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Development of an Analysis Tool to Promote the Communication of Knowledge about Nanotechnology

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Abstract

Nanotechnology is regarded as a key technology of the 21st century [1] and requires adequate communication of knowledge between teachers and pupils as well as between scientists and teachers. Therefore, the objective of this qualitative study is the development of an analysis tool to identify barriers within the communication between persons with different expertise.

The development of the analysis tool is based on the theoretical assumption that the personal view regarding new technologies is determined by the following four components: "key concepts and subject knowledge", "perception of risk", "beliefs and attitudes" and "understanding of nature of science" [2]. According to the Common-Ground-Theory [3; 4] successful communication between persons of various communities (e.g. experts and lay persons, scientists and teachers, teachers and pupils) can only appear in the overlapping areas of understanding, the so-called areas of common ground.

Based on the theoretical frame an interview study was conducted with scientists in the field of nanotechnology (N = 3) and biology teachers (N = 3). The interviews were analysed based on the paradigm of Meuser & Nagel [5; 6].

The findings demonstrate profound differences between scientists and biology teachers in respect to the component "key concepts and subject knowledge about nanotechnology". One of the core teachers´ misconceptions is to make the small size a subject of discussion only. In contrast the scientists specify that due to the small size the surface of nanomaterials increases and therefore changed characteristics can occur. However, significant differences in the other three components cannot be identified between the group of scientists and the group of teachers, but differences between the individual persons. In respect to the component "perception of risk" scientists as well as teachers estimate both the risks and the chances as being high. Although there are concerns expressed in the component of "beliefs and attitudes", all interviewed persons support the further development of nanotechnology.

1. Introduction

Nanotechnology is regarded as a key technology of the 21st century [1] and brings nowadays a rapid development with it. Nanomaterials can be significantly more reactive in comparison to the bulk material because of a greater surface to volume ratio [7; 8]. Because of their small size nanoparticles even can enter cells and may cause effects within these cells [8]. Due to the increasing use of nanomaterials in almost all areas of life it becomes more and more important to consider the risks and chances caused by these nanomaterials regarding to oneself, the society and the environment. However, the risk-research is lagging behind the production and marketing of nanotechnology [9]. Therefore, it is even more important to ensure an adequate communication of knowledge to enable consumers to assess the potential risks and chances of nanotechnology. This opens up following starting point for science education: Consumers should be conveyed at an early age to understand the potential risks and chances including the requisite subject knowledge. Hence, teachers in science education play a decisive role in communication about nanotechnology as acting as a link between researchers and pupils.

2. Theoretical Background

The development of the analysis tool is based on the theoretical assumption that the personal view regarding new technologies is determined by the following four components: "key concepts and subject knowledge", "perception of risk", "beliefs and attitudes" and "understanding of nature of science" [2].According to the Common-Ground-Theory [3; 4] successful communication between persons of various communities (e.g. experts and lay persons, scientists and teachers, teachers and pu-

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pils) can only appear in the overlapping areas of understanding, the so-called areas of common ground (figure 1).
The main interest of this study is to identify differences in the personal view of scientists and biology teachers in the field of nanotechnology. They form the basis of possible barriers, which might influence the communication between scientists and lay persons.

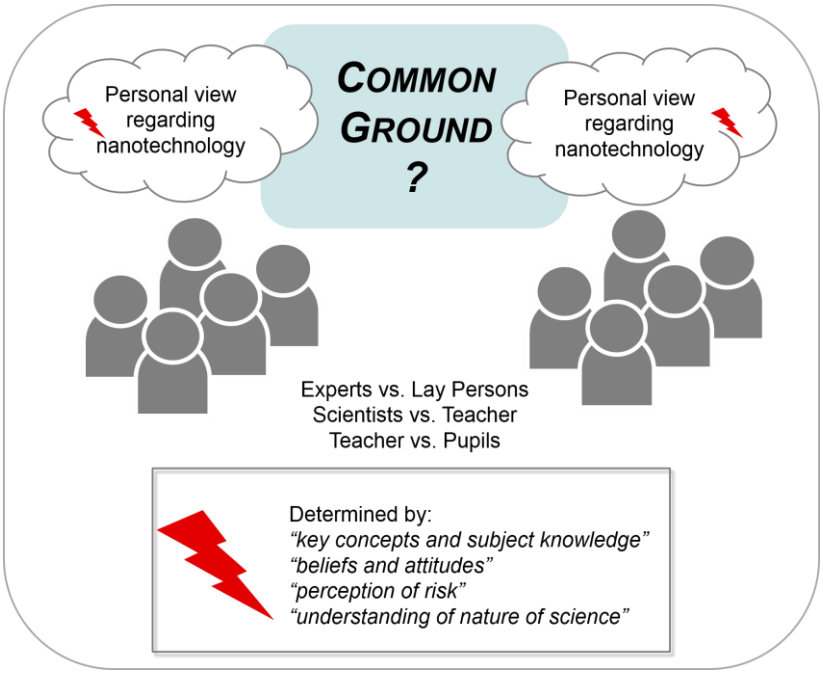

Figure. 1: Communication between persons with different expertise.

3. Design of Research

Based on the theoretical frame semi-structured interviews were conducted with scientists (N = 3) and biology teachers (N = 3) about the four mentioned components which may influence the personal view. The interviews were analysed based on the paradigm of Meuser and Nagel [5; 6], which focuses on thematic units and includes the following partial steps: 1. *Transcription* of the taped interviews, 2. *Paraphrase*: sequencing of the transcribed text according to thematic issues. 3. *Coding*: condensing the transcribed text by ordering the paraphrases thematically. 4. *Thematic comparison*: Within this step the focus is on finding thematically comparable passages from different interviews, which are tied together and coded with a category. This step enables to identify overlapping areas and as a consequence also differences in the personal views of the interviewees.

4. Findings and Discussion

4.1 Component "Key Concepts and Subject Knowledge about Nanotechnology"

Within the component "key concepts and subject knowledge about nanotechnology" following common category for thematically comparable passages can be identified within the interviews of the biology teachers: ***"comparative scale of size"*** [T1, T2, T3]. All teachers make the small size in the field of nanotechnology a subject of discussion and refer this to other sizes (e.g. the size of a cell, a molecule, visible spectrum). Also for the scientists a common category can be identified: ***"changed characteristics due to enlarged surface area"*** [S1, S2, S3].
The findings demonstrate profound differences between scientists and biology teachers in respect to this component. The teachers make the small size within the nanotechnology a subject of discussion only, whereas the scientist specify that due to the small size the surface area of nanomaterials increases and therefore changed characteristics can occur. These findings are consistent with the teachers' self-estimation, all of them described their subject knowledge as being limited. Additionally, it is striking, that the teachers make comparisons to sizes which are fa-

miliar to them. The use of comparisons with familiar terminologies indicates that the dimension of "nano" appears more tangible to them in this way.

4.2 Component "Beliefs and Attitudes"

To measure the beliefs and attitudes of the interviewees, the interviewer read aloud five statements (see table 1). Afterwards the scientists and the teachers should point out to what extend they agree and justify their agreement.

Table 1: Overview of beliefs and attitudes in the field of nanotechnology.

		Agreement (N) (strongly or rather)	
		Scientists	***Teachers***
a.	I am skeptical about the progressive development of nanotechnology.	*1* [S3]	*2* [T2+3]
b.	I have no concerns about the progressive development of nanotechnology.	*0*	*0*
c.	Based on the example of nanotechnology you can experience how many surprising new findings are possible. [10]	*3*	*3*
d.	Nanotechnology will provide amazing opportunities of technical development for us. [10]	*3*	*3*
e.	We should promote the nanotechnology, but also keep an eye on the risks. [10]	*3*	*3*

The findings demonstrate no remarkable differences between scientists and teachers in this component. The agreement or disagreement with regard to the statements b.-e. is identical for all scientists and teachers.

4.3 Component "Perception of Risk"

Within the component "perception of risk" following common category can be identified within the interviews: ***"great chances for oneself, society and environment"*** [S1, S2, T1]. The interviewed persons point out, that they see great opportunities for oneself, the society and the environment, even though they mention different fields and examples (e.g. medical field, economic perspective, computer technology, reducing environmental pollution). T2 comments the chances for oneself only, but says nothing about the chances for the society and the environment. T3 is much more skeptical. He points out, that in the end he has great hopes only directed to the medical field. Another common category which can be identified is ***"risk and state of not knowing"*** [S1, T1, T2, T3]. They consider the risks being high because they cannot be assessed yet.
The findings demonstrate no remarkable differences between scientists and teachers in this component as well.

4.4 Component "Understanding of Nature of Science"

Within the component "understanding of nature of science" following common category can be identified: ***"science generates knowledge"*** [S2, T2]. Another similar category is ***"science answers questions"*** [S1, S3, T1, T2, T3]. Afterwards the interviewees were asked about the differences between natural sciences and other disciplines. For S3, T1 and T3 the following common category can be identified: ***"theory vs. practice"***. They point out, that for them the natural sciences are more fact-orientated and tangible. It must be noted, however, that T3 in contrast to S3 and T1 is much more valuing the social sciences in a negative way. In his opinion the social sciences partly belong to science. In contrast S2 is the only one answering that all scientific disciplines do have the same approaches. Another question in the interviews referred to the importance of science in society. The following common category can be identified: ***"high importance of science in society"*** [S1, S2, S3, T2, T3]. With the exception of T1 all interviewed persons suppose that science has a high value in society. T1 is the only one who points out that science is not of significance for society, because science is too abstract for most people and they are only interested in the quintessence of science.

As well as in the components “beliefs and attitudes” and “perception of risk” the findings demonstrate no remarkable differences between scientists and teachers.

5. Conclusions

In summary, the findings demonstrate profound differences between scientists and biology teachers in respect to the component “key concepts and subject knowledge about nanotechnology”. However, significant differences in the other three components cannot be identified between the group of scientists and the group of teachers, but differences between the individual persons. Based on these findings a special attention will be on promoting the “subject knowledge about nanotechnology” to achieve an understandable communication between persons with different expertise. The aim of future research is to apply the findings in educational concepts for teaching nanotechnology in biology classes. They developed interview guideline is a successful analysis tool for the investigation of the prerequisites of communication.

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