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Evaluating the New Secondary Informatics Curriculum in The Netherlands
The Teachers' Perspective

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Abstract. Since the introduction of Informatics as an elective course in secondary education in the Netherlands in 1998, the implemented curriculum is being regularly monitored. The results of the large 2013 secondary Informatics teachers survey contributed to the revision of the Informatics curriculum. This revised curriculum came into effect in 2019. In line with regular curriculum monitoring practices, the Netherlands Institute for Curriculum Development is polling the secondary Informatics teachers to understand their views and opinions on the intended curriculum and to learn about their implemented curriculum The results indicate that the majority of the respondents find the new Informatics curriculum better than the old one and that it offers a solid foundation for their teaching practice. A minority either misses some content in the curriculum or considers it overloaded with content, and some find it not to be up to date. Furthermore, the results of this survey are compared to the results of the 2013 survey to assess to what extent the new Informatics curriculum meets the teachers' needs and recommendations better.

Keywords: Informatics curriculum · Computing curriculum · Secondary education

1 The Position of Informatics in The Netherlands

In the Netherlands, the Informatics course in secondary education was introduced in 1998, during a reform of the upper secondary education. Informatics is positioned as an elective subject taught in the 10th and 11th grade of senior secondary education (in Dutch: HAVO) and grades 10 though 12 of pre-university education (in Dutch: VWO). Upper secondary education in HAVO and VWO in the Netherlands is split up in four so called profiles. Each profile serves a specific target group of the student population. These target groups are stratified based on the students' interests and the demands of their expected further education. The two humanities profiles are called Culture & Society (C&S), and Economy & Society (E&S). The two science profiles are Nature and Health (N&H), and Nature and technology (N&T). The elective subject of Informatics is to be offered in all of these four profiles. The schools, however, are not required to offer Informatics. This

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implicates that the curriculum has to be appealing for all of the upper secondary school students. That is why twelve elective themes were added to the curriculum, broadly varying from ‘Social and individual impact of informatics’ (humanities oriented) to ‘Computer architecture’ (technology oriented).

Contrary to most of the other subjects, Informatics is assessed through a school exam only and not through a national exam at the end of secondary education. When it was initially introduced in 1998, the curriculum—i.e., the learning standards—consisted of 53 learning goals specified in great detail. In 2007, the curriculum was streamlined resulting in a list of 18 briefly outlined learning goals [6]. In 2013, the government commissioned an inquiry resulting in a report by the Netherlands Institute for Curriculum Development (in Dutch: Stichting Leerplanontwikkeling, SLO) to explore the teachers' ideas about the necessity to change the Informatics curriculum and their views on a possible introduction of a national examination for Informatics. Similarly to the inquiries in other countries [2, 8] this opportunity was seized to chart the characteristics of the Informatics teacher population regarding their demographics, educational background and teaching experience as well [10]. Within weeks of the publication of this report in 2014, the government appointed a committee to revise the Informatics curriculum. The gist of that Dutch report and the events leading to this new informatics curriculum are described in detail in [5] The curriculum revision process finished in 2016 and resulted in a new Informatics curriculum which met a number of set requirements, including not favoring any specific pedagogic approach and being able to count on the wide support of the teacher community. This curriculum contains 18 learning objectives. Six of them are compulsory themes forming the core curriculum: (A) Skills, (B) Foundations, (C) Information, (D) Programming, (E) Architecture, and (F) Interaction. Another twelve themes are elective: (G) Algorithms, computability and logic, (H) Databases, (I) Cognitive computing, (J) Programming paradigms, (K) Computer architecture, (L) Networks, (M) Physical computing, (N) Security, (O) Usability, (P) User Experience, (Q) Social and individual impact of informatics, and (R) Computational Science. In addition to learning about the core curriculum, the HAVO students are required to learn two elective themes and the VWO students four elective themes as well. The curriculum came into effect in 2019 [1]. By that time, the textbook publishers produced teaching materials for the core curriculum, while the teaching materials for elective themes were produced by teacher teams under guidance by SLO [5]. (In the rest of this paper, we refer to these teaching materials as SLO teaching materials.) Several parties provided professional development courses for teachers, primarily focusing on the newly introduced topics.

In 2022, the first cohort of the students attending pre-university education and a second cohort of those attending senior secondary education have finished the Informatics course based on this new curriculum. In line with the Dutch curriculum monitoring policy, this signals the moment for SLO to start to check how the intended curriculum, containing the description of learning goals and underlying rationale, works in classroom practice. The examination of other aspects of the implemented and the attained curriculum—such as looking at the actual process of teaching and learning, and at learning experiences and learning outcomes of the learners—are mostly beyond the scope of the regular monitoring process by SLO.

As our work summarized in [5] describes the intended curriculum, this paper focuses on the evaluation of the implemented curriculum [11] as it is perceived and interpreted by the teachers. Furthermore, it reports on the status of the subject in schools and the context of Informatics in a broad sense.

The research questions we strive to answer are:

1. What are the experiences of Dutch informatics teachers with the new informatics curriculum?
2. To what extent are Dutch informatics teachers satisfied with the new informatics curriculum?

2 Background and Method of the Evaluation

This study takes the Dutch informatics curriculum as described in [6] as a point of departure and reports on the next step taken in 2022–2023 in The Netherlands with respect to a systematic way of evaluating the curriculum.

In this chapter, we describe this step and the method used, and we first look back at the history of Dutch secondary informatics education so far. In its current form, as stated above, the curriculum stems from 1998 [6]. Apart from a technical curriculum alteration in 2007, it was not before 2013 that policymakers acknowledged the pressing need for reform the Informatics curriculum. By then, the Royal Netherlands Academy of Arts and Sciences (Dutch: KNAW) published a report Digital literacy in secondary education [7]. This report, among other issues, asked for a reform of the Dutch informatics curriculum and states, "At general secondary (HAVO) and pre-university (VWO) levels, the subjects Information science and Informatics have a marginal status. Their quality is insufficient and their content is outdated. Urgent action is needed." (p10). It goes on to recommend to, "Completely overhaul the optional subject Informatics in the upper years of general secondary education (HAVO) and pre-university education (VWO). By a flexible and modular design, the subject should remain up to date and appeal to students regardless of their focus area." (p11).

The Dutch Ministry of Education, Culture and Science requested SLO to investigate whether these recommendations were supported by the population of Dutch informatics teachers. In the resulting report [10], the results of a literature review, teacher interviews, a survey and expert consultations are described. The survey was completed by almost 60% of the teacher population. This survey conducted in 2013 served as the initial reference for the survey conducted in 2022. Its purpose was to examine whether the recommendations put forward by the teachers, which had also been confirmed through literature reviews and interviews with both teachers and subject matter experts, were effectively implemented in the curriculum introduced in 2019 and fulfilled their expectations.

SLO, the Netherlands Institute for Curriculum Development, has extensive experience in setting up and conducting research regarding the evaluation of the implemented curriculum, mainly carried out by its department of Advice and Research. In fact, SLO did so following every single curriculum reform that has been developed in the Netherlands for the last decades. These reforms were usually initiated by urgent need in some discipline, and there was never a systematic redesign of the secondary curriculum in full width, but only for one subject at a time, or sometimes a few of subjects simultaneously.

This led to a tailor-made evaluation practice, and this way, longitudinally monitoring has been impossible. In our view, this practice is not optimal, and therefore, by re-using the format of our 2013 Informatics curriculum evaluation, we hope to contribute to a more systematic and consistent way of curriculum evaluation. There are cautious movements in The Netherlands that the whole system of curriculum development will be set up in a more structured way, concerning all subjects, repeatedly over a constant period of time. This way, a more comparable way of evaluation will be facilitated. The fact that in this paper we report about data that have been collected with an instrument that has been used before may hopefully be seen as a first step. In 2019, Falkner and colleagues reported on an evaluation instrument called MEasuring TeacheR Enacted Computing Curriculum (METRECC) [4]. The goal of this instrument is to survey teachers in K-12 schools about their implementation of informatics curriculum to understand pedagogy, practice, resources and experiences in classrooms around the world. The reason we did not use METRECC was that we chose to be consistent with our 2013 measurement, when METRECC did not exist. Nevertheless, given the impact of METRECC internationally, for the next step in monitoring the implemented informatica curriculum, we will try to merge METRECC's merits with our existing evaluation method. This means trying to find the delicate balance between consistency, validity and international consensus.

3 Informatics in Dutch Schools

In this chapter, we first present the current situation of the secondary school subject Informatics in the Netherlands. With this situation as a perspective, we present the results of our survey. We remark that not all the respondents answered all the questions, and conversely, some questions allowed for multiple responses. Therefore, the numbers of answers do not always correspond to the number of the respondents.

3.1 Schools and Students

The data provided by the Dutch government institution charged with the education implementation (in Dutch: Dienst uitvoering onderwijs, DUO) reveal that during the academic year 2021–2022, some 45% of both HAVO and VWO schools offered informatics with about 10% of the total HAVO student population and almost 13% of the total VWO student population choosing it [3]. According to the respondents to our survey, almost a quarter of the students are girls.

3.2 Teachers

A total of 57 informatics teachers filled in the survey, 12 of them identifying as female. Regarding their education to obtain informatics teacher qualification, 32 indicate having a university level teacher qualification, 7 followed CODI[1], course [6], and 24 mention

[1] In 1998, with the introduction of informatics, a consortium was set up among 12 universities and universities of applied science (in Dutch: Consortium Omscholing Docenten Informatica, CODI.) The aim was to collectively train teachers who would be responsible for implementing the informatics course in schools. During the period from 1998 to 2005, this consortium served as the exclusive pathway for individuals seeking qualification as informatics teachers.

something else, for example: still being a student, having teacher qualification for math or physics, or no teacher qualification at all. 22 of these teachers have been teaching Informatics for at least six years. Thirty of the teachers are the sole informatics teacher in their schools.

3.3 Implemented Curriculum

In this section, we report on teachers' views about the new informatics curriculum and the teaching practices they report.

Almost all the teachers are familiar with the new curriculum. Their opinions about it are shown in Table 1.

Table 1. Opinion on 2019 informatics curriculum.

What is your opinion in the 2019 informatics curriculum?	agree	somewhat agree	somewhat disagree	disagree	no opinion
It is better than the old curriculum	28	10	0	2	17
The learning goals are current and up-to-date	24	28	4	1	0
I miss topics	11	14	17	9	4
There are too many topics	16	8	18	13	2
This curriculum offers sufficient guidance for good educational practice	29	15	8	3	2

Regarding programming, 35 teachers find that it gets enough attention in the new curriculum. 37 teachers are satisfied with the topics, skills and themes contained in the new curriculum, and finally, 37 teachers are satisfied with the distribution of topics, skills and themes across the core program and the elective themes. In the comments, several teachers say they miss data science in this curriculum. Furthermore, they mention that there are too many topics, that the curriculum is too abstract and that they miss learning goals related to practical skills. Several teachers raise the question of the purpose of this Informatics subjects, and one of them says, "I would like to draw more attention to the objective of the subject and to a broader social definition of the subject (instead of the scientific definition as a starting point)."

All but three teachers feel somewhat or sufficiently equipped and supported (through available materials, refresher courses, teacher networks, etc.) to be able to shape their teaching practice properly with the new curriculum. Some are reluctant to teach particular elective themes because they lack sufficient expertise. Many are not satisfied with the availability and quality of teaching materials and resort to writing their own. In many cases, teachers use the available teaching materials to familiarize themselves with particular elective themes.

We asked a number of specific questions regarding the elective themes: Do you feel competent enough to teach elective themes? To how many HAVO students do you teach the elective theme? To how many VWO students do you teach the elective theme? What assessment form do you use for elective themes? The teachers' answers are in Table 2. The full names of the elective themes are listed in the introduction chapter.

Table 2. Teaching practice.

		Algorithms	Databases	Cognitive comp	Prog. Paradigms	Comp. Arch	Networks	Physical comp	Security	Usability	User experience	Impact	Comp. Science
Competent	Yes	30	49	20	31	34	25	35	32	37	34	33	31
	Somewhat	23	5	19	18	15	23	20	22	17	19	18	15
	No	4	3	18	8	8	9	2	3	3	4	6	10
HAVO	All	11	38	8	10	20	19	26	29	21	28	23	9
	Some	13	10	14	17	12	15	16	10	14	17	9	14
	None	32	8	31	27	23	22	14	17	18	12	24	32
VWO	All	27	43	17	26	24	32	34	34	25	28	24	26
	Some	11	10	13	13	16	15	14	12	15	15	10	10
	None	17	2	25	17	15	9	8	10	15	13	20	21
Assessment	Written exam	22	33	12	17	24	24	12	27	11	11	8	14
	Practical assignment	23	44	24	36	21	34	48	28	38	43	28	28
	Other	2	4	1	3	1	4	1	1	4	2	2	3
	I do not teach this	19	2	26	17	20	10	7	11	12	11	24	20

Regarding other forms of assessment, the teachers mention a *master's project*—a large (individual) practical assignment, a presentation, and a portfolio containing reports, reflection, and logbooks. When choosing the elective themes to teach, in four cases the students make a decision, in 41 cases the teacher decides, and in 12 cases the choice is made together. Individual choice for students is possible in 26 cases, while in 31 cases the choice is made for the whole class. Regarding the teaching materials for elective themes, for the HAVO the use of the textbooks is reported 29 times, 14 teachers use their own teaching materials and 4 use something else. In VWO, textbooks use is reported 65 times, teacher's own materials 41 times and something else 9 times. Table 3 indicates, per elective theme, whether the teachers teach it, and if so, whether they use the SLO teaching materials, a commercially available textbook, or some other form of teaching materials.

Table 3. Use of teaching materials.

		Algorithms	Databases	Cognitive comp	Prog. Paradigms	Comp. Arch	Networks	Physical comp	Security	Usability	User experience	Impact	Comp. Science
Teaching materials	SLO	11	16	5	9	5	12	15	12	16	18	11	15
	Textbook	18	28	16	17	21	24	14	17	17	14	16	11
	Other	25	37	17	23	19	29	31	24	21	26	21	16
	I do not teach this	17	2	26	17	17	9	9	12	12	12	21	23

The new curriculum was developed with equity in mind and intended to be equally attractive and relevant for all students: girls and boys, students in humanities profiles as well as those in science profiles. Regarding the attractiveness of Informatics curriculum for girls, about 10% of the respondents find it not attractive. The reasons for this lay in the technical and theoretical nature of the curriculum. On the other hand, the majority of teachers, those who do not find it unattractive for girls, point out that a teacher has ample room for differentiation in their lessons and that girls tend to perform better on complex projects which require planning and taking responsibility.

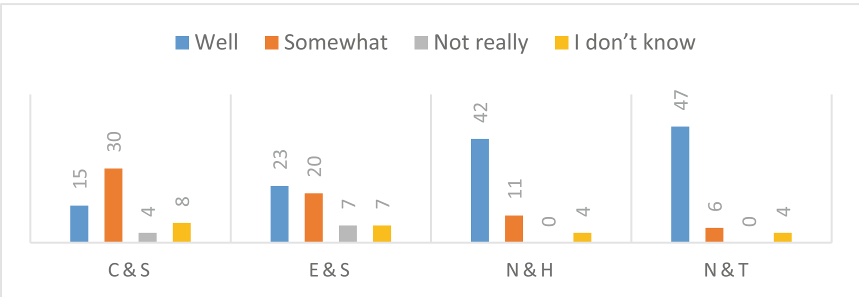

Fig. 1. Suitability of curriculum for various profiles (Culture & Society, Economy & Society, Nature & Health, Nature & Technology).

We enquired to what extent do the teachers think the elective themes do justice to the profiles. The responses are shown in Fig. 1. Some teachers comment that they miss the creative aspects of informatics such as making a website or using a 3d printer, in particular for the Culture and Society profile. Others point out that projects related to, for example, game development give students the opportunity to, "mix the coding, modelling, art, and creativity" and thus cater to the needs of students following various profiles. It is pointed out, however, that out of the twelve elective themes, eight are concerned with technical topics and only four with the societal. Some teachers regret that they have no time to offer sufficient customization for students from all profiles. Finally, some teachers find that the curriculum does not prepare the students in the humanities profiles for their subsequent studies which require ICT skills.

With this informatics curriculum, it is possible to combine the (elective) theme in teaching practice. We asked the teachers what combinations they considered promising. The results are shown in Table 4. The row labeled total shows how many times a particular (elective) theme was mentioned. Other rows show the frequencies of particular pairings. Since some teachers mentioned combinations of three or more (elective) themes as well, some themes are counted several times when in combination with others.

Table 4. Combining (elective) themes.

	Skills	Foundations	Information	Programming	Architecture	Interaction	Algorithms	Databases	Cognitive comp	Prog. Paradigms	Comp. Architecture	Networks	Physical computing	Security	Usability	User experience	Impact	Comp. Science
Total	0	28	21	44	12	20	23	17	4	16	12	14	18	11	27	29	13	7
Skills		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Foundations			6	13	0	0	8	1	0	3	2	0	4	1	0	0	2	1
Information				8	2	1	1	9	0	1	0	0	0	0	1	0	2	1
Program					0	0	14	6	2	10	0	0	3	1	1	1	2	3
Architecture						3	0	1	0	0	2	4	1	3	0	0	0	0
Interaction							1	0	0	0	0	0	0	1	11	11	3	0
Algorithms								1	2	3	0	0	1	1	0	0	0	1
Databases									1	1	0	1	0	1	0	0	1	0
Cognitive c										1	0	0	0	0	0	0	1	0
Prog. Par											1	0	2	0	0	1	0	3
Comp. Arch												7	5	0	0	0	0	0
Networks													3	3	0	0	0	0
Phys. Comp														0	1	1	1	0
Security															0	1	2	0
Usability																20	0	2
User ex																	3	1
Impact																		0

One teacher remarked that many combinations are possible but not necessarily desirable. Another one saw no necessity to combine (elective) themes.

Finally, we enquired about the desire to introduce a national exam—a persisting and recurring issue that has been resurfacing periodically since the introduction of Informatics in 1998. Sixteen of our respondents would welcome a national exam for the core curriculum, three for elective themes, and 41 do not want it at all. In their comments, the proponents mostly argue that a national exam would help to take informatics as a school subject more seriously by the relevant stakeholders. Furthermore, a national exam would serve as a quality control instrument—thus, serving the same purpose it has for all the school subject which do have a national exam. The opponents mention that a written exam is contrary to the nature of informatics where student mostly do practical work. They expect that teachers would start *teaching to the test*—a practice widely observed in subjects with national exam. Most of all, they point out that without a national exam, there is a lot of freedom to choose what to teach and how to do it (often in the form of large group projects) which provides ample room for differentiation and to cater to students' needs. Finally, the opponents address the issue of teacher quality and their scarcity, expressing concern that a significant number of teachers might stop teaching informatics. Consequently, schools would cease to offer the subject, potentially leading to a negative impact on the national level.

4 Discussion and Conclusion

This paper explores the situation of the secondary school subject Informatics in the Netherlands, and in particular the implementation of the new Informatics curriculum from the Informatics teachers' point of view.

4.1 Schools and Students

We see that there is a decline in the number of schools offering Informatics, while the total student numbers seem to stabilize. Furthermore, there is an increasing number of schools employing more than one Informatics teacher (c.f. [5, 6]). A number of schools recognize the importance of Informatics education, offer programming classes in lower secondary grades and actively promote Informatics in the upper secondary grades. Consequently, such schools employ more than one Informatics teacher. Some other schools, with small numbers of students choosing Informatics, chose to discontinue the Informatics course for financial reasons. Finally, the general teacher shortage in the Netherlands, and in particular shortage of (qualified) Informatics teachers, regularly compels schools to either employ an underqualified Informatics teacher, or to discontinue offering Informatics altogether.

4.2 Teachers

A significant proportion of our respondents—those with no Informatics teacher qualification and those with CODI qualification—have a field of initial study other than computing. Similar results are reported about Informatics teachers in French-speaking Switzerland [8] signifying that the Netherlands is not unique in this aspect.

We asked the teachers their opinion about the new 2019 Informatics curriculum. Seventeen out of 57 teachers have no opinion on whether it is better that the old one. None of these teachers have been teaching for longer than six years and it is plausible that they never taught Informatics according to the 2007 curriculum. The majority of the teachers find that the curriculum is modern and up to date, which was stated as one of the goals when it was being revised. However, the topic of data science is absent while it could be argued that it is becoming an essential part of any modern Informatics curriculum. A number of teachers mention the curriculum is too broad, too abstract, or lacking learning goals related practical skills. Yet, the majority of teachers state that it offers sufficient guidance for good educational practice. When interpreting these results, we realize that some teachers see the Informatics curriculum as intended curriculum [11] (formal curriculum, i.e., learning standards prescribed by law), while others equate the curriculum to its interpretation in textbooks. The entire curriculum contains 18 themes, and the first one, Skills, is intended to be taught only integrated with others. Consequently, a HAVO student would need to learn about eight (elective) themes (six in core curriculum plus two electives) and a VWO student about ten (elective) themes. Furthermore, all but one teacher see chances to combine teaching of (elective) themes.

It is therefore somewhat surprising to realize that some teachers perceive the curriculum as overloaded, despite its original intention of addressing overload through elective themes. A further remark concerns the abstract nature of the curriculum. It was the intention of this curriculum to offer the essence of computing as scientific discipline and express the learning goals on a rather abstract level, at the same time trying to be *future proof* (as much as possible in a discipline characterized by rapid developments) [1, 10]. In line with the Dutch tradition, it is up to teachers—and in practice, often up to textbook writers—to interpret the curriculum. The remark about missing practical skills can be seen in the same light.

The teachers reported on how well they felt equipped and supported to shape their teaching practice. The issues they mention are present since the introduction of Informatics in 1998: those not fully qualified might not possess the necessary expertise, and the teaching materials vary greatly in quality or are even non-existent for certain elective themes [5, 6, 9]. Fortunately, the development of SLO teaching materials for elective themes was in almost all the cases accompanied by free courses on corresponding topics which provided the opportunity for teachers to familiarize themselves with, for example, Physical Computing, or agent-based modeling for the elective theme Computing Science.

Regarding the elective themes taught, we see that Databases score the highest. This finding confirms that the decision to include this topic into the new Informatics curriculum was right, and prompts for the discussion to include it into the core curriculum, should the Informatics curriculum be revised in the future. Physical Computing scores high as well, and we assume that this fact is due the high availability of Arduino, micro-bit and similar platforms, and extensive availability of teaching materials and online courses. Some elective themes are not taught often. Algorithms, computability and logic; and Computer architecture might be perceived as technical and abstract. The same holds possibly for Cognitive computing, which is about artificial intelligence and machine learning. What these three elective themes have in common is that there are scarce teaching materials and that SLO materials have just recently became available. Social and individual impact of informatics scores low as well. This theme is not technical at all and may therefore feel unfamiliar to a computer scientist or Informatics teacher. Furthermore, it reflects Dutch societal norms and values and therefore—contrary to many technical themes—depends on Dutch teaching materials. Finally, Computational Science is about modeling and simulation. Again, a computer scientist or Informatics teacher is not necessarily familiar with this topic. The SLO teaching materials implement modeling and simulation through the use of NetLogo software and agent-based modeling paradigm, which is possibly new to many Informatics teachers.

All teachers but one see opportunities to combine (elective) themes, which is in line with the intentions of the new curriculum. Many (elective) themes share certain aspects: for example, developing an agent-based model in NetLogo for the elective theme Computational Science means using a programming paradigm other than imperative (mentioned in theme Programming in core curriculum), and thus implies elective theme Programming Paradigms. Programming (in the core curriculum) is most frequently mentioned theme suitable to combine with other themes, and that is not surprising, considering that programming plays a role in the production of just about every digital artifact. Usability and User experience are next, and the combination of these two is the most frequently mentioned combination. The themes taught less frequently are also less frequently mentioned as candidates for combined teaching. Extensive analysis of this aspect goes beyond the scope of this paper, but it would be interesting to further explore teachers' views on this: for example, how come no one mentions the combination of Programming and Physical Computing?

Regarding the introduction of a national exam, 72% of our respondents are against it. We obtained similar results in our 2013 survey, and even in a survey preformed in 2007, about 55% of the respondents were against a national exam, and some 28% were in favor [9]. Throughout all these years, proponents and opponents keep mentioning similar reasons in favor or against a national exam.

4.3 Answers to the Research Questions

With the analysis of the data above, we are now able to answer our research questions.

1. What are the experiences of Dutch informatics teachers with the new informatics curriculum? In general, the teachers share positive experiences. As we saw in 2013, teachers do not consider themselves to be completely competent for teaching the curriculum. For instance, regarding the elective themes, there is quite some variation. Regarding the theme Cognitive computing, 34% of the teachers feel they lack competence, while this is the case for just 5% when it comes to the theme Databases. We see that the teachers obviously feel more competent regarding the traditional themes than with respect to the new ones. Approximately 75% of the assessments are in the form of a practical assignment, and 25% in the form of a written exam, which in our view is justified by the dominantly practical character of the subject.
2. To what extent are Dutch informatics teachers satisfied with the new informatics curriculum? The vast majority (about 88%) of the teachers is positive about the new curriculum. Nevertheless, they consider this curriculum clearly to be more suitable for students in the nature profiles than for those in the society profiles. Approximately the same proportions of the teacher population consider the range of elective themes to be either too narrow or too broad.

On the most global level, we conclude that the new informatics curriculum is a substantial step in the good direction, but that we need to work on fixing the bias towards the suitability for the nature profiles in order to really make Informatics 'an all-around subject". Furthermore, the professional development of teachers, as was pointed out in 2013, is still a huge issue.

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