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## Education

# Where have all the students gone?

**Foreign colleagues are usually flabbergasted when they hear that the number of mathematics students in the Netherlands has declined by about 70% between 1975 and 2005, in a world where the paramount importance of mathematics has become increasingly evident. Indeed, currently Holland as a whole sports about as many mathematics students as a single typical large university in a neighbouring country. How can this be? What is being done to turn the tide? The author, Klaas Landsman, is professor of Mathematical Physics at the Radboud University Nijmegen. He was the principal applicant of the** GQT**-cluster and was a member of the** Mathematics Soundboard **of the ministry of Education, Culture and Science. He is currently one of the authors of the** Masterplan Toekomst Wiskunde**, in which the long-term future of Dutch mathematics is being laid out.**

Holland is one of the wealthiest countries in the world. Its technological infrastructure is impressive and Dutch civil engineers enjoy a worldwide reputation. At the beginning of the 20th century, Dutch physicists won one Nobel Prize after another. Multinationals like Philips, Shell and AKZO-Nobel rely heavily on research and development. Hence one would expect to find an exemplary educational system, culminating in science students formidable in both quantity and quality.

### Diagnosis

Whoops! In actual fact, at the time of writing an official 'parliamentary enquiry' has just come to an end. Its goal was to find out how standards of learning could possibly have deteriorated so much over the past 30 years that 40% of our first-year *university* students are now unable to spell even elementary verbs correctly and more than half of the science and economics students fail elementary algebra tests. The situation at teacher training colleges is equally desperate. Serious Dutch newspapers cover this theme on a daily basis, sometimes even featuring some new negative educational statistics of the above kind as breaking news on their front page. Our population is getting increasingly nervous, politicians following in the wake — at last!

For us, as mathematicians, the main effect of this general demise of learning has been a dramatic decrease in the number of mathematics students: in 1975 about 700 students — already a less than impressive number — entered an undergraduate mathematics degree program at some general or technical university but in 2005 the number had dropped below 200. In addition, even though topics like differentiation and integration of functions of a single real variable have remained part of the mathematics curriculum at school, genuine insight into these and other mathematical operations among schoolchildren is rare. At school, most computations are nowadays performed on an electronic pocket calculator and algebraic formulae are simply copied from a 'formula card' without any understanding of their derivation. Only a few prodigies are able to produce a correct deductive argument, let alone a proof of a theorem.

### Anamnesis

Part of the decline in mathematics students may be accounted for by the rise of computer science since 1975, which has certainly attracted students who otherwise would have chosen mathematics. Also, the idea that the biosciences have replaced the hard sciences at the frontier of human knowledge has undoubtedly played a role. But these arguments are not peculiar to the Netherlands, whereas the situation sketched above surely is. Thus we have to look for reasons unique to Holland, if only to find out how to reverse the downward trend.

Two major factors appear to have played a role. First, over the past thirty years the teaching profession as a whole has been systematically undermined by a combination of policies. These include:

- Salary cuts;
- Loss of power and influence to school managers;
- Educational reforms.

The salary cuts for teachers, which went beyond those for civil servants, were among the financial measures taken by Prime Minister Lubbers and his various governments from 1982 onwards in response to gross overspending by his predecessors Den Uyl (1973–1977) and Van Agt (1977–1982). The trade unions had their way as well, in that starters had to carry the main burden. The management layer at schools used to consist of the teachers themselves but began to form a separate caste in the wake of government-demanded mergers, which led to schools with thousands of pupils. The reforms — going under the name of 'new learning' — aimed at replacing teachers with 'coaches' who no longer teach but admire their pupils whilst

they find out the truth — necessarily subjective — themselves by, for example, surfing the Internet.

Consequently, starting a career in teaching became an unattractive option in many ways. Since especially those with a university degree had other opportunities, the proportion of university-educated teachers has dropped substantially compared with teachers who obtained their qualification from a teacher-training college, or, indeed, have no teaching qualification at all. The latter phenomenon is especially common in mathematics, in which there is such a shortage of qualified teachers that schools are desperately trying to fill their vacancies with whoever is simply willing to teach mathematics, be it an economics teacher or a former driving instructor.

The second factor is slightly controversial, although academic mathematicians appear to be united in bringing it up even as the main culprit. In the mid-80s, the Dutch mathematics curriculum in secondary education was drastically reformed in order to make mathematics 'realistic'. In fact, what this has come to mean in the Netherlands is that children learn a bag of tricks, which they are supposed to apply to problems typically posed to them in the form of stories. Since genuine applications of mathematics to science or society would require some previous stage of abstraction, these stories are actually rarely realistic at all, typically involving completely artificial if not infantile settings. What little theory and abstraction has remained in textbooks is frequently remote from serious mathematics and is sometimes even plainly erroneous.

The introduction of 'realistic' mathematics was partly a response to the 'New Math' ideology of the 60s, which in its extreme implementations based highschool mathematics on set theory and even in softer versions made the subject far too abstract and inaccessible for the average adolescent. However, it seems equally wrong to remove practically all abstraction, as in the 'realistic' ideology: with the loss of the very essence and power of mathematics, namely the *interaction* between abstraction and application, the baby has been thrown out with the bath water.

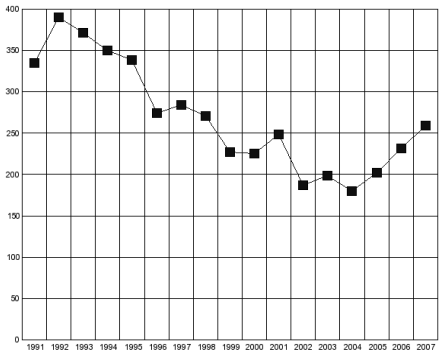
Those responsible for the 'realistic' mathematics program would typically say that mathematics has become more palpable this way, so that — as allegedly shown by PISA (Programme for International Student Assessment) tests — the average level of mathematical understanding among the Dutch school population has risen since it was introduced. The interested reader is referred to the critical literature on PISA for a rebuttal of such claims [1]. For me, it suffices that the numerous schoolchildren I have been in close contact with over the past few years during promotional activities of the kind described below *themselves* complain that they understand neither what mathematics is nor why it is important to science or society. Similarly, in an unprecedented petition called *Lieve Maria* (*Dear Mary*), offered to our previous Minister of Education, Culture and Science Mrs Maria van der Hoeven in January 2006, the 10,000 signatories *themselves* complained that their mathematical training at secondary school had been insufficient.

**Treatment**

Initially, with a few exceptions, the response from the academic community to the steady drop in enthusiasm for mathematics among teenagers and the concordant decline in students was lukewarm, not to say indifferent. One professor is even on record as saying that he welcomed this decline, as it gave him fewer exams to mark. Fortunately, this introvert attitude — which reminds one of the avoidable assassination of Archimedes — has decisively changed over the last five years. Indeed, academic mathematicians began to feel the impact of low student numbers through dras-

Photographer: Dick van Aalst

From left ro right: Mirte Dekkers, Dieuwertje Ewalts, two high school students, Ruben van den Brink, Klaas Landsman, Jozef Steenbrink




Number of first-year mathematics students in the Netherlands (1991–2007)

tic cuts in their own numbers. At Nijmegen these went so far that the Dean of the Faculty of Science even decided to close down the entire mathematics department. This decision was revoked after nationwide and international protests but the community had been warned and began to take action at last!

In view of such immediate threats, one of the earliest initiatives was not directed at schoolchildren but rather at the universities themselves. Prompted by mathematicians Marinus Kaashoek and Henk van der Vorst in 2002, the Netherlands Organization for Scientific Research (NWO), in conjunction with both the Ministry of Education, Culture and Science and the Ministry of Economic Affairs, made millions of euros available for mathematics research from 2005 onwards, provided this research was to be carried out collaboratively in so-called *clusters*. At the moment, three such clusters are active:

- DIAMANT, standing for *Discrete, Interactive & Algorithmic Mathematics, Algebra & Number Theory*, a collaboration between Eindhoven Technical University, Leiden University, Radboud University Nijmegen and the National Research Center for Mathematics and Computer Science in Amsterdam;
- GQT, i.e. the *Fellowship of Geometry and Quantum Theory* in which the University of Amsterdam, the Radboud University Nijmegen and Utrecht University take part;
- NDNS+, for *Nonlinear Dynamics of Natural Systems*, involving the University of Groningen, Leiden University, the Vrije Universiteit Amsterdam and the Center for Mathematics and Computer Science.

Apart from a renewed élan of Dutch mathematical research as a whole, the main effect of these clusters so far has been that further budget cuts appear to have been avoided, at least in the areas involved (typically, faculty positions gained by the clusters were lost elsewhere in a given mathematics department). On the other hand, areas like stochastics and logic, which have not been organized into a cluster, remain fragmented with huge imbalances between universities.

An enterprise that *will* directly affect secondary school mathematics is the preparation of a wholesale reform of the curriculum due in 2012 (this is being done for all the sciences). In 2004, the Ministry of Education, Culture and Science charged a *Committee for the Future of Mathematics Teaching* chaired by Dirk Siersma with the difficult task of overcoming the ideological conflict between the academic community and the educational establishment and drawing up a new exam program. Dutch Parliament subsequently called for the installation of a second committee, the *Mathematics Soundboard* chaired by Jan van de Craats, whose job it was to assess the relevance of the new programs to higher education and advise the ministry to amend these programs if necessary. After all, it is higher education that is suffering most from the 'realistic' mathematics curriculum. The latter committee also included three students, two of whom were involved in the *Lieve Maria* petition. At the end of the day, to the satisfaction of most this process has resulted in a balanced curriculum in which abstraction and application both play a central role.

Of course, the universities cannot wait until this program takes effect. Meanwhile, we literally go out of our way to show teenagers how mathematics can *really* be applied to science and society, precisely because of the availability of some abstract theory also displaying the intrinsic beauty of the subject. As an additional bonus, in showing that mathematics is ubiquitous, one simultaneously makes it respectable in the eyes of the general public (instead of a source of misunderstanding if not derision). This is particularly effective if mathematics is combined with a certain measure of success; think of former geometer Jim Simons' hedge fund *Renaissance Technologies*, whose secret mathematical trading strategy made him a billionaire. Alternatively, consider the mathematics behind Google, MP3 players or mobile phones. As pointed out by visionary PhD student Ruben van den Brink, immersing mathematics into society and being proud of it will actually have a positive effect on student numbers as well, for the reason that schoolchildren contemplating a mathematics degree are now going to be admired by their friends, rather than being evaded as nerds. Given the undeniable fact that mathematics is very hard indeed, such admiration may provide the decisive push in actually going for such a degree.

This philosophy is brought into practice through activities like master classes and web classes for upper level schoolchildren (every mathematics department in Holland now organizes at least one of these), help in writing mathematics essays, mathematical summer camps and a yearly mathematics tournament at Nijmegen for 100 teams of 5 teenagers each, with a trip to New York for the two winning teams. Such activities are accompanied by campaigns organized by both industry (combined in the *Jetnet* platform) and the Government, who organize numerous activities to point out the importance of the sciences as a whole. In the public sphere, the *Platform Bèta Techniek* is a particularly efficient vehicle, through which millions of euros are spent each year on a chain of programs starting at primary school and ending at the labour market.

Finally, visibility of Dutch mathematicians in the media has increased markedly. Here Robbert Dijkgraaf leads by example as a TV personality and regular newspaper columnist, besides his normal activities in string theory and mathematical physics, supplemented by his recent appointment as President of the Royal Netherlands Academy of Science (KNAW). Last summer, he and another renowned Dutch mathematician, Hendrik Lenstra, even became pop stars for one day through their appearance at the Lowlands Festival, where Dijkgraaf gave a talk about Einstein and Lenstra explained the mathematics behind Escher's drawings.

Has any of this really helped? Yes, it has! In 2005 less than 200 students enrolled in an undergraduate mathematics degree programme; in 2007 the number was just above 300. This is still a far cry from the 700 it once was but with applications for 2008 once again on the rise, the worst crisis appears to have been overcome and the future for Dutch mathematics looks bright!

**References**

1 The unreliability of the PISA tests was one of the conclusions of the parliamentary enquiry mentioned at the beginning of this article. See also www.beteronderwijsnederland.nl/?q=node/1340. Although this web site is in Dutch, it links to a large number of pertinent documents in English. Another relevant website is www.math.nyu.edu/~braams/links.