THE SCIENTIST AS A GLOBAL CITIZEN

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Abstract

In today's public communication of science and technology, not only citizens need to be informed of science, but scientists must also be able to understand and empathize with their fellow citizens, and be able to engage with them in interactive communication. These are the pillars of the MSc-program 'Science Communication', launched at Groningen University in 2003, which converts highly specialized scientists into flexible mediators in the various interfaces of science and society: the scientists as a global citizen.

Students enter this program as a Bachelor in a single scientific discipline (e.g. Biology, Chemistry, Astrophysics), and then pass through a two-year curriculum, encompassing six months of scientific research in their original discipline, twelve months of communication classes and reflective topics (e.g. scientific methods, public dialogues), and six months of optional subjects and/or an apprenticeship. Embedded in current theory and philosophy of education, communication and science communication, and with its range of 'real-life' assignments and master classes given by professionals from the field, this MSc-program is tailored both to the needs of our specific type of students, and to those of present-day and future PCST.

Their highly specialised Bachelor-education and their scientific Master-research supplies our students with much more knowledge and awareness of the realities of scientific labour than an average journalist or communication expert has, whilst their communicative and reflective skills are much better developed than those of regularly educated scientists. In this way, our graduates fill up a niche in society, as is established by the various work placements our students find for their apprenticeship and the varying professional careers of our first graduates.

Keywords: Educating PCST-professionals, Higher education, Curriculum development

1. Introduction: highlights of the current state of affairs

Last winter, biology bachelor Edwin prepared television items for a science program on a national Dutch television station. His fellow-student Tamara designed a bone determination system to be used as an information and educational instrument on the website of the Leiden Natural History Museum. Their recently graduated class-mate Siëlle worked as a trainee-writer of news items and feature articles at the Munich-bureau of *Nature*. Edwin, Tamara and Siëlle belong to the first generation of Dutch science alumni that have received explicit education in the theories and practices of science communication. During their curriculum, they not only learned how to write newspaper articles about recent discoveries, how to communicate about health risks, and with which language and images complex knowledge can be made accessible to children. They also spent six months doing scientific experiments in a lab or observations in the field, analysing intricate data and executing statistics, thereby encountering all the difficulties, technicalities and frustrations of scientific labour. This makes Edwin, Tamara, Siëlle and their fellow-students into a rare breed in Dutch academia and society, disposing of skills, knowledge and insights from two traditionally remote worlds. We trust that with their exceptional combination of scientific and communicative skills and knowledge, and with their capacity to empathise with non-specialists, they will contribute to the scientific literacy of non-academics and hopefully to the societal literacy of scientists as well. This will add to the expansion and improvement of the interfaces between science and the rest of the world – interfaces whose application possibilities seem to have dropped behind on the requirements and developments both on the side of science and technology and on that of society.

In the next section, we will give a profile of our program, first by roughly outlining its context and background, secondly by characterising each of our courses and giving examples of assignments, and finally by briefly sketching the pedagogic principles that form their base. In the third section, we will elaborate on the rationale of our program, and the sources of inspiration we had when designing our curriculum. The final section briefly deals with our ongoing adjustments in the curriculum, and with a factor that impedes optimal improving of our program.

2. A curriculum for science communicators

Edwin, Tamara, Siëlle and their fellow-students passed through a program which is part of the MSc-program for Education and Communication in Mathematics and Natural Sciences ('EC'). This MSc-program takes two full years (120 European Credits, equal to 3360 hours of study). It is accessible for students with a BSc-degree in Mathematics,

Computing Science, or one of the Natural Sciences. These BSc-programs are highly specialised, taking three full years (180 European Credits, 5040 hours of study) of disciplinary education and scientific research. Usually, students also take their majors and minors within Mathematics and Natural Sciences. As a result, their intellectual and professional competences are primarily focussed on operating in a research setting and on communicating among peers. Our MSc-program takes this two steps further: not only do we want to train students to communicate with various audiences of non-scientists, but we also want them to become aware of relationships between so-called experts and so-called lay-persons, and of science-society interdependencies. In our view, this will prepare them for global citizenship as science communication-facilitators.

Our program originates in a covenant between the Ministry and the Dutch universities. In this agreement, universities were permitted to offer extended MSc-programs in Mathematics and Natural Sciences (covering two years, instead of the regular one-year Master-programs) under the condition that they would set up specific tracks for those students that did not want to pursue a research career. Thus, all universities now offer 'societal' master profiles, leading to jobs in business or policy in which scientific knowledge can be applied, and 'education-communication' profiles that lead to jobs as science teachers or science communicators. It is hoped that these profiles will increase the retention in science curricula, that it will attract a wider range of students, and that it will contribute to the general interest in science and technology.

We received so-called 'education renewal funds' to develop our curriculum. The development group was composed of an enthusiastic fivesome from very various academic backgrounds: a mathematician specialised in science history, a mathematics/ICT teacher, a professor in science didactics, a communicative skills teacher with a grade in literature history and experience as theatre director, and a chemist who had experience in teaching science-society classes and was experienced in communicating with citizens through the science shop. The synergy and enthusiasm in this team was what made the current program into what it is at present. Also among these scientists, a curriculum such as ours was long awaited.

The Communication-pathway in our MSc-program now encompasses six courses (that will be characterised below), an individual design or writing assignment for a 'real world' client, and optional courses or internships in the field of science or science communication. Moreover, it also contains a fulltime semester of doing scientific research. At present, we have an intake of roughly ten students per year – a number that allows us to retain the intensive character of our courses, in which we can provide our students with a lot of individual feedback and attention.

2.1 Courses and assignments

'Write an 80-word 'highlight' of a recently published research project in the same way as *Nature* and *Science* do in their websites'; 'draw a metaphor in which you explain the working of a mass spectrometer to an eight-year-old child'; 'find out how people imagine the difference between a virus and a bacterium'; 'write a piece of fiction which shows that you are both a creative writer and a scientist'. These are typical examples of the assignments our students carry out in the most fundamental course of our curriculum, *Communication and Presentation*. This course aims at improving and amplifying our students's skills in writing, oral presentation, dialogue, visualisation, and IT. It also encompasses thorough practice in finding reliable information in libraries and specialised databases, and a component in which they learn about the way in which people construct knowledge. In this course, the students build a strong awareness of the surplus value of being both an experienced, learned and critical scientist *and* a skilful communication expert.

Designing is a course about the design of communicative or educational documents, either through IT-techniques or with more traditional media. Even more than in the other courses in our program, the assignments in this course are genuinely real. We procure them, often through mediation of the four science shops, from groups or individuals in the outer-academic world. Teachers in secondary schools might need an interactive computer program about genetics; or a museum may want a multimedia presentation. Our students design and produce these in this course.

A third course, *Science, Media and the Public,* is a course consisting of master classes by professionals in the field of Science Communication. In this course, students learn about the possibilities for science communication through museums and science centres, radio and television, newspapers and other written media, theatre and science writing in books and magazines. The professionals who act as their 'masters', confront them with realistic assignments, for instance: 'make a proposal for an exhibition in the local University Museum'; or 'write a news item for the science section of a newspaper'; or 'make a radio item to be broadcasted on a national radio station'. This year, a new component is introduced in the course: each of the students reads and reviews two or three 'classics' in science writing, such as Stephen Hawking's *Universe in a Nutshell,* or Stephen Jay Gould's *Panda's Thumb*, Tijs Goldschmidt's *Darwin's Dream pond*, or Frans de Waal's *Good Natured* (to mention two originally Dutch biology writers). They also present a lecture about these books, thereby catching themselves and their fellow students up with non-fiction they, as science communicators, ought to be familiar with, but which they often haven not even heard of before.

In another course, *Science, Communication, and Society,* the students are acquainted with relevant institutions and infrastructures in the field of science, and the instruments these institutions employ to enter into a dialogue with the public, be it risk communication or public dialogue about controversial scientific developments that may affect society as a whole. A typical assignment reads 'find out how citizens, various experts, policy makers and other stakeholders see

the risks of living next to a UMTS antenna, and how this affects their communication'. The students need to dig in risk communication literature as well as interview various stakeholders to learn how these view the issue, which gives real eye openers. In another part of the course students are asked to 'write an opinion article in which you plea for or against a public debate about nanotechnology'. An assignment such as this obliges them not only to deeply go into the current nanotechnological research, but also to ask themselves what the social and ethical implications of these developments might be, and – third learning effect – what the merits and constraints are of engaging in a debate with broad audiences. Often it takes time before they thoroughly realise that thinking about such problems, and phrasing an informed opinion about them is one of their responsibilities as a scientist, and even more so as a science communicator. An additional but no less important learning effect lies in the practice of writing an argumentative document. During their BSc-phase, they have had little or no training in writing in a format different from the standard IMRD research report. Often they find it hard to become aware of the rhetorical situation they occupy when trying to convince readers of their opinion. It is in this course that they most explicitly learn to put the alleged dichotomy 'expert' vs. 'lay' into perspective, and to realise that communication from 'lay' persons to scientists can also be part of what we call science communication – an important understanding, especially in knowledge transfer jobs, science shops [2] or public debates.

Backgrounds of Scientific Research is a course which aims at moulding the students into broadminded scientists, by widening their specialised knowledge from one disciplinary field (Biology, Mathematics, etc.) by asking them to find out the current state of development in another scientific discipline. Also, they refresh their competences and critical awareness of scientific methods, research design and statistics. And they learn about the history of science and research – which enables them to put their own knowledge and axioms into a wider perspective, and to get acquainted with important scientific momentums and developments in history. It also trains them to dig into a new topic in a short time and read scientific claims with a critical perspective. Writing an interview article about a scientist is one of the more practical assignments in this course – a task that turns out to be more difficult than the students initially think it is.

The final course we offer is entitled *Introduction to Research in Science Education and Communication*. In this course, students are requested to read a number of scientific articles and analyse and discuss these. Moreover, they are required to make a short research proposal themselves. Optionally, students do their own research, though our possibilities to offer research projects is at this time still limited.

Additional to the course program, the *External Assignment* has students autonomously (though under supervision of a staff member) execute a task for a real world client, be it a series of news paper articles, a design for a website, or a museum installation. Students have worked for science and natural museums, patient associations, the National Research Council, university communication department, etc. Optionally, students do an internship as well.

Throughout the curriculum, students build an e-portfolio, in which they collect their products, the reviews of their work, and their self-assessments. This enforces them to explicitly phrase their own learning process, their qualities and the weaknesses they encounter during the courses. We encourage them to assess themselves regularly, so they will not only become learned and skillful, but also become aware of their own competences. They should be 'life-long learners'.

2.2 A philosophy of learning

As these courses and examples of assignments demonstrate, we try to offer the students learning opportunities through realistic communication tasks, in which several skills are involved and in which they are forced to imagine how audiences understand and create knowledge. In the perspective of a philosophy of learning, this is largely inspired by our conviction that people learn best by doing what they need to learn and by reflecting upon their experiences while performing these tasks. The reflection occurs not only through self-assessment but also through co-operation and peer reviewing: while working together on tasks, and by commenting upon each other's work, the students are obliged to make their working and learning processes explicit. By putting into words what they do and experience, they develop so-called meta-cognition, which has, in our view, a strong surplus value when compared to the mere input of knowledge, theories and tricks presented by a 'sage on the stage'.

Also, we try to challenge our students to develop their creativity, to think beyond (alleged) fences, to be imaginative, to adopt a professional working attitude and to optimise the quality of everything they produce. Not all candidates in our program have a natural inclination to this kind of inventiveness and perfectionism. Or, rather, in their previous education, they have not learned or experienced the necessity of such a perfectionist working attitude. As for writing, for instance, many of them seem to believe that professional writers produce their pieces in one single writing session, in which a perfect draft emerges immediately, without struggling with structure, phrasing and countless rewriting and editing. For most students, it is a revelation that producing a high quality document demands a lot of time and effort and a constant willingness to redesign and rewrite – as long as the deadline for the document allows for (in this, we try to maintain real-life standards as well).

This aspect of quality requirements needs a lot of attention, since we cannot avoid the entrance of students lacking the proper attitude. In the Netherlands, there is a great reluctance to stating admission requirements; officially, universities are not allowed to select students on the basis of tests. A so-called VWO-diploma (*Voorbereidend Wetenschappelijk Onderwijs*, in English: Preparatory Academic Education; one of the pathways in secondary education) is considered as a guarantee for sufficient knowledge and skills to enter and complete an academic

curriculum. Likewise, a BSc degree is considered a guarantee for sufficient skills and knowledge for our MSc-program. Nevertheless, we stipulate the completion of a preparatory Bachelor course in communication skills, or the fulfilment of an assessment in which we test the student's writing and IT skills. In the following section, our underlying agenda for these demands will become clear.

3. Rationale: why we designed our curriculum this way

The educational philosophy briefly described above is not the only source of inspiration for our curriculum design. It is also directed by our experiences as lecturers in the Bachelor's programs of our University and by the impressions of the future work field for our alumni we received during an expert meeting with professionals from this field. A fourth guiding principle lies in our own experiences, convictions, and missions, being both ordinary citizens and professionals in a society that is dealing with rapidly growing scientific and technological expertise that has an increasing influence on the lives of its inhabitants; an expertise that, however, seems to lack the proper resources to interact and communicate with the rest of the society.

3.1 Institutional context

As lecturers in the Bachelor's program of our University, we were strongly aware of the fact that our students would primarily be specialists in one single field, knowing very much about very little, grinded and moulded in the habits of researchers in their own field, and having received little training in social and communicative skills – and if at all, these would be competences no other than the type of skills required for performing in scientific subcultures: speaking at a conference, writing a research paper. The only text format they would be familiar with, and not even consciously so, would be that of an IMRD-document. This lack of meta-cognition is largely caused by the way their teachers have learned their trade themselves: by trial-and-error, they may have achieved the proper skills, but not the meta-knowledge required for the transfer of these skills. Their teachers in the Bachelors' phase also seem to have lost their sensibility for genres other than that of a research report or a conference paper.

This high level of one-sided specialization is caused by the largely compartmentalised system of higher education in our country. Traditionally, the Dutch higher education system saw strong divisions between different educational pathways, separating between vocational training in *hogescholen* (colleges) and scholarly or scientific training in *universiteiten* (universities). Within the universities, the academic disciplines are likewise separated. To date, programs have been primarily geared to educate researchers, and students choose for one major field, in which courses with a wider orientation and communication intensive courses are scarce or – more often – completely absent. Since the European universities embraced the so-called Bologna declaration (1998), more generally oriented programs are being developed, in a system modelled after the Anglo-Saxon Bachelor-Master-system. But still we are coping with a heritage of old habits among staff, who are convinced that their students ought to have learned how to write and present themselves before entering the University in their secondary schools. Many of them are even reluctant to provide their students with training in these skills. It is only recently that the new Bachelor/Master system is introduced, and that bachelors in a science discipline can proceed their education either in a research Master or in a Master in business and policy or education and communication.

So still, we receive students that are moulded by academics who are stuck in their own discipline and its introvert discourse system. They show a poor inclination to peer into their neighbour's backyard, and though they have developed a highly critical and analytical mind, and are very good with numbers and statistics, they seem to have adopted (surprisingly quick: in only three years time!) the tendency of their teachers to think and speak in science's secret language, and to have atrophied their imaginative powers and their feeling for the outside world and its needs. It takes a lot of effort to transform our students into persons who are aware of the fact that not everyone knows what a dendrimer or a suprachaismatic nucleus is – let alone to make them invent ways in which they can explain such concepts to someone with a more common knowledge level, and, moreover, explain what impact research on these issues has on society.

3.2 Professional input

One might conclude from this being the case in Dutch universities, that a program such as ours would be warmly welcomed by workers in the field of science communication. Initially, however, this was not the case, as we experienced during a meeting in 2002 with professionals from the field, which we organised in order to reflect upon and assess our plans and ideas. We invited about ten science communication specialists, journalists, science writers and illustrators, who turned out to receive our plans with a certain scepticism, and with the tacit conviction that science communication is not something that people should explicitly learn in courses, but rather something one should pick up on the job; that, for instance, a good science writer simply is a scientist who has the urge, the ambition, and the talent to write well. Obviously, this was the way in which they themselves learned their craft, and hence they might have found it hard to imagine or accept that young scientists now get the opportunity to receive explicit training in this same craft.

Some expressed the fear that MSc-programs such as ours would create an overpopulation in the field, including the not-too-talented people who would manage to pass through the program without being very good or ambitious – that it would pervert the system of 'natural selection' which had ruled this work field so far; a system in which only the very best and ambitious could find and fight their way to science communication jobs. Also, we were – justly – cautioned for the undesirable reputation of being a shelter for the poor science students: students who would fail in being a good researcher, could easily see our program as an easy escape route to the Master's diploma.

Optimistically though, we managed to extract good counsel from these notes of scepticism and warning. We translated them into a strong awareness of the need to tailor our curriculum in such a way that it would produce alumni with a surplus value, both in comparison to common science students, and to the generally educated journalists, web designers, communication specialists etc. They led us to strongly emphasise the research components of the curriculum: our students spend a quarter of their communication curriculum executing research in the field or in a lab, thereby encountering all the realities of scientific labour. Together with the subject matter in the course *Backgrounds of Scientific Research*, mentioned above (including statistics, history of science, etc.), this guarantees our students' identity as experienced, widely oriented and critical scientists. As to the allegedly 'cushy' components of the curriculum – those that might tempt lazy students to choose for our program in order to acquire a Master's diploma the easy way – we maintain a high standard, by emphasizing that students need to have a strong ambition and that science communication is more than 'just' explaining how things work and make flashy websites. In the courses, we make high demands as to the qualities of our students' products, and by engaging professionals for master classes. Also, we introduced theoretical components in the communication skills courses, that are taught by lecturers who are familiar with current knowledge in fields such as document design, communication analysis, risk communication, and interaction between science and society.

3.3 A third dimension of PSCT

To date, a precise definition of science communication has not emerged from the varying descriptions that are circulating [1]. We felt the urge, however, to add a dimension of PSCT to our curriculum which is often neglected among both scientists and policy makers. Economic and cultural motives seem to prevail when universities or institutions argue for the improvement of communication skills in scientists, thereby more or less obscuring democratic motives. Renewed interest in science communication was primarily prompted by a shortage of scientists and engineers. The Lisbon agreement (1998) of the EU member states says that the EU should be the leading knowledge economy in the world by 2010. Therefore, science communication aimed at attracting science and technology students is considered as an economic necessity, for which many subsidies are available. Science communication is also seen as a way to abolish the knowledge deficit of the public, leading to a better trained workforce (and, probably erroneously, to more acceptance of scientific developments and public funding of scientific research). Finally, also 'valorisation' activities connecting scientific output with economic activities are highly valued. Next to the economic motive, popularisation of science and technology is traditionally seen as well wanted science communication activities – the cultural motive. The success of magazines for popular science is a clear sign of an urgent need in this case. Thus, science communication from economic or cultural motives is accepted, and also creates good employment for our graduates.

For our curriculum, however, we prefer a less narrow definition of PSCT, and also try to recognise the importance of science communication from a democratic point of view. It is in this form of science communication that we focus on interactions between science and society through interactive events such as public debates and consensus conferences, and to citizen involvement in planning research (upstream involvement), for instance through science shops. These science communication activities are sometimes seen as a necessary evil, and hence get a small part of funding in larger programs (such as the EU's Science & Society Program). Even these days, it seems that at least some scientists and science policy makers prefer science to stay in its ivory tower, to only allow citizens a view from the top by sending pictures from above or by occasionally opening the door for a guided tour, instead of interacting. In our view, the real science communicator is truly an interface, who can understand both the world inside the ivory tower and that outside, with its many companies, governments and citizens. Understanding is the basis for doing.

By taking this position, we define 'science communication' as a hybrid between 'science and technology studies' and '(applied) communication sciences'.

4. Quality assurance, and its limitations

Although we are assured that Edwin, Tamara and Siëlle are well-prepared for their traineeships and jobs in the real world, we constantly assess and, if needed, adapt our program. On a very regular basis, the staff has meetings in which the program is discussed and in which expertise is exchanged. Sometimes we decide to shift components from one course to another to improve the coherence of courses; often new components are introduced as a result of the progression of our own knowledge. Our strategies to constantly assess the quality of our program also encompass standard evaluation of courses in a committee in which staff members and students are represented. Furthermore, our tight contacts with professionals in PCST, who deliver master classes in our courses, and with clients who provide us

with traineeships and with the input of real or virtually-real assignments from society make sure that we have a state of the art acquaintance with the working field and its demands. We also keep in contact with our alumni, who can point out which skills and knowledge they miss when doing their jobs. And finally, we regularly confer with colleagues from other universities in the Netherlands and in the rest of the world – through conferences such as this one – to exchange ideas and good practices. Through our meetings with colleagues from other Dutch universities, we make sure that each of our curricula has a specific profile; the 'Groningen profile' (Groningen being located in a relatively remote part of our country) is characterised as being an all-round program, offering courses in all conceivable PSCT-fields, whereas other universities offer a science communication master that is more specialised in one specific field (popularisation, ethics, health/environment, etc).

One important condition for optimal quality improvement, however, is still lacking. None of the staff members has so far been allowed to devote part of their time to research in the field of PCST, and so far, a research program in this area has not been developed. Having a research program would not only help us to further professionalize ourselves as lecturers in this field and to keep our courses up to date; it would also enhance the status of our MSc-program, and imply the recognition of the importance of PCST. It would show that our university takes full responsibility for PCST and for the deliverance of professionals in this field.

Our program thrives on having students work on real(istic) assignments, in which they can combine skills, understanding and overview. At the moment, however, our faculty is under severe financial pressure, and translates this into painful cuts – precisely in organs through which it maintains contacts with the outer-academic world. As we write, the Executive Board of the Faculty of Sciences has announced that its four science shops, after a quarter of a century of sorely needed academic outreach service to the rest of society, especially those who cannot afford expensive consultancy, will be discontinued. If these plans are not reversed by the Faculty Council or University Board, this will also affect our curriculum, since the science shops used to provide us with some of the most important learning opportunities for our students: real-life assignments, of which society could truly profit.

5. To conclude

In a few years time we managed to build a master program on science communication that offers a broad base for scientists to become facilitators of science – society interactions. Our first graduates so far end up in suitable jobs (patients association, science centre, science journalism). Over the next year, we will have interviews with professionals in the broad field of science communication, again to further improve our qualitative overview of the field and its required competences. This is a follow up to our initial meeting with professionals, when we started to make our curriculum. We still lack a quantitative survey of job opportunities, which we hope will one day be possible at a national level (though definitions of what is a 'science communication' job will surely make that problematic).

For now, we are happy to have had graduates like Edwin, Tamara, Siëlle and their classmates; profession: scientist and global citizen.

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