directed at including teachers of Informatics in secondary education, teachers of Informatics in higher education, authors of Informatics educational methods, students of the pre-service teacher trainings programme, education experts of the pre-service training institute and people that are concerned with policy making on the subject of Informatics.

The analysis of the data consisted of a frequency analysis and a factor analysis. In the frequency analysis a score is provided indicating the *value* of each thesis by multiplying the frequency of a given choice with the value of that choice $(-3, \ldots, +3)$. The possible range of this value is from $-3N$ to $+3N$ with N as the number of respondents. A high positive score indicates that the respondents generally value the thesis positively. A high negative score indicates that people generally value this thesis negatively. A thesis with an average score either indicates that people disagree, or do not feel strongly about the thesis. The factor analysis used the program PQMethod 2.11 (Schmolck, 2010).

Results

From the 89 invited potential respondents, 59 reacted and sorted the theses according to the prescriptions. Among them were fifteen secondary education teachers, fifteen higher education teachers, ten students from pre-service teacher training, nine authors, eight educational specialists and two policy makers, all in the area of Informatics.

Analysis of Frequencies

The frequencies of the answers indicate that almost all choices occur. For most of the theses, the answers given vary from -3 to $+3$. This confirms the claim of the introduction that there are many different opinions on the subject.

In Table 2, the five items at either side with extreme scores are listed. As we can see, items 33, 32, 11, 34, and 36 have a high positive score and items 12, 30, 5, 14, and 22 have a high negative score. The group as a whole has the opinion that Informatics in secondary education is underdeveloped and insufficiently recognised by school leaders and pupils. On the other hand, there was only one item, item 19, with strong overall consensus. Everyone slightly disagrees with the thesis that 'The distinction between the HAVO and VWO level does not exist within the domains, but in the educational style.'

Factor analysis including varimax factor rotation were performed on the data using the program PQMethod 2.11 (Schmolck, 2010). After examination of various possible factor solutions, a four-factor solution resulted as the best one. These factors will be discussed in succession.

Table 2

Items with extreme values and their frequency distributions

No.	Frequencies from −3 to +3	Value	Thesis
33	1 0 1 10 20 12 15	+85	Every HAVO/VWO school should offer Informatics as an optional subject.
32	1 0 8 8 20 15 7	+60	School leaders and school counsellors know too little of the content of the subject of Informatics.
11	1 2 5 13 16 11 11	+59	The subject of Informatics has not been developed sufficiently.
34	0 1 8 13 17 11 9	+56	There should be a Informatics module for junior high to prepare students in choosing it as a subject in high school.
36	1 0 11 17 21 4 2	+44	The job combination of teacher of Informatics – System manager/ICT co-ordinator is giving a wrong signal of the subject.
12	5 15 14 19 4 1 1	−50	Students of all optional profiles should be offered the same Informatics programme.
30	5 12 17 22 2 1 0	−52	The professional knowledge of CODI-educated teachers is sufficient.
5	10 9 17 16 5 2 0	−56	Working-in-a-project is a didactical method and should therefore not be part of the exam programme of Informatics.
14	7 19 20 8 3 2 0	−72	The subject of Informatics can be well examined without a written test, namely only with a practical component and a project component.
22	23 24 6 3 3 0 0	−120	If students use a lot of HTML coding in building a website, they fulfil the requirements of the ‘programming’ component of the exam programme.

Factor 1. The Negative-Critical View

Table 3 contains the twelve items Factor 1 agreed with most (highly positive Z-score) and disagreed with most (highly negative Z-score).

Sixteen respondents load highly on this factor. One of these respondents loads highly negative.

The group consists of twelve higher education teachers (of which five are also involved in teacher training), two students of the pre-service teacher training programme, one secondary education teacher and one policy maker. The secondary education teacher is loading negatively, so he or she thinks exactly the opposite.

Doubts as to the quality and the organisation of the current education seem to arise from the analysis. These respondents feel the need of a central final exam. The subject of Informatics is to be developed more and every school should offer it. The judgement on CODI-educated teachers is harsh. The methods used in classroom can be improved. The general view seems to be critical with a negative tendency. This factor can be characterised as the negative-critical view, often found among computer scientists teaching in higher education.

Factor 2. The Positive-Realistic View

Table 4 contains the twelve items Factor 2 agreed with most (highly positive Z-score) and disagreed with most (highly negative Z-score).

Table 3

Descending array of 12 extreme Z-scores and theses for Factor 1, 'The negative-critical view'

No.	Strongly agreed thesis	Z-score
16	A centralised (written or practical) final exam is necessary for securing the level and quality of the examination.	2.241
4	A centralised (written or practical) final exam in Informatics is desirable.	1.917
36	The job combination of teacher of Informatics – System manager/ICT co-ordinator is giving a wrong signal of the subject.	1.574
32	School leaders and school counsellors know too little of the content of the subject of Informatics.	1.522
33	Every HAVO/VWO School should offer Informatics as an optional subject.	1.349
11	The subject of Informatics has not been developed sufficiently.	1.319
No.	**Strongly disagreed thesis**	**Z-score**
22	If students use a lot of HTML coding in building a website, they fulfil the requirements of the 'programming' component of the exam programme.	−1.885
30	The professional knowledge of CODI-educated teachers is sufficient.	−1.561
14	The subject of Informatics can be well examined without a written test, namely only with a practical component and a project component.	−1.355
9	The current available methods for Informatics are satisfactory.	−1.226
12	Students of all optional profiles should be offered the same Informatics programme.	−1.126
24	Teachers, licensed to teach Informatics, should be licensed to teach NLT too.	−0.984

Twelve respondents load highly on this factor. Seven of them are teacher from secondary education and five are higher education teachers. This factor seems to represent the secondary-teachers' view.

The resistance against a centralised exam and the wish for an Informatics module for middle school is striking. Every school should offer Informatics. Making Informatics appealing to girls is obligatory. The subject can vary for pupils from different profiles. Project work is an obvious part of Informatics. The overall impression seems to be positive, but realistic. So, we call it the positive-realistic view.

Factor 3. The No-Nonsense View

Table 5 contains the twelve items Factor 3 agreed with most (highly positive Z-score) and disagreed with most (highly negative Z-score).

Twelve respondents load highly on this factor. Most of them are secondary education teachers and a considerable number of them are co-authors of one of the Informatics textbooks.

The following theses stand out: OO-concepts are not too complex. No shaping is needed in the direction of science. Width is strength. Current textbooks are satisfactory. Differentiation inside the classroom for pupils from various profiles is necessary. There is no need for an artificial intelligence module or for a basic theoretical module. This factor represents a no-nonsense view: it is very well possible to work with what is already there, there are ample opportunities.

Table 4

Descending array of 12 extreme Z-scores and theses for Factor 2, 'The positive-realistic view'

No.	Strongly agreed thesis	Z-score
34	There should be a Informatics module for junior high to prepare students in choosing it as a subject in high school.	2.125
33	Every HAVO/VWO School should offer Informatics as an optional subject.	1.648
13	The website www.informaticavo.nl is indispensable for Informatics teachers in secondary education.	1.472
25	It is a duty for Informatics teachers to teach the subject as appealing to girls as possible.	1.445
36	The job combination of teacher of Informatics – System manager is giving a wrong signal of the subject.	1.292
11	The subject of Informatics has not been developed sufficiently.	1.214
No.	**Strongly disagreed thesis**	**Z-score**
22	If students use a lot of HTML coding in building a website, they fulfil the requirements of the 'programming' component of the exam programme.	−2.025
5	Working-in-a-project is a didactical method and should therefore not be part of the exam programme of Informatics.	−1.950
12	Students of all optional profiles should be offered the same Informatics programme.	−1.271
4	A centralised (written or practical) final exam in Informatics is desirable.	−1.234
24	Teachers, licensed to teach Informatics, should be licensed to teach NLT, too.	−1.155
6	The programme for Informatics is lacking a fundamental theoretical module, containing, for instance, logic and automat theory.	−1.119

Factor 4. The Innovation View

Table 6 contains the twelve items Factor 4 agreed with most (highly positive Z-score) and disagreed with most (highly negative Z-score).

Seven respondents load highly on this factor. Four out of these seven were taking the pre-service teacher training course during the research and two of the respondents were involved in this course as teachers.

This group is the most critical of the current situation. Informatics should be further developed; a theoretical module is missing. A clearer distinction between the HAVO and the VWO level is needed. Written exams are a must. There are doubts with the professional level of the CODI-educated teachers. This group is focused on the contents of Informatics. Taking a more positive interpretation, one could call this group the innovators. A negative designation would be the dissatisfied ones. However, we prefer the first description. Therefore, Factor 4 will be named as the innovation view.

The Dilemma

All in all, no less than four very diverse opinions stand out, shortly described as the negative-critical view, the positive-realistic view, the no-nonsense view, and the innovation view. The consequences of these four views could lead to two extreme positions with

Table 5

Descending array of 12 extreme Z-scores and theses for Factor 3, 'The no-nonsense view'

No.	Strongly agreed thesis	Z-score
33	Every HAVO/VWO School should offer Informatics as an optional subject.	2.052
32	School leaders and school counsellors know too little of the content of the subject of Informatics.	1.952
10	The width of the subject is the power of the subject.	1.498
13	The website www.informaticavo.nl is indispensable for Informatics teachers in secondary education.	1.116
9	The current available methods for Informatics are satisfactory.	1.034
35	There is a need for differentiation inside the classroom for students from the various profiles.	0.935
No.	**Strongly disagreed thesis**	**Z-score**
28	Informatics should profile itself as a science subject.	−2.341
14	The subject of Informatics can be well examined without a written test, namely only with a practical component and a project component.	−1.877
22	If students use a lot of HTML coding in building a website, they fulfil the requirements of the 'programming' component of the exam programme.	−1.551
8	The concepts of object orientation are too complex for high school students.	−1.410
18	A module on Artificial Intelligence should be a component of the compulsory subject matters of Informatics.	−1.368
6	The programme for Informatics is lacking a fundamental theoretical module, containing, for instance, logic and automat theory.	−1.130

Table 6

Descending array of 12 extreme Z-scores and theses for Factor 3, 'The innovation view'

No.	Strongly agreed thesis	Z-score
11	The subject of Informatics has not been developed sufficiently.	2.409
6	The programme for Informatics is lacking a fundamental theoretical module, containing, for instance, logic and automat theory.	2.057
24	Teachers, licensed to teach Informatics, should be licensed to teach NLT, too.	1.822
1	In the exam programme the distinction between the HAVO level and the VWO level is insufficient.	1.196
34	There should be a Informatics module for junior high to prepare students in choosing it as a subject in high school.	1.062
33	Every HAVO/VWO School should offer Informatics as an optional subject.	0.935
No.	**Strongly disagreed thesis**	**Z-score**
22	If students use a lot of HTML coding in building a website, they fulfil the requirements of the 'programming' component of the exam programme.	−2.568
14	The subject of Informatics can be well examined without a written test, namely only with a practical component and a project component.	−1.454
30	The professional knowledge of CODI-educated teachers is sufficient.	−1.387
7	The best choice for information modelling for the HAVO level is ERM.	−1.182
9	The current available methods for Informatics are satisfactory.	−1.173
17	The best choice for information modelling for the VWO level is FCO-IM.	−1.076

regard to Informatics as a school subject: dispense with it or strengthen it. In fact, this actually has happened in current discussions about the future of Informatics education in the Netherlands. The *first position* proposes dispensing with Informatics in secondary education. The main argument here is that the current teachers have too little knowledge of the subject matter in order to be able to teach it adequately, and as a result of which students feel so little stimulated that they do not choose to study Informatics in their further education. This viewpoint is particularly prevalent in the university Informatics departments and it has also been expressed by the chairman of the 'Informaticakamer' of the VSNU (consultative body about Informatics in universities, part of the Association of Universities in the Netherlands) (Groote, 2008). As one might expect, this position has led to a great deal of disquiet amongst current teachers.

The *second position*, which is adopted by the authors of this article, is that Informatics is so important from a social/societal point of view that the subject should certainly not be abolished but, on the contrary, that it should be strengthened from its current position so that it can better fulfil its social function. For us, the decisive underlying principle is that the purpose of Informatics in secondary education is not to prepare someone for studying it in higher education but instead to impart knowledge and skills which are relevant for every educated Dutch citizen, as was stated when Informatics was first introduced as a school subject (Hartsuijker, 1996). However, this position does not preclude, in due course, extra work being carried out in order to prepare students for the study of Informatics in higher education if there are more fully-qualified Informatics teachers who have completed the teacher training course (i.e., the Master of Science in Science Education and Communication) which contains a track for students to become a fully qualified Informatics teacher for secondary education. One could consider the possibility of creating the subject/course 'Informatics B' for secondary education.

Regarding the arguments for the first position, one can indeed observe that the great majority of fully-qualified Informatics teachers have a limited knowledge of the subject matter. The question is to what extent this leads to the small intake of students for the BSc courses. In any case, this question has not been investigated yet.

In the discussion which follows, we substantiate our position in a number of ways. We do this on the basis of the long-term objectives which Informatics has as a school subject or, in our view, ought to have. We also examine what research into Informatics education can teach us. We use ideas from the novice-expert approach, enculturation and situated learning. Our approach is not and cannot be the final answer to the problem of the lack of Informatics background of most of the Dutch Informatics teachers, but we are convinced that it can help.

Of course, another position is also possible, namely, leave everything as it is. To put it briefly, we do not regard this as an option. The subject matter of Informatics is still changing, which will most certainly lead to changes in the curriculum. Furthermore, the pedagogy of Informatics and research into it is only now gathering momentum. The knowledge and experiences generated as a result must find a place in the teaching of Informatics in secondary education.

The Teacher's Perspective: The Long-Term Objectives and the Novice-Expert Approach

The themes mentioned in the paragraph about Informatics education in the Netherlands and the objectives to be derived from it, especially for the long term, give the following picture. Informatics at HAVO/VWO level is a broad subject which can be used in all sorts of situations (themes Informatics in perspective and Contextual usage) and for which a large number of knowledge elements and corresponding skills are necessary (themes Technology and skills and Systems and their structures). However, it seems that no choice has been made between an in-depth approach (a lot from one theme, little from the rest) and an 'in-width' approach (a little from all themes), see also Grgurina and Tolboom (2007). This is in contrast with what happens in many other countries where the emphasis is mainly on a single aspect of the in-depth approach, namely the teaching of programming. Incidentally, Figure A1 in Appendix 2 shows that the in-depth approach is possible, albeit to a limited extent. This non-choice in the curriculum generally means that the teacher him/herself makes the choice between the in-width or in-depth approach, whereby personal preferences, beliefs and educational background naturally play an important role. Since the majority of Dutch teachers have no background in Informatics, one may suppose that when making these decisions, arguments which are derived from the field of Informatics or its importance may unfortunately not be taken into consideration. Therefore, it is all the more necessary to formulate and discuss the long-term objectives.

Whether all the concepts listed under themes Technology and skills and Systems and their structures are necessary (and whether other unnamed concepts are not), is unclear. As in the Dutch curriculum, there is no clear focus on the long-term objectives in the international literature. Therefore, we are forced to a certain extent to take our own beliefs as a starting point. But one thing is clear: in the Netherlands we are dealing with a subject which cannot have the long-term objective of preparing students for further studies in the subject, due to its position as an elective. Therefore, it should be clear what a HAVO or VWO matriculate should retain of Informatics after the completion of their school studies and, in particular, what sort of attitude towards the subject they may adopt. Informatics with its current position should give students a clear insight into the core concepts, how these concepts function and what their possibilities and limitations are, because all HAVO or VWO students will be faced with Informatics in their continuing education, profession or position as a citizen. In addition, secondary education must prepare students by showing something of the 'next world' and the role of Informatics in it and by further exploring a number of concepts which play a role in that world. Therefore, we believe that an important aspect of the long-term objectives for Informatics in secondary education is learning to recognise when, how and why particular elements of Informatics can be used when tackling and solving all sorts of problems. A self-evident component of this approach is that students must tackle and solve some problems with help from Informatics. In other words, the matriculated students must be able to tackle and solve appropriate problems with the aid of Informatics. This involves (see also Zwaneveld, 2005 and Zwaneveld, *et al.*, 2010):

- having insight into the (im-)possibilities of Informatics;
- recognising whether a problem lends itself to a Informatics approach;
- knowing Informatics approaches, such as analysing, using design techniques and applying prototyping;
- having an understanding of and insight into the significance, possibilities and limitations of the Informatics approaches to be applied;
- giving the user a central role in this process, taking the social and ethical aspects into account.

Formulated in this way, it seems that we see Informatics primarily as a science subject. This is by no means the case. Informatics also has aspects of the humanities (e.g., linguistic aspects) and social sciences (e.g., the role of ICT in daily life, in further education and professional life and the rise of Web 2.0). See also Mulder (2002) who argues that Informatics can be seen as a new type of discipline besides the well-known alpha-, beta- and gamma-disciplines.

A possible approach to contribute to the achievement of such a long-term objective is the novice-expert approach; see for example Schoenfeld (1985, 1992) and Glaser (1992). An expert has a great deal of subject-matter knowledge, but is also highly capable of assessing the possibilities and limitations of Informatics him- or herself, when faced with particular problems. The novice is prepared to learn everything, but does not yet know ways of approaching a problem and is still hardly capable of assessing the possibilities and limitations of the discipline. Indeed, that is what he or she still has to learn. At the beginning of an educational track (secondary Informatics education, BSc course in Informatics, MSc course in Informatics, a career as a graduate with a number of years' experience in the application of the knowledge in practice or research) one is a novice and, in the end, an expert. Of course there is no real end: everyone should continually learn in the field of Informatics throughout life. We believe that the Dutch secondary school student, who has reached what is described in the previous paragraph after completion of the Informatics course, can be named an expert at his or her level.

We now come to another aspect of the teacher's role: enculturation.

The Teacher's Perspective Continued: Enculturation

Booth (2001) has observed that, in order to function professionally in the field of Informatics, not only 'hard' knowledge and skills are of importance. On top of that, the type of community of practitioners with the corresponding culture is decisive for the way in which newcomers view, understand or experience central phenomena from the subject area, such as concepts and principles, working methods and situations. (See also Lave and Wenger, 1991.) Of course, in the school environment that community is represented by the teacher. Booth distinguishes three such communities, which she calls 'cultures'. The first she calls the *academic datalogical culture*: people, structures and artefacts around research and development as carried out in higher education and the R&D departments of the computer industry. Besides programming, it consists of mathematical terms, program structures, computer architectures, abstract models of Informatics, and human-machine interaction, whereby the solving of problems and mathematical proofs are the basic principles. In this culture, Informatics students are prepared for higher education. This often induces a culture shock on their part because Informatics turns out or appears to be very different than at school.

The second culture which she names is that of the *professional datalogical culture*: this concerns people who work as ICT professionals in practice, for example university trained engineers. Here the emphasis is more on computers and their structure than on mathematics and logic. She cites Denning (2001, p. 21) who has noted that two types of knowledge are of importance for professionals:

'A person's professional competence is measured mostly by embodied skills demonstrated in action. . . . Professional knowledge is different from the conceptual knowledge we learn in most classrooms. It comes from experience, apprenticeship to more competent professionals, and lots of practice. IT professionals need to understand and appreciate both kinds of knowledge and maintain a balance between the two.'

Finally, she mentions the *informal datalogical culture*: this culture exists outside of higher education and industry, but is just as important in her view. It concerns, for example, hobbyists who create web pages and games, sometimes even making a contribution to the development of Linux, people who use Excel or Access for their business and even people who hack for pleasure or destructive purposes. Here the emphasis is on uses and applications. Relevant in this regard is the fluency gap, the gap between people who have access to computers and who are able to handle them, but have too little background understanding to be able to do so fluently and people who do have that knowledge. Booth cites Resnick (2001, pp. 144–145) in this regard: 'If computers are truly to transform our lives in the future, we must treat computational fluency on a par with reading and writing.'

To some extent some of these three datalogical cultures are comparable with some of the four factors from our research:

Academic datalogical culture ↔ negative-critical view.

Professional datalogical culture ↔ positive-realistic view.

Research by Perrenet and Taconis (2008, 2009) has revealed some interesting findings in relation to these cultural aspects. Their research into the enculturation of BSc students in Mathematics shows that they adjust their generally limited, school-based vision of Mathematics as a closed, 'cast in stone' subject to that of a much more open and creativity-inducing pursuit as a result of their participation in the academic Mathematics culture. The introduction of this culture into school Mathematics could lead to a greater number of students opting for Mathematics. It is certainly worth investigating whether a similar situation exists for Informatics. The first Dutch study by Perrenet (2009) suggests that BSc students in Informatics start with beliefs which they gradually adjust (enculturation), for example with regard to the beliefs that computer scientists spend the majority of their time programming and that it does not matter how a program is constructed provided it functions properly. Assuming that we may apply these findings into teaching and learning of Informatics in secondary education we suggest the combination of the novice-expert approach and enculturation with an appropriated mix of the three mentioned datalogical cultures.

In the next section we substantiate our position in the Dutch Dilemma a bit further by eollaborating the idea of the cultural communities.

The Teacher's Perspective Continued: Situated Learning

The mentioned cultural communities or Communities of Practice (CoPs) or learning networks play an important role in current beliefs about learning. They increasingly form a necessary component of the lifelong learning which of course begins at home and at school (Lave and Wenger, 1991). In order to avoid misunderstanding, we should note that such communities are not just digital CoPs. In addition to the term 'situated learning', whereby Lave and Wenger mean learning in or via such communities, they also use the term 'legitimate peripheral participation' in order to indicate that the participation of a newcomer in such a community is legitimate in the eyes of all the participants present, that it concerns a newcomer who initially operates on the periphery but whose aim it is to become a fully-fledged participant. In this sense the ideas of Lave and Wenger are an expansion of the novice-expert approach and the enculturation approach. All these can be seen as alternatives or at least expansions of the cognitive approach to learning.

Ben-Ari (2004) builds on this and on the work of Hakkarainen *et al.* (2002) who have shown that neither a cognitive nor a social approach alone can lead to expertise. He believes that elements of situated learning are of relevance for Informatics education. It is about an analysis of what actually happens in CoPs of Informatics professionals and, based on that, about a design of learning activities which stimulate students to the relevant tasks, of course within the limitations of the school environment. These are not so much projects as well as activities which are characteristic of a CoP and which are given an integrated place in cursory education. Ekaterini *et al.* (2003) provide some foundation for this in their research into the beliefs of Informatics students in secondary education exposed to a problem-guided environment of learning. Ben-Ari mentions also some unavoidable limitations of his approach. As an example of those limitations of situated learning, he cites the fact that software development for aircraft builders such as Boeing or Airbus cannot take place in an open, digital CoP.

For Informatics education and its teaching methodologies, there is, besides the three cultures of Booth, space for a fourth relevant community, namely the *Informatics education CoP* in which Informatics teachers and Informatics education researchers work and learn together with computer scientists. Lewis and Smith (2005) have noted that if the issue of the content of an Informatics curriculum is left only to the computer scientists, there is a tendency for one of the following three groups to gain the upper hand: the 'segregationists', these are the people who only want the traditional subjects to be offered, the 'integrationists' who, conversely, wish to modernise and the 'synergists' who wish to integrate traditional and new subjects. Doyle and Lister (2007) illustrate this with the debate on the question of whether UNIX should be included in a Bachelor programme.

In addition to the ‘hard’ knowledge derived from the academic or professional datalogical culture, there is a tendency in Informatics education to make also room for the often implicit knowledge of the informal datalogical culture of ‘hobby’ users. The research cited (Booth, 2001; Resnick, 2001; Lave and Wenger, 1991; Hakkarainen *et al.*, 2002; Ben-Ari, 2004; Ekaterini *et al.*, 2003; Lewis and Smith, 2005; Doyle and Lister, 2007) supports the interests behind this approach, but it is not (yet) evidence-based.

Summarising the Perspectives

The notions of the novice-expert approach, enculturation and situated learning as described above, are all based on the long-term objective that students should have a broad idea of the role of Informatics (or ‘what every Dutch citizen should know about Informatics’). So, secondary Informatics education can be positioned as education which, admittedly to a limited degree, contains components which belong to academic and professional datalogical culture, but which is also focused on the use of Informatics in informal datalogical culture. This last culture is that of the novice students – using ICT – when they start with their secondary Informatics course. Part of this culture is also what their Informatics teacher represents. And since that teacher in the Netherlands is nearly always a retrained CODI teacher, he/she generally has a very limited view of what goes on in the academic and professional culture. So, we think that by using an Informatics education CoP with teachers, researchers, computer scientists (and why not also students?), the lack of content knowledge of the teachers can be reduced. In a sense, this community then incorporates the three datalogical cultures mentioned by Booth (2001). Of course, students should be able to tackle and solve certain problems with the aid of Informatics.

An Example

Perhaps the mentioned teacher roles do not make a great difference to the contents of the Informatics curriculum, but they do entail considerable differences in the teaching methodology. After all, education which primarily focuses on individual knowledge elements and corresponding skills will defer from education with the long-term objectives as we have formulated.

Let us take an example: The following anecdote is circulating amongst the Dutch secondary Informatics teachers. A teacher assigns his students to search for a programming course on the Internet, without giving any criteria, for instance with respect to its quality. The teacher thinks that if the students read the course documentation this is in compliance with the programming objectives in the curriculum (Schmidt, 2008, p. 9).

This story can be viewed from various perspectives: from a pedagogic-professional perspective (how does the teacher exercise his/her profession? with a possible answer being: this teacher is taking the easy route) and from an objective-based perspective (which long-term objective is this teacher striving towards?). In order to be able to make a competent analysis from this last perspective, we require more information, but the following reasoning based on a number of suppositions is not unlikely. Suppose that the students have to create an application which tackles a specific problem. That is the short-term objective. Long-term objectives in this regard could be as follows:

- the students must experience how such a process works, so that they become conscious of certain aspects, including recognising whether or not a problem lends itself to a Informatics approach;
- the students should learn which aspects or features of Informatics are relevant in approaching and solving a problem so that they become conscious of the possibilities and limitations of Informatics applications;
- the students should realise the role of the user in using the application so that they can take this into account during the development phase.

Searching for a programming course and going over the course documentation can then make a contribution towards the achievement of these long-term goals. With the supposition that the creation of an application relates to a specific problem, programming or the learning of programming will also be a component of the education. Long-term aspects can also be distinguished in the learning of that programming. For HAVO/VWO students, it should at least be a point of consideration whether or not all students should actually be taught programming. Relevant considerations in this regard include the limited time available and the complexity of the programming, in addition to the question of whether it fits in with the long-term objective concerning the knowledge of Informatics which every Dutch citizen should possess.

Depending on one's perspective, or more precisely, on one's objectives (short-term or long-term) teaching actually can be assessed.

Our Position: A Framework for Improving Informatics as a School Subject

In general, the work of the computer scientist can be characterized by the triplet 'design, develop and implement', whereby all sorts of refinements occur, for example modelling, specifying, programming and testing. Specific IT tools belonging to each of these activities are based on theoretical concepts. Examples: modelling techniques based on specific schematisations, information processing as storage, adaptation, searching, using data bases, algorithms, etc. However, in practice, the expert does not work in this way, or at least not exactly in this way. Thanks to his or her expertise, (s)he is able to take a global overview, zoom into relevant sub-aspects and his or her experience allows him or her to ascertain in which way (s)he can best approach the problems associated with these sub-aspects. The most important reason why education is not able to fully present this expert way of working is that a novice has no experience with the totality of these activities and is therefore unable or barely able to carry out these activities for a problem which is new to him or her. Furthermore, the novice still does not have the capacity to intervene if the process stagnates. Participation in a relevant community can make a meaningful contribution towards supporting the novice in his or her development.

In current Dutch Informatics educational practices, the novice-expert approach is used, while ideas form enculturation or situated learning are hardly present. We think that a design of secondary Informatics education wherein all these ideas have a place will result in a better design: the students become increasingly more competent in tackling and solving Informatics problems, using concepts and tools developed in the field of Informatics. To support this we recommend not only the three mentioned perspectives, but also a more general perspective on how people conduct complex cognitive tasks, introduced by Schoenfeld (2010).

Research into teaching methods in Mathematics has shown that it is not effective, or at least is not sufficient, to tell novices how they should perform by referring to the working methods of experts. See, amongst others, Schoenfeld (1985), who has noted with regard to the solving of mathematical problems by students that Pólya's approach (Pólya, 1945) – containing the steps: understand the problem, draw up a plan, carry it out and check the result – only began to work after his students had already acquired a reasonable degree of experience in solving mathematical problems and therefore were no longer novices. There are enough data in the research literature which confirms this for all sorts of fields or subjects, see for example Graham (1994), and there is no reason to assume that this would be any different for Informatics.

On the basis of his observations regarding how his students approached the solving of mathematical problems, Schoenfeld (1985, 1992) has developed his own framework in which he appears capable of understanding what happens not only in the tackling and solving of mathematical problems, but also generally more in the cognitive complex, result- or objective-orientated tasks such as solving problems, teaching, preparing and carrying out research. In Schoenfeld (2010), he describes his framework as follows: someone enters into a specific context with a specific amount of knowledge (facts, algorithms, skills and heuristics), objectives and orientations (beliefs, opinions, preconceptions, values, preferences). Pieces of information and knowledge are evoked and activated in a particular orientation. Precise aims are stated or adjusted. Decisions are taken both consciously and unconsciously. In known situations, this will generally happen unconsciously and relatively automatically. If the situation is new or relatively so, decisions are taken on the basis of all sorts of considerations. The next step is the implementation. During this implementation, the progress, whether effective or not, is continuously monitored. This is a cyclical process at all sorts of levels. For example, routine actions may have sub-routines with their own objectives. Objectives can be adjusted via decision-making. If the process is interrupted, for example due to it progressing poorly or differently than desired, there again comes a moment at which a decision has to be made. Monitoring and self-regulation as a component of meta-cognition play an important role.

We are convinced that Schoenfeld's framework also applies in the Netherlands to the development of the Informatics novice into an expert, and that teachers and lecturers should be conscious of this. For teachers, this means that they need to investigate with which knowledge (facts, algorithms, skills, heuristics), objectives and orientations (beliefs, opinions, preconceptions, values, preferences) students enter the field of Informatics and that they tailor their teaching to it and reiterate it during the course of the education they provide. A practical consequence of this is that teachers should make greater use of what the students – at their level – already know and that they focus less attention on explaining how – according to the 'laws' of Informatics – the world works. Indeed, they should only do this if the students require it. In this way, the students are given the opportunity to formulate their own objectives and orientations, to ask for and place the necessary information themselves and to take more responsibility for their own learning processes.

A concrete way of effecting this change in the Dutch situation is the development of a retraining course for those trained by CODI. This course would consist of two parts: a pedagogic and a cultural component. The first component should be taught by pedagogues and should be focused on conveying the importance and the application of the pedagogic outlooks, as described above in relation to the novice-expert approach and enculturation. A suitable point of action could be the explanation and tackling of typical student errors, misconceptions and naive conceptions (see, for example, Kolikant, 2008, on the 'correctness of a curriculum' and Perrenet, 2010, on the concept of 'algorithm'). In the second component, academic and industrial computer scientists could talk about their profession and the culture surrounding it. With a greater focus on students, Informatics should be more involved in the linking activities between secondary and higher education which are beginning to take a more defined shape for specific subjects in the form of master classes, keynotes, thesis support etc.

Concluding Remarks about the Dutch Situation

We are well aware of the fact that our position and recommendations are necessary but not sufficient. It helps with respect to the teachers' content knowledge. For the problem caused by the retirement of the teachers in the next ten years (Schmidt, 2008), it is surely not sufficient, because the teacher training institutes do not have yet enough students to combat this deficiency. But we hope that Informatics education, as we propose, will result in a profession which attracts more students.

As previously noted, the curriculum as shown in Fig. A1 of Appendix 2 is divided into a core programme and an advanced component. This core programme offers in particular the opportunity to strengthen the basic component by focusing more on the novice-expert approach, enculturation and situated learning, based on the long-term objective of 'what every Dutch citizen should know about Informatics'. The advanced component can then be more focused on preparing students for the BSc in Informatics. The first requirement needs a thorough reflection on the contents of such a core programme and advanced programme by educationalists from secondary and higher education and from the ICT sector. An adequate training programme must then be developed and implemented on the basis of this updated curriculum. A number of schools should implement the programme in parallel with this. Following a thorough evaluation, this programme can then be introduced as the new curriculum. At the same time as the introduction of this new curriculum, a well-founded decision must be taken regarding a currently controversial issue, namely the national final examination. Our advice would be positive. At first, a central examination would give more direction to contents and form of the subject. Secondly, it would give Informatics a less marginal position in the curriculum compared to other subjects.

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Appendix

1. The Dutch School System

After primary education (age 4 to 12) secondary education is divided in three parts with a common first year:

A VMBO (preparatory vocational secondary education (age 12 tot 16)
B HAVO (senior general secondary education (age 12 to 17)
C VWO (university preparatory education (age 12 to 18).

In the last two years of HAVO and the last three years of VWO students choose one of the four profiles, each with its own disciplines besides Dutch, English and (dedicated) Mathematics: Culture and Society, Economics and Society, Science and Health, Science and Technology. Informatics is an elective in each of the four profiles.

2. The Dutch Secondary Informatics Curriculum

VWO	HAVO
Free scheduling, 90 hours	
Project, 60 hours	Free scheduling, 90 hours
Deeping of subject knowledge, 90 hours Databases, OO-programming	Project, 60 hours

Core program of 200 hours across themes A, B, and D:

- A Informatics in perspective
  - 1 Science and technology
  - 2 Society
  - 3 Study and professional environment
  - 4 Individual
- B Technology and skills
  - 1 Data and information
    - 1.1 Data-processing systems
    - 1.2 Communication
    - 1.3 Data-representation in a computer
  - 2 Hardware
    - 2.1 Working of the computer
    - 2.2 Peripheral equipment
  - 3 Software
    - 3.1 Programs as structured solution
    - 3.2 Application of software
  - 4 Organisation
- C Systems and their structures
  - 1 System theory
  - 2 Computer systems
    - 2.1 Communication and network
    - 2.2 Operation systems
  - 3 Systems in practice
  - 4 Information systems
    - 4.1 Information system development
    - 4.2 Information analysis
    - 4.3 Relational databases
    - 4.4 Database management systems
    - 4.5 Human-machine interaction
    - 4.6 System development project
  - 5 New developments
- D Contextual usage
  - 1 System development and project management
  - 2 Social aspects

VWO	HAVO

Fig. A1. Dutch secondary Informatics set-up (Schmidt, 2008).

N. van Diepen started his professional career as a math teacher in secondary education. In the mid-eighties he became an informatics teacher in the Informatics Department of the University of Twente. He was involved in the start of the pre-service teacher training programme in informatics in The Netherlands. As an educational specialist he became informatics didactics teacher at the Teacher Training Institute ELAN of the University of Twente. His areas of interest are informatics didactics, especially computer programming didactics, in-service teacher training and teacher professionalisation, and the use of ICT in education.

J. Perrenet participated in various mathematics education research projects and was involved in the development and innovation of higher technological education for many years. Nowadays he is associated with the Eindhoven School of Education at the Eindhoven University of Technology (TU/e), for teacher training in science education and communication, for supervising PhD students, and for research into mathematics and informatics education. He is also associated with the mathematics and computer science programmes of the TU/e for developmental advice and participates in the project Academic Competencies and Quality Assurance that measures the academic profile of programmes at the TU/e and at other technical universities.

B. Zwaneveld started his professional career as a math teacher in secondary education. In the mid-eighties he became a course developer in the Informatics Department of the Open University of the Netherlands. After his PhD research about structuring mathematics knowledge he was the chair of the consortium that organised and executed the training of acting teachers to become informatics teachers. Since 2004 he is full professor in professional development of teachers in mathematics and informatics at the Ruud de Moor Centrum of the Open University. His main areas of interests are the didactics of informatics and mathematical modelling.

Kokia informatikos mokymo ateitis Nyderlandų bendrojo lavinimo mokyklose? Nyderlandų dilema

Nico van DIEPEN, Jacob PERRENET, Bert ZWANEVELD

Nyderlandų bendrojo lavinimo mokyklos mokymo programoje kompiuterinis raštingumas įtrauktas kaip privalomas dalykas ir jo mokoma žemesnėse klasėse, informatiką galima rinktis tik kaip fakultatyvinį kursą aukštesnėse klasėse. Šiame straipsnyje aptariama informatikos mokymo Nyderlandų bendrojo lavinimo mokyklose ateitis. Panaudoję Q metodiką (skirtą analizuoti ir interpretuoti subjektyvių klausimų, tokių kaip asmeniniai požiūriai, nuomonės, ir pan. atsakymų rezultatus) straipsnio autoriai aptaria keturis informatikos mokymo metodus (tarpinius požiūrius): neigiamas-kritiškas, teigiamas-realistiškas, tiesmukiškas ir novatoriškas. Autoriai aptaria įvairius argumentus, ar skatinti informatikos mokymą kaip privalomąjį mokyklinį dalyką, ar ne. Straipsnyje taip pat nagrinėjamos informatikos mokytojų perspektyvos.