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Proof by example Portraits of women in Dutch mathematics

Vivi Rottschäfer

In 'Proof by example', Francesca Arici and Clara Stegehuis portray women in Dutch mathematics. This edition portrays Vivi Rottschäfer, professor by special appointment of Industrial Mathematics at the Korteweg-de Vries Institute of the University of Amsterdam and associate professor in the Analysis and Dynamical Systems group at Leiden University. Her expertise includes nonlinear dynamical systems, partial differential equations, pattern formation and singular perturbation theory. Her research currently focuses on mathematical modelling and analysis of applications from pharmacology and ecology.

Can you tell us about your path to becoming a mathematician? At what point have you realised you wanted to do mathematics?
"It was during the fourth year of high school when, all of a sudden, I started to like mathematics. I think this was the result of having a good teacher who was very enthusiastic about the subject.

On top of that, I had always wanted to become a teacher and my high school teacher recommended me to study mathematics in Utrecht, as it would be a good place for that. So I started my university studies there—even though my chemistry teacher thought this was a bad idea—and I really enjoyed it. I liked the work on my doctoral thesis so much that it made me realise I did not want to be in front of a group of high school students but I wanted continue with research. After completing my PhD, I was still happy with doing maths and research and that has been true ever since."

How did you become interested in mathematical modelling and dynamical systems?
"During my studies, I liked most of the topics and I tended more towards the abstracter analysis. For example, I wrote a short thesis with Hans Duistermaat on De Rham cohomology. During the fourth year of my study, I followed a course on the theory of dynamical systems and I really liked it! So, I took more courses in that direction, like PDEs, and ended up writing my doctoral thesis in that field."


Vivi Rottschäfer

You are currently working on mathematical models of drug distribution in the brain. Can you tell us more about this? Are there any insightful results you have obtained?
"This is a joint collaboration with a colleague from the pharmacology department in Leiden and was the topic of the PhD thesis of Esmée Vendel [3–6]. We aim to develop a mathematical model that can describe the transport and binding of medication (drugs) in the brain. A lot of medication has to enter the brain and bind to its targets to have an effect. This is true for a drug that one takes to reduce headache or other pains, like paracetamol. We know paracetamol easily reaches the targets in the brain but there are many other drugs for which this is not the case. For instance, it could happen that a drug simply does not reach its target and thus has no effect. Also, it could be that the drug does reach the targets, but the dose is so low that it does not have any effect, or that, on the other hand, the dose is so high that the drug becomes toxic.

One of the main complicating factors is that one cannot perform measurements in the (human) brain, or at least, I would not volunteer for this! As a consequence, there hardly exists any data that shows the performance of a drug in the brain.

Therefore, there is a need for a model that is able to predict drug distribution and binding to targets in the brain, as well as elimination from the brain.

So far, we have taken a first step by developing a basic mathematical model that relies on brain physiology. The final goal is to develop a full-scale model (micro to macro) that in the future can help to select the best drug to use for a specific disease."

What do you like the most about your work as a mathematician?

"I really enjoy working together with researchers from other disciplines, like pharmacology and ecology. This takes quite some time and effort, as one has to learn how to talk to researchers with a different background, but I find this very refreshing and stimulating.

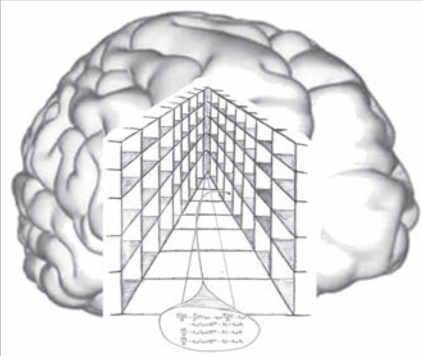
In my experience, these collaborations lead to new mathematical challenges in the modelling and in the analysis of the models. It turns out that one often has to develop new mathematical tools to be able to analyse the models at hand."

Any concrete example in mind?

"Currently I am collaborating with researchers from the department of environmental sciences at Leiden and from the RIVM on a project that concerns the toxicity of nanoparticles that dissolve in nature. My collaborators came to me for a mathematical model that could describe the dissolution of nanoparticles. In experiments, one observes that this process stops after a certain time when the nanoparticles have dissolved partly, though it is not clear why the process stops. On top of that, there are several other challenges when modelling: for instance, the process is different when dissolving the particles in water compared to another solution and for different nanoparticles.

I hope that this will increase our knowledge of the toxicity of particles that are released in nature.

From a mathematical viewpoint there are still a lot of extensions that can be incorporated to make the model more realistic. For example, my collaborators told me that the particles also aggregate into larger clusters and that they precipitate.



Graphical representation of mathematical model for the brain

So far, we have assumed that this is not the case, and we might extend the model to take this aspect into account in the future. In any case, I anticipate that the results of this project will have an impact on society in the long run."

Speaking of societal impact, you are the chair of the Innovation Commission (Commissie Innovatie) of PWN, the Dutch Platform for Mathematics. Can you tell us about your experience in the committee and about the activities you are organising?

"The aim of the Innovation Commission is to increase collaboration between mathematicians (from universities and universities of applied sciences) and companies and non-profit organisations. For this we organise several activities. First of all, we coordinate the organisation of the Study Group Mathematics with Industry (SWI)—[see Report on page 120 of this issue, Ed]. In relation to that, we also received funding to hire a 'Contact person Mathematics and Companies' who contacts the companies after the SWI to inquire if they have interest in continuing with the project and to be involved in long-term collaborations with mathematicians.

Apart from the SWI, we have organised a series of College Tours for companies, we award a prize for the best master thesis written in collaboration with a company, and we have a LinkedIn group where we post announcements and activities [1].

At the moment, we are in the process of organising the first Math Community Event that will take place online on 1 September 2021. Our goal is to bring together mathematicians from universities and universities of applied sciences, companies, and non-profit organisations [2].

Moreover, we wrote a report, titled *Making Math work*, that outlines a plan to expand the activities of the Committee. We are very excited about going forward with the plans recommended in the report."

Why do you think it is important that mathematicians invest time in transfer of knowledge to other disciplines, by taking part in events like the SWI?

"Well, why not? These collaborations can be very challenging and worthwhile. Personally, I find it gratifying to see that you can really contribute and make a difference. It usally takes quite some effort to understand what the companies taking part in the SWI are interested in, and what questions they would like to answer. Often, the process of formulating the right questions is an essential part of the project.

It is certainly an occasion where you can learn a lot, and it often leads to challenging mathematical questions. On top of that, participating in the SWI is fun, and often the projects from the Study Group are very nice examples of what you can do with mathematics."

Rererences

1. LinkedIn Wiskunde met de Industrie, https://www.linkedin.com/company/studiegroep-wiskunde-industrie.
2. Math Community Event, https://platformwiskunde.nl/math-community-event, visited on April 10, 2021.
3. Esmée Vendel, Vivi Rottschäfer and Elizabeth C. M. de Lange, Improving the prediction of local drug distribution profiles in the brain with a new 2D mathematical model, in Special Issue: Mathematics to Support Drug Discovery and Development, *Bulletin of Mathematical Biology* 81(9) (2018), 3477–3507.
4. Esmée Vendel, Vivi Rottschäfer and Elizabeth C. M. de Lange, The need for mathematical modelling of spatial drug distribution within the brain, *Fluids and Barriers of the CNS* 16:12 (2019).
5. Esmée Vendel, Vivi Rottschäfer and Elizabeth C. M. de Lange, A 3D brain unit model to further improve prediction of local drug distribution within the brain, *PLOS ONE* 15(9) (2020), e0238397.
6. Esmée Vendel, Vivi Rottschäfer and Elizabeth C. M. de Lange, The 3D brain unit network model to study spatial brain drug exposure under healthy and pathological conditions, *Pharmaceutical Research* 37 (2020), 137.