217. Optimizing a Context-Based Science Communication Course for Science PhD Students

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Abstract. These days scientists are increasingly called upon to communicate about their work and its social and economic relevance to a variety of different target groups and stakeholders. To support this challenge, in 2007 a science communication course of four days within a month with a focus on engagement was developed at the Faculty of Science of Utrecht University, intended for PhD students with a special interest in public communication.

Over the past three years about 40 students have participated in 7 editions of the course, which comes in a Dutch- and an English language version. The course links theory of science communication to practice by facilitating participants to present their own research to real live audiences (i.e., context-based) with the intention of engaging the public and fostering dialogue.

This paper focuses on a critical retrospect of the course based on empirical data and various theoretical perspectives so as to further improve the course. The course aims to establish a change in mindset of the students: 'from telling them what you know, to telling the public what they want to know.' So the course is strongly focused on public engagement and based on the view of situated learning. Learning by doing is crucial in the field of communication, so the PhD students communicate about their own research in 'real life' situations, such as writing for publication on the web, or presenting for an actual school class. In addition peer feedback plays an import role. Participants learn a lot from and with each other through feedback sessions.

In collecting and analysing the data sets, which include observational notes, student evaluations and student performance, three different levels are distinguished: the intended level (course objectives), the operational level (actual teaching and learning process), and the attained level (learning experiences and outcomes of students). Differences in learning style, attitude towards science communication, domain specific background, and cultural background are explored in search of criteria for fine-tuning course in terms of format and for different student types.

Results show that aiming for two concrete products – an oral presentation and an article for a general audience – as the outcome of the course is a feasible goal. The quality level of the product is strongly related though to a person's language proficiency. In addition the educational approach of 'learning by doing' combined with 'social learning' is a suitable approach for such a science communication course for PhD students, on the condition that the students' apprehension for the unfamiliar approach in teaching the course is overcome in the first day of the course.

Introduction

Four years ago at Utrecht University a science communication course for science PhD students was developed with a focus on engagement. This was in response to the latest developments in the science communication field where a paradigm shift is being seen from the 'classical' or 'cognitive deficit model' to the 'contextual model' (Wynne, 1991). This means that the public more and more becomes an active partner in the communication process and is not perceived solely as a 'receiver', as is the case in the so called 'deficit model'.

In addition (young) scientists feel an increased demand to communicate about their work and its social and economic relevance to a variety of different target groups and stakeholders. These days the EU only accepts research proposals in their 7th Framework Programme for Research and Technological Development, if a paragraph about the societal impact of the research is included. So research should have added value. The results should be useful - in some way or other - to society, and citizens should get to know about it. So PhD students have to train their communication skills and should be able to set out in simple terms why their research project is worth pursuing.

At the same time governments in Europe and elsewhere around the world see the added value of 'setting up a dialogue' with the public. The antagonism against genetically modified foods and 'socio-scientific' issues such as mad cow disease and the dioxin crisis ask for public involvement in decision-making processes. Science has become so complex and has such a global reach that many politicians feel decision-making in this realm cannot be left to the scientific community alone. Citizens should have their say about future developments in, for instance, nanotechnology.

That's why within science communication Dutch government wants scientists to enter more into dialogue

(Commissie Esmeijer, 2003). Two-way communication is emphasized: scientists inform citizens and citizens inform scientists. Regional initiatives are sought after. An explicit mention is made of direct contact between scientists and high school students.

So the new science communication course needed to have an emphasis on 'engagement' and it should have added value to what was already available. First of all there were the books (for instance: A field guide for science writers, Blum et al, 2005) and websites with heuristics that are available on the issue. In addition short one-day courses on science communication with the public were available for PhD students, and Utrecht University offered several courses on academic communication skills (peer-to-peer communication). This meant the course had to fill the following niche: a more extensive course focused on communication with the general public and focused on 'real life' experience and the generation of concrete products.

As this course was developed by the Freudenthal Institute for science and mathematics education (FIsme) of Utrecht University, the following commonly held notions within the institute were used as a guideline for design criteria: engagement, concern-based, situated learning (hence also context-based), experiential learning, and the teacher is 'facilitator'. These notions are derived from constructivist views on learning. These views emphasise the active role of the learner in building understanding and making sense of information (Woolfolk, 2008: 411). (For a further elaboration of the notions see section 3).

Initially in the development process of the course these educational notions were taken as 'given' and now after four years, seven courses and 45 participants in total, it's time for a critical retrospect on the implementation of the notions in the course using goal-based criteria and an evaluation of the learning objectives of the course. Empirical data and theoretical perspectives will be used to answer the central research question in this study: How feasible and effective is the context – based science communication course for science PhD students?

Based on the outcome of the study suggestions will be formulated to optimize the course itself, and more general recommendations will be given for training and courses in science communication.

The Original Set-Up of the Course

In 2007 the science communication course was first developed for a total of 8 PhD students, ideally with different science backgrounds to stimulate the interactive learning process. During the course participants learned the basic principles that govern science communication to a general audience. They also had to implement this knowledge in two concrete communication products about their own research: a short interactive presentation and a popular scientific article. For a more elaborate overview of the educational design of the course see appendix 1.

The course participants worked together as a learning community. They learned a lot from and together with each other through feedback sessions. As a consequence the role of the teacher was that of 'facilitator' of the learning process and not of 'instructor'. On the basis of science commu¬nication theory, personal experience, reflection, and analysis of a range of different example cases, PhD students developed their own specific communication products.

The course sessions themselves took up three full and two half days during one month. During the same month, PhD students had to set aside a minimum of four more days to prepare and revise their presentation and article. As communicating with the public is something one mainly learns by actually doing it, the course strongly focused on 'real life experience'. So in addition to a trial-run presentation within the group, the final presen¬tation was held at a public event for a general audience at the local Utrecht University Museum. The popular article was written with the aim to have it published.

For the first version of the course five learning objectives were formulated. At the end of the science communication course for science PhD students the course participant should be able to:

- switch his/her mindset from 'telling them what you know, to telling the public what they want to know'
- practice 'dialogue' rather than 'monologue' (i.e. engagement) with the publicdevelop and carry out a public presentation and write a popular scientific article based on basic communication principles
- assess the quality of communication products, both his / her own and those of others
- reflect in groups supported by giving and receiving feedback

For the first version of the course the PhD students were asked to participate by the teacher through personal invitation, using her personal network. The courses that followed were accompanied by a small advertisement campaign. Four months before the start of a course, the course was promoted by a mention in the newsletter of the science faculty and in the Utrecht University PhD newsletter. In addition a letter was sent to all scientific directors of the research groups in (veterinary) science and medicine, kindly requesting them to bring the course to the attention of the PhDs in their group (see appendix 2 for the accompanying course leaflet). The argument given in the letter and

in the course leaflet to promote PhD students to participate in the course, was the increased demand on scientists these days to communicate about their work and its social and economic relevance to a variety of different target groups and stakeholders.

Elaboration of the theoretical framework

The new science communication course had to be developed with a focus on 'engagement in communication and setting up a dialogue'. This was in response to the latest developments in the science communication field where a paradigm shift is being seen from 'transmission' (the 'deficit') to 'transaction' (the 'contextual model') (Wynne, 1991). In this shift the public is increasingly being viewed as an active and equal partner in the communication process. During dialogue knowledge is being co-constructed by both parties in the communication process.

When 'engagement' is the central focus of the course and when one wants to gain credibility, one has to 'practice what you preach', also in the educational design of the course. So the learning individual should be seen as active and equal and as a partner in the co-construction of knowledge. Social constructivist views on learning embody these views.

Constructivism views learning as more than receiving and processing information transmitted by teachers or texts. Rather, learning is the active and personal construction of knowledge and acquiring skills (De Kock, Sleegers and Voeten, 2004). And the outcomes of this process of personal knowledge construction and acquiring skills are often tested against the experience, knowledge and competencies of others. So meanings are negotiated and co-constructed. Therefore social constructivists see learning as increasing our abilities to participate with others in activities that are meaningful in the culture (Windschitl, 2002).

So from the perspective of (social) constructivist learning theory the notions, that were taken as a 'given' for the development of the course, will be further elaborated on.

1. Engagement: 'fostering dialogue with the public' is a central idea in the course. This means co-construction of knowledge is important. The learning theory of (social) constructivism fits well with such principles.
2. Concern-based: Learning is the active and personal construction of knowledge and acquiring skills. Each learner has unique needs and a unique background. So in this course there should be enough space for each participant to 'tailor' the course to his or her needs. To a certain degree the course can be and should be 'personalized'.
3. Situated learning: Situated learning is based on the idea that skills and knowledge are tied to the situation in which they are learned and difficult to apply in new settings (Woolfolk, 2008: 414). They are context-based. So science communication skills should be learned in 'real-life' situations and learned in a 'cultural setting' that is familiar to the science PhD students.
4. Experiential learning: Constructivism is associated with 'learning by doing' (Kolb, 1984), by participants being actively involved in the learning process and by reflecting on that process. This is what experiential learning is focusing on and this way of learning is integrated in the set-up of the course.
5. Teacher is 'facilitator': Social constructivism focuses on how individuals themselves make sense of information and generate knowledge in interaction with the social environment they are in. They should learn to discover principles, concepts and facts for themselves. Therefore the course teacher should facilitate that process, and steer away from the 'instructor' role. Participants should become 'owners' of their own learning process. This is the best way to ensure lifelong learning.

For a critical retrospect on the implementation of these five notions in the course and an evaluation of the learning objectives of the course, the following evaluative questions can be formulated:

1. Was the course set up in such a way that it did focus on 'engagement'? Can at the end of the course a participant switch his/her mindset from 'telling them what you know, to telling the public what they want to know'? Is at the end of the course a participant able to practice 'dialogue' rather than 'monologue' (i.e. engagement) with the public?
2. Did the course have 'space' to adapt the course to a participant's needs? Did the participants use this 'space'?
3. How is 'situated learning' integrated in the course? How is situated learning perceived by the participants? Is situated learning a good approach for a course like this one?
4. In what way does the course offer room for experiential learning? Did the participants work well through experiential learning? Did peer feedback work?
5. How is the teacher's role shaped? How did the participants perceive the teacher's role? Did the teacher stick to his / her 'facilitator' role?

6. To what extent were the learning objectives met?

As the course is based on notions derived from social constructivism, social interactions and cultural context are important. Therefore the following aspects of the population of PhD students will be clarified in the respondents' section of this article: cultural background, gender, and science background.

Respondents, data collection and analysis

Respondents

The respondents of this study are both course teachers - first author (6 courses) and Robert Kerst (1 course) - and the 45 PhD students who participated in the science communication courses. Liesbeth de Bakker is science communication lecturer at Utrecht University and developer of the science communication course. Robert Kerst is science communication officer of the science faculty of Utrecht University. Information about the PhD students regarding their cultural background, gender and science background was derived from the registration forms for the course. In total over a time span of four years seven science communication courses were held: four Dutch language versions and three English language versions. In total 45 PhD students participated: 28 to a Dutch language version and 17 to an English language version of the course. (Sixty percent female, fourty percent male).

For an overview of the cultural background of the participants see table 1. Table 2 gives an overview of the science background of the participants.

Table 1. Overview of cultural background of participants

Cultural background	No. of participants
Dutch	35
Asian	6
European	2
North American	1
African	1

Table 2. Overview of the science background of the participants

Science background	No. of participants
Pharmaceutical science	10
(Bio) medical science	10
Physics	9
Chemistry	5
Biology	4
Geology	3
Astronomy	2
Veterinary science	2

Data collection and analysis

By using a typology used in curriculum studies (Goodlad, 1979) the course was studied on three different curriculum levels: the intended (course objectives), the operational (actual teaching and learning process), and the attained curriculum (learning experiences and outcomes of students). For an overview of the data sources used for analysis of the science communication course on the three different curriculum levels see table 3.

Table 3. Data sources and levels of analysis

	Curriculum levels		
Data sources	Intended		Operational
Attained			
Course documents √			
Observational notes			√
Student evaluations			
√			
Student products			
√			

The intended curriculum was uncovered by content analysis of relevant documents, such as the original documentation on the course (De Bakker, 2007). The operational curriculum was studied on the basis of observational notes on the actual teaching made by the course teachers. Finally, through student evaluations (see appendix 3 for the evaluation form) and assessment of student performance and products by the teacher, the attained curriculum could be determined.

Results

In an attempt to answer the main research question of this study - How feasible and effective is the context – based science communication course for science PhD students? – first of all the evaluative questions as formulated in section 3 will be answered, and where necessary and relevant for the three different curriculum levels: the intended, operational and attained curriculum.

Engagement

Intended curriculum: Was the course set up in such a way that it did focus on 'engagement'?

From the original documentation of the course it appears that on the first course day the focus lies on 'from telling them what you know, to telling the public what they want to know.' The public should become the starting point in communication. And the public should become perceived as a serious partner in communication – a partner in dialogue. In the two assignments (the presentation and the written article) this perspective of 'putting your audience central' is emphasized, so interactivity in the presentations is strongly emphasized and promoted. An exercise such as writing a popular scientific article though has very little scope for interactivity or 'dialogue'.

Operational & attained curriculum: Can a participant switch his/her mindset from 'telling them what you know, to telling the public what they want to know'?

At the start of the course the attitude towards science communication of the PhD students was judged by the remarks they made on the first day of the course. It was clear that all of them perceived science communication from a 'classical' perspective. They were the 'sender' and the public the 'receiver'. So they worked within the settings of the 'deficit model'. Remarks like: "I want to tell the public about science because they know so little about it and unknown makes unloved", were often heard when the students spoke about their motives for wanting to be involved in science communication. The contextual model where the scientists co-construct knowledge with the public was still far from their minds.

Gradually, as the science communication course progressed, it became clear from participants' remarks and their written evaluation reports that most of them made a switch in thinking. In developing their products their first question often became: what would the audience like to know? As one Dutch female participant with a pharmaceutical science background put it: "A strong point of the course is that it forces you to step out of your scientific role and to put yourself into the shoes of the public." As a consequence the participants' communication products are (to a large extent) accessible and interesting for a lay audience. Still, a strong focus on communicating plain facts and ideas remains. The notion that it might be possible or desirable to generate knowledge in dialogue with a public is something that's too far fetched for the participants.

Attained curriculum: Is at the end of the course a participant able to practice 'dialogue' rather than 'monologue' (i.e. engagement) with the public? Even though the PhD students were explicitly invited to interact with their public during their presentation, it did not result into the desired attained level of the course. Most of the PhD students (about 50%) only managed to

ask the public one or more questions during their presentation. About 20% of them really did something interactive with the public but these efforts did not yet lead to something that resembled a 'mini-dialogue'. The rest of the course participants chose not to directly involve the public and only allow questions at the end. One Dutch male participant with a medical background remarked: "I don't like it, to ask the public questions mid-way the presentation. It disrupts my own story and it makes me nervous because you never know what answers they come up with." About a quarter of the course participants felt the same way.

Concern-based

Intended curriculum: Did the course have 'space' to adapt the course to a participant's needs? Even though the general set up of the course was fixed, e.g. five sessions over the course of a month in which two communication products had to be made: a presentation and a popular scientific article, the separate course sessions left plenty of room for the participants to address specific issues that they were concerned about. On the first course day all participants were asked for their general personal learning aims and the teacher would keep these aims in mind for each individual during the course. In addition, if one participant would develop a special interest in a specific aspect of science communication, additional literature and guidance would be provided for the PhD student. ***Operational curriculum:*** Did the participants use the 'space' to adapt the course to their own needs?

Only very few students tailored parts of the course to their own needs. When asked for their general learning aims at the start of the course, most of them expressed very general aims. "Learn to how to 'translate' a scientific message to one that can be understood by the public" was the most frequently uttered learning aim (15 times). Some participants were more focused on improving their presentation skills (8 times), others their writing skills (4 times). So the course in general provided the information and the training of skills that were sought after. Hence the participants felt little need to use the space to adapt the course to their own needs.

Only two PhD students (one male and one female, both Dutch and with a medical background) explicitly asked to write a press release about their work as they had almost finished their PhDs and wanted to generate media attention for their work. This was facilitated by extra literature and more specific feedback.

There also was a female North American PhD student from veterinary science who felt she needed more assistance when it came to 'risk communication', so she received extra literature on the matter. This is of course an 'academic learning' approach but due to time constraints there was no possibility to deal with the matter in a more constructivist manner. Through self-study the PhD student used some of the information in the development of her presentation and written article.

From the student evaluations it emerged that most participants agree they've now got the 'basic' knowledge and skills for science communication, but still they feel there's a lot to learn. About 10% of participants feel they would have wanted more in-depth knowledge about different target groups and assignments for different target groups (so not only adults or high school students).

Situated learning

Intended curriculum: How is 'situated learning' integrated in the course? The starting point of this course is the authentic practice of the PhD students themselves. This means the course is based in the context of their own PhD research. Part of that context and practice is communication about their work, not only peer-to-peer, but also to other target groups such as the general public, or the funding agency. To foster the interactive learning process ideally eight participants from different science backgrounds are selected for the course.

In addition, the course's practical tasks are set in a 'real life' situation. The participants talk to a journalist about their research project, they present their research to a lay audience on a public event, and they write their popular scientific article with the aim to really publicize it, i.e. on a popular science website or the news magazine of Utrecht University.

Such 'real life' assignments take time. So 32 hours of contact time with the group were scheduled. This included ample time for feedback sessions to critically assess the products mid-way and to give constructive feedback. In addition each participant individually had to reserve a similar amount of time to make and revise the products at home.

Operational curriculum: How is situated learning perceived by the participants?

It's positively perceived. Many PhDs expressed they felt connected, part of a group with lots in common. This sentiment was most strongly experienced by the PhD students with a non-Dutch nationality. One male PhD student from African origin and with a background in chemistry remarked: "It's great to finally meet PhD students from a

different science background and to find out we all struggle with the same problems, like publication deadlines and difficulties in explaining to family and friends what exactly it is you are doing."

In addition all PhD students were very happy to communicate about their own research and their own results if there was no risk in jeopardizing their official academic publications. Some students followed the course very early in their PhD track and they therefore did not have any results to report about. In that case they communicated about the social relevance of their research. One male Dutch PhD student with a geology background who did the course in the first half year of this PhD project remarked: "It's interesting to find that by thinking in the science communication course about the social relevance of my research project, I now also get a better grip on the research question of my PhD project".

Attained curriculum: Is situated learning a good approach for a course like this one?

Based on the reactions on the student evaluation forms the answer is yes. Many of the assignments were as 'life-like' as possible and this scored high marks. The workshop in which the PhD students met up with a professional journalist who asked them all sorts of general questions about their research was a real eye-opener to the participants. Immediately they got a feel for their public and the 'low' or general level of interest the general public has in their PhD project. One Dutch female participant with a pharmaceutical science background remarked: "I was really surprised that a journalist expects you to have some facts and figures ready about the disease or illness you're studying just an aspect from."

In addition, the fact that the presentation and the writing exercise were set in a 'real life' situation was earmarked as the highlight of the course. Interestingly though, when it came to publication of the popular scientific articles which were written for the course, very few ended up in the public domain. Only six articles out of 45 were finally published: two on a popular science website for high school students (http://www.kennislink.nl/ search for articles by Vasco Verlaan and Paul Leclercq), two as a hand out with the presentation which was held within the framework of the course, one in the Utrecht University newspaper (www.dub.uu.nl) and one as a press release.

The reason that the other 39 articles weren't publicized was twofold. Often the PhD students did not have concrete results yet, so the texts didn't meet the requirements of the publisher. And occasionally the PhD students themselves decided they weren't ready or willing to publicize their text just yet. One Dutch female participant with a physics background wrote in her evaluation: "The time to write an article is simply too short to be happy with the final product. I need more time to think things over and process it all. I guess in another month a final rewritten version will come out."

Experiential learning

Intended curriculum: In what way does the course offer room for experiential learning? In experiential learning one makes meaning from direct experience. So the course was organised in such a way that the participants had to develop their own heuristics for science communication through dedicated exercises and experiences. The PhDs are put in 'real life' communication situations and afterwards they are stimulated to reflect on their experiences. This process is supported by the fact that the course participants are divided into two teams. Every course session these teams help each other in feedback sessions. They are taught to give constructive criticism on each other's presentations and popular articles. And at the end all participants are asked to actively reflect on their own performance and communication products by answering a short questionnaire (see appendix 4).

The feedback and reflection moments that were built into the course were aimed at a group size of eight participants from different science backgrounds. However, often less than eight PhD students registered for a course, so the ideal mix could not be established. Only two courses had a good mix. Three courses had 50% of candidates with the same science background (biology and astronomy), so the mix was less than ideal. And in two courses there were more than 50% candidates with the same science background (medical and pharmaceutical science) but due to a lack of participants that was the best that could be achieved.

Operational curriculum: Did the course participants work well through experiential learning? Did peer feedback work?

Even though the course was set up in such a way that the participants had to develop their own heuristics for science communication through dedicated exercises and experiences, it soon appeared there was too little time and support for a full implementation of this approach. One male Dutch participant with a physics background said: "It's all very nice to have to talk everything through with the group but I'd rather have the teacher tell us what to do and how to do it best." So in the first course the participants made a strong plea for a reader with science communication

literature and clear handouts with heuristics on the basis of which they could start developing their products. Only then they were willing to work with and learn from each other in peer feedback sessions.

Once started these peer feedback sessions worked well and in general it was thought that the process went in a constructive manner. Occasionally though some PhD students felt that their fellow students focused too much on the detail in the articles and in the presentations and not enough on the overall structure and approach to the communication products. In an attempt to steer the feedback process more into the right direction, special feedback sheets were made (see appendix 5). Another interesting observation was that 5 of the 6 participants with an Asian background had to get used to giving and receiving direct constructive criticism but after two course days they usually lost most of their reservations.

Teacher is 'facilitator'

Intended curriculum: How is the teacher's role shaped?

During the course the teacher takes on a facilitating rather than an instructing role. The participants themselves have to find answers to questions through discussion or feedback sessions. The teacher guides this process and tries to avoid giving direct answers. Within communication there are few black and white rules. Every course participant should find a way of communication, which suits him or her best and the teacher aims to facilitate this process, rather than to steer it into a particular direction.

Operational curriculum: How did the participants perceive the teacher's role? During the first course it became clear that mainly the two participants with a physics background had difficulty

with the constructivist approach to learning that was applied in the course. They felt a need to have clear guidance from the teacher and asked for a 'instructing' role rather than a 'facilitating' role. The male participant with the physics background told the teacher: "You're the professional, you tell me what to do. I don't think it's a good approach to figure it all out for ourselves in discussions and feedback sessions." Later on his stance changed but only after he'd seen the teacher facilitate the exercise with a professional journalist interviewing some of the course participants. It was an exercise he'd appreciated a lot and had learned a lot from. He'd come to realize that there are other ways to learn than just straight from a teacher or a textbook.

Operational & attained level: Did the teacher stick to his / her 'facilitator' role? The teachers had to grow in their roles as 'facilitators'. Both are used to the 'teacher' role and often they were too

prone to give the 'right' answer or to come up with a ready made list of heuristics relevant for science communication. When it also appeared that the participants, certainly at the beginning of the course, preferred the 'teacher' approach, a decision was made to start the course in the 'teacher' modus but to change the approach when facilitating the production process of the two communication products. This intermediate model appeared to be working well both for the teachers as well as the course participants.

Learning objectives

Attained curriculum: To what extent were the learning objectives met?

The first two learning objectives have been discussed earlier under the heading 'engagement' as these two learning aims are directly connected to that notion. The other three learning objectives about developing the products on the basis of basic communication principles, assessment of quality of product, and the capability to reflect, will be discussed below.

When looking at the final products of the participants of the course the question 'whether the participant can develop a product on the basis of basic communication principles' can only be indirectly answered through the quality of their products. In all instances the final presentations were of sufficient quality and so were the written texts. However in 4 of 45 cases the PhD student had to carry out another rewrite of the final version before it was assessed as 'adequate'. One important aspect in judging whether a product was of 'adequate' quality was, whether or not the presentation or article was clearly of interest to a lay audience and understandable for them. And in some cases the text still looked like it was written for a fellow researcher. In other instances the structure still was unclear.

It's interesting to note that when the overall quality of texts is compared, a clear distinction can be drawn between texts which were above average quality and texts which were below average quality. Those above average quality were always written by people writing in their native tongue and those below average quality were written in English by people to whom English is their second language. So it seems language proficiency is related to the quality of a PhD students' product. This relationship also emerged when looking at the quality of the presentations.

When it comes to the assessment of products and reflection on the process and products, it became clear during the course that all course participants were able and willing to judge the quality of their other team members' products. In addition, from the students' self reflection sheets a clear sense of weak and strong points in their own presentation emerged. Many of them remarked that at the end of the course they felt they had made products that were better than before but that these products still could be improved on. "Science communication is something learned by doing it a lot", one Dutch female PhD student with a medical background remarked. "Practice makes perfect."

Conclusion and Discussion

Based on the results as described in the previous section it is now possible to answer the main question of this study as mentioned in the introduction:

How feasible and effective is the context – based science communication course for science PhD students?

Feasible

At the end of the course all participants had produced both a presentation and a popular scientific article of adequate quality. So despite the language problems some PhD students had to overcome, all of them clearly had put their target audience central in their thinking and products.

Crucial factors when it comes to 'feasibility' are: enough time, constructive feedback and 'real' assignments. In terms of time, one should allow five course sessions over the course of a month, with a total of 32 hours. The PhD students should at least dedicate the same amount of time for 'home work', i.e. making the presentation and the article.

Peer feedback and feedback from the teacher are crucial in improving the products. By bouncing ideas off on other PhDs with a different science background it becomes possible to check whether your products are understandable and of interest.

Finally, working towards a presentation on a public event with a real lay audience is the ultimate stimulus to perform well and on time. There's a real feeling of urgency and it's seen as a real 'deadline'. It would be good to organise some sort of a similar stimulus for the writing exercise. This is lacking at the moment.

Effective

When it comes to reaching the learning objectives of the course, they are only partly met. The practical part of the course - making the products and assessing quality of the products and reflecting on the process and the products - can be termed effective.

However, in terms of 'engagement' the course is much less effective. Most of the participants now do mention in their reflection or evaluation that they are aware that they should put the public central in their thinking and products. This change in mindset though is only present in their products in the sense that they are (to a large extent) accessible and interesting for a lay audience. However, taking this train of thought further and opening oneself up to a dialogue with the public and getting into 'real engagement' with the public and the co-construction of knowledge, is still far off.

The answers to feasibility and effectiveness of the course are given with respect to a course that has undergone the following changes on the basis of the student evaluations in the past four years:

1. A reader of modest size was made to accompany the course
2. Teacher becomes a mix of 'instructor' and 'facilitator'
3. Instruction sheets were made to facilitate and focus the feedback process

It's interesting to note that all these three aspects veer away from a pure constructivist approach to learning. And they were made to accommodate the PhD students that participated in the course. If a teacher wants to 'practice what he/she preaches' he/she needs to put the students' needs central in the development of the course. In this case it appeared that the science PhD students were often only used to academic learning: receiving and processing information transmitted by teachers or texts. Situated and experiential learning is therefore totally new to them. That's why it was decided to start the course in a more 'academic' fashion and gradually introduce the situated and experiential learning approach. In practice this meant that the transfer of the 'theory', i.e. the heuristics for communication, was taught in an academic way and the production of the products was supported by situated and experiential learning. This also suited the teachers as they are also used to academic learning and were still growing in their roles as 'facilitators'.

As a consequence the course has become 'feasible' as it fits better with the students' and teachers' needs but at the same time it 'waters down' the situated learning approach. It is therefore no surprise that the ultimate goals of 'dialogue' and 'co-construction of knowledge' are far from being reached.

Is this a problem? In hindsight one has to say, no. It can be concluded that the course as it is held now fits the PhD students' needs. Improving their communication skills with presentation and writing assignments that are examples of more 'classical forms' of communication, focused on transmission rather than on transaction, are just what the participants need at the moment. They are not 'up' to transaction just yet, but the first step in terms of awareness raising on the issue of engagement has been made.

So the course should not stray from its focus on 'engagement'. In both public communication and education it's a goal worth striving towards. As this notion of 'engagement' becomes more well known in the academic world, and if learning in academia slowly but surely - partly - undergoes a change towards situated learning, then maybe in 10 or 20 years' time the PhD students then may well be up to whole-hearted 'engagement' with the public.

Implications for Educational Practice

1 Based on this critical retrospective the following suggestions can be made for the context-based science communication course for science PhD students (these suggestions aim to both keep the PhD students' needs in mind while at the same time work towards reinforcement of the social constructivist character of the course):

1. Just like the presentation exercise the writing exercise should be made for an actual target audience who would also give (direct) feedback. Bring the target audience into the course sessions. Or, as an alternative, a professional journalist could participate and give feedback on the articles. This would give the writing exercise just as much urgency as the presentation exercise. At the moment this is lacking.
2. Currently the social constructivist foundation on which the course is built is not emphasised, let alone mentioned. This should change. As the group thinks about a changing society and the consequences for communication (from transmission to transaction), one should immediately link through to the consequences for education.
3. More participants from different science backgrounds are needed. At the moment less than 1% of all science PhD students of the faculty of Science at Utrecht University participates per year. Apparently the course leaflet is not powerful enough in emphasizing the value of adequate science communication skills. Maybe focusing on the value of better public communication skills for grant proposals should be emphasized as well. Another suggestion might be to try and invite the supervisors of the PhD students to follow the course themselves. This way they can personally experience the relevance and importance of the course for their PhD students and facilitate and enthuse their PhD students for the science communication course. Or, last but not least, ex participants of the course who have made a mind switch and have become enthusiastic, could be asked to bring the course to the attention of their peers.

More in general the following recommendations can be made for science communication training and courses:

1. A focus on 'engagement' as a starting point for a science communication course is a good one but one has to realise that most people are not ready yet for 'dialogue' and the 'co-construction of knowledge'. Therefore adapt the course to your participants' needs and see 'engagement' as the ultimate goal the group is working towards.
2. As communication is learned mainly by doing it, situated and experiential learning is the ideal basis for a communication course. Allow enough time for feedback sessions, reflection and the production and revision of the actual concrete communication products.
3. Ideally the teacher should be a 'facilitator' but the teacher can only take up this role once the students have embraced the idea of situated and experiential learning. Therefore, make sure that in the first day of the course the educational set-up of the course is explained and that the teacher gains credibility through establishing him- or herself as a professional in the science communication field.
4. Try to work from 'real-life' experiences as much as possible. Establish at certain times in the course contact between the course participants and their target audience of preference.
5. (Peer) feedback and reflection are crucial in the learning process, but such things don't come naturally to many of the course participants, so make a point of actively asking them to engage and give them enough support during this process.

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Reference list

Blum, D., Marantz Henig, R. and Knudson, M. (eds.) (2005) A field guide for science writers (second edition), Oxford University Press.

De Bakker, L. (2007) Raamplan cursus wetenschapscommunicatie voor promovendi, Utrecht

De Kock, A., Sleegers, P. and Voeten, J.M. (2004) New learning and the classification of learning environments in secondary education. Review of Educational Research, 74, 141-170

Commissie Esmeijer (2003) Visie op Wetenschaps- en Techniekcommunicatie. In: WeTeN gewogen, de WTC-toekomst getekend; Van Sisyfus tot Hercules, 39-58

Goodlad, J.I. (ed.) (1979) Curriculum inquiry. New York: McGraw-Hill

Kolb, D.A. (1984) Experiential learning: Experience as the source of learning and development, Englewood Cliffs, NJ: Prentice Hall

Windschitl, M. (2002) Framing constructivism in practice as the negotiation of dilemmas; An analysis of the conceptual, pedagogical, cultural, and political challenges facing teachers. Review of educational research, 72, 131-175

Woolfolk, A., Hughes, M. and Wallup, V. (2008) Psychology in Education, Harlow, England: Pearson Lowman

Wynne, B. (1991) Knowledges in context. Science, Technology and Human Values, 16, 111-121.

Appendix 1

Educational design

for the context-based science communication course
for science PhD students
(brief English language summary of the original course documentation in Dutch)

drs. Liesbeth de Bakker
FIsme
Utrecht University
May 2007

The science communication course is developed for a total of 8 PhD students, ideally with different science backgrounds to stimulate the interactive learning process. During the course participants learn the basic principles that govern science communication to a general audience. They have to implement this knowledge in two concrete communication products about their own research: a short interactive 10-minute presentation and a popular scientific article of about 800 words.

The course sessions themselves take up three full and two half days during one month. During the same month, PhD students have to set aside a minimum of four more days to prepare and revise their presentation and article.

To foster a good learning process several times the full cycle of experiential learning has to be completed. This learning cycle exists of the following phases: concrete experience (CE) >> observation and reflection (OR) >> formation of abstract knowledge (FAK) >> active application of knowledge (AAK). Through AAK one immediately ends up again at the beginning of the learning cycle: phase CE. Through repeated cycles a course participant gradually grows towards the fulfillment of the learning objectives and the development of relevant knowledge and competencies.

For each day of the course the learning activities will be described and the learning phases (CE / OR / FAK / AAK) will be included.

Day 1: "Focus on target audience" Morning session: introduction of the course (CE); getting to know each other and each other's research (CE / OR / FAK / AAK); identification of aspects in th research that are difficult to explain to each other (OR); search for possible solutions (FAK); communication theory (FAK).

Afternoon session: all participants formulate their 'research in a nutshell' (AAK / CE); peer feedback instruction (FAK); peer feedback session on 'research in a nutshell' texts (OR / FAK); formulation of a heuristic for proper science communication with a lay audience (FAK); professional journalist interviews participants about their work (CE / OR / FAK / AAK)

Homework: rewrite your 'research in a nutshell' text and develop plans for your written article and your presentation for a general audience.

Day 2: "Focus on product"
Morning session: Short theoretical introduction on presentation skills (FAK); analysis of a presentation of a scientist on DVD (CE / OR / FAK); peer feedback on initial presentation plans (AAK / CE / OR / FAK)

Afternoon session: Short theoretical introduction on writing skills (FAK); analysis of two popular science articles (CE / OR / FAK); peer feedback on rewritten 'research in a nutshell' texts and initial plans for article (AAK / CE / OR / FAK)

Homework: Group 1 writes their first version of their article. Group 2 prepares their first version of their presentation.

Day 3: Product analysis I

Morning session: Peer feedback session on trial-run presentations (CE / OR / FAK / AAK); peer feedback session on first versions of articles (CE / OR / FAK / AAK)

Afternoon session: More theory on writing and presentation skills (FAK); metaphor exercise aimed at finding new ways of explaining difficult concepts in research (CE / AK / FAK / AAK)

Homework: Group 2 writes their first version of their article. Group 1 prepares their first version of their presentation.

Day 4: Product analysis II

Morning session: Peer feedback session on trial-run presentations (CE / OR / FAK / AAK); peer feedback session on first versions of articles (CE / OR / FAK / AAK)

Homework: Everybody works on their final versions of their presentation and their written article.

Between ‘Day 4’ and ‘Day 5’ all presentations will be held in front of a ‘real’ general audience (CE / OR)

Day 5: Completion

Morning session: Feedback from teacher on articles (OR / FAK); reflection on presentation and article (OR / FAK); evaluation of course (OR / FAK)

Appendix 3
Course evaluation 'Science communication for PhD students'

Course dates	8 January – 26 February 2010
Presentation	Anna van Rijn College / University Museum (3 / 5 Feb)

1. General course remarks

1.1	Are the general aims / objectives of the course clear?	Unclear Clear	1 2 3 4 5
1.2	Does the course offer you enough space to tailor its contents according to your own needs?	Insufficient Sufficient	1 2 3 4 5
1.3	Do you think the practical approach (working towards two concrete products) is useful?	Not useful Useful	1 2 3 4 5
1.4	Do you think the peer review / feedback sessions are useful?	Not useful Useful	1 2 3 4 5
1.5	Does the course have the right level of difficulty?	Too low Too high	1 2 3 4 5
1.6	What do you think about the balance: invested time / quality of your product?	Bad Good	1 2 3 4 5
1.7	What's your overall level of appreciation for the course?	Low High	1 2 3 4 5

Strong and weak points General course remarks

2. Content

2.1	How useful did you find the course material which was offered?	Unuseful Useful	1 2 3 4 5
2.2	How challenging did you find the assignments?	Boring Challenging	1 2 3 4 5
2.3	How clear did you find the assignments and course material?	Unclear Clear	1 2 3 4 5
2.4	How satisfied are you with the feedback on the 'elevator talks'?	Dissatisfied Satisfied	1 2 3 4 5
2.5	How satisfied are you with the creative exercises (mind map / dictionary exercise)?	Dissatisfied Satisfied	1 2 3 4 5
2.6	How satisfied are you with the 'metaphores' exercise?	Dissatisfied Satisfied	1 2 3 4 5
2.7	How satisfied are you with the general communication theory?	Dissatisfied Satisfied	1 2 3 4 5
2.8	How satisfied are you with the presentation theory and the film of Hans Rosling ('Debunking myths')?	Dissatisfied Satisfied	1 2 3 4 5
2.9	How satisfied are you with the writing theory and accompanying exercises?	Dissatisfied Satisfied	1 2 3 4 5
		Dissatisfied Satisfied	1 2 3 4 5

2.10	How satisfied are you with the interview workshop?	Dissatisfied Satisfied	1 2 3 4 5
2.11	How satisfied are you with the feedback on the try- out presentations?	Dissatisfied Satisfied	1 2 3 4 5
2.12	How satisfied are you with the feedback session on the articles?	Dissatisfied Satisfied	1 2 3 4 5
2.13	How important is presenting in front of a real 'lay' audience for you?	Unimportant Important	1 2 3 4 5

Strong and weak points Content

3. Lecturer

3.1	How satisfied are you with the supervision / support of Liesbeth de Bakker?	Dissatisfied Satisfied	1	2	3	4	5	
3.2	How clear was the teaching of Liesbeth de Bakker?	Unclear Clear			1	2	3	4 5
3.3	How inspiring did you find Liesbeth de Bakker as a lecturer?	Uninspiring Inspiring	1	2	3	4	5	
3.4	How satisfied are you with the contactability of Liesbeth de Bakker?	Dissatisfied Satisfied	1	2	3	4	5	
3.5	How satisfied are you with the guest lecturer of the interview workshop (Marnie Chesterton)?	Dissatisfied Satisfied	1	2	3	4	5	

Strong and weak points Lecturer

4. Learning aims / Competences

4.1	How adequate is your knowledge / skill now in terms of presentations for a lay audience?	Inadequate Adequate	1 2 3	4 5
4.2	How adequate is your knowledge / skill now in terms of writing a popular scientific article?	Inadequate	1 2 3	4 5
4.3	How adequate is your knowledge in terms of different target audiences?	Adequate		
4.4	How adequate is your knowledge / skill now in terms of giving feedback?	Inadequate Adequate	1 2 3	4 5
4.5	How adequately can you now convey your inspiration for your work?	Inadequate	1 2 3	4 5
		Adequate		
		Inadequate Adequate	1 2 3	4 5

4.6 Overall, how much have you learnt? Not much
1 2 3 4 5 A lot

Strong and weak points Learning aims / Competences

Any other comments you'd like to make …. ? (for more space p.t.o.)

Appendix 4

Personal evaluation presentations (Anna van Rijn / University Museum)

Can you please give me (the lecturer) insight into a couple of issues:

- Please write down a strong and a weak point of your own presentation (your personal opinion)

- What were the main comments from your public (strong / weak) ?

- Did you learn anything new during the experience of presenting itself?

- Did you find out what the public wanted to hear from you (need-to-know)? Please write it down in 5 sentences.

Appendix 5

Appendix 1: Concise feedback form (for reviewing the first version of the article)

Author / Title: ……Feedback from:

1. Read through the article in one go. Mark where the text reads smoothly and where reading is hampered. Text might be uninteresting, confusing or too difficult.

2. Please write down for the following categories what the strong and weak points of the article are. Add suggestions for improvement:

   a. Does the lead contain the right information (e.g. a summary and an incentive)?

   b. Is the focus (angle to the story) maintained throughout the whole article?

   c. Does each paragraph contain one main thought?

   d. Is there coherence within the text and each paragraph?

   e. Does the article have a clear (summarizing) ending?

   f. Is the most important information put first and the less important information placed more towards the end?

   g. Does the text read smoothly (a pleasant style and tone)?