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The Societal Dimension in German Science Education – From Tradition towards Selected Cases and Recent Developments

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This paper reflects the theory and practice of societal-oriented science education in the past and present of German science teaching. Starting from a quite unique German justification for more thorough societal-oriented science education and some historical reflections a model for socio-scientific issues-based science teaching will be presented. The model was developed and operated in the last ten years in Germany along many cases of curriculum design and classroom-based research. Along selected cases it will be discussed how the curriculum design and action research triggered innovation process contributes to theory development in the field of socio-scientific issues-based science education.

Keywords: science education, STS, socio-scientific issues, scientific literacy

INTRODUCTION

For many years now, science education in general and chemistry or physics education on the secondary level in particular have been described as not being very popular among students (Holbrook, 2008; Osborne & Dillon, 2008). One of the main reasons is seen in a lack in the students' perception of relevance of science learning resulting in low motivation (Holbrook, 2008, Jenkins & Nelson, 2005; Osborne, 2003). Consequently science teachers are constrained to make their science teaching more 'relevant' for the students (Holbrook, 2005; Newton, 1988). However, it is not always quite clear what is meant by making science education 'relevant' as it can take different pathways. Based on a broad analysis of the literature, Stuckey, Hofstein, Mamlok-Naaman, and Eilks (2013) recently suggested that the relevance of science education can be understood by three dimensions: individual, societal, and vocational relevance. Among this three it seems that the societal dimension of science education is often the most neglected one (Hofstein, Eilks & Bybee, 2011).

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This paper elaborates on the societal dimension of science education in the case of theory and practice of teaching science in Germany. The discussion will start with the unique central European concept of Allgemeinbildung (Klafki, 2000a) that in recent years slowly found its way into the international literature in science education (e.g. Fensham, 2004; Elmose & Roth, 2005; Hofstein et al, 2011, Sjöström, 2013). Some reflections will be given on initiatives and the state of the art of a societal view in German science education. In the center of the paper is the description of a German model towards socio-scientific issues (SSI)-based science education: The socio-critical and problem-oriented approach to science teaching (Marks & Eilks, 2009). The model was developed along many different cases (e.g. Marks & Eilks, 2010) that led to new curricular topics in science education (e.g. Stolz, Witteck, Marks & Eilks, 2013), new pedagogies (e.g. Marks, Otten & Eilks, 2010), and contributed to theory development in the field of SSI-based science education (e.g. Eilks, Nielsen & Hofstein, 2014). This paper puts

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State of the literature

- Relevant science education encompasses necessarily a societal dimension for developing scientific literacy in the students and preparing them for societal participation. However, the societal dimension of science education is often neglected.
- Socio-scientific issues provide a framework for motivating science education and the promotion of general educational skills.
- Models, examples, and theoretical resources are needed for innovations in science teaching and science teacher education.

Contribution of this paper to the literature

- The history of societal oriented science education in Germany is reviewed. The paper discusses the concept of Allgemeinbildung as another theoretical resource for justifying a more thorough societal orientation of science education.
- Some recent developments in German societal-oriented science education are reported. The paper discusses the socio-critical and problem-oriented curriculum model for science education as it was developed in Germany in recent years and led to several new pedagogies and resources for science education.
- Special foci are provided concerning criteria for reflecting societal issues for science teaching, the question of relevance of science education, and teaching and learning about the science-to-society link.

the suggested curriculum model into a historical context of German science education. It provides an overview about selected cases of curriculum design and classroom based research, as well as it reflects recent contributions to theory development in a joint format.

The Allgemeinbildung-based perspective on science education

A theoretical justification for a strong societal focus in science education can be derived from the central European tradition of Bildung (Sjöström, 2013). Since the late 18th century, this concept was developed in the German speaking part of Europe, neighboring countries and Scandinavia (Schulz, 2009). After essential contributions to the understanding of Bildung were hardly available in non-German language publications in science education for a long time the terms Bildung and Allgemeinbildung in recent years became increasingly recognized in the international literature (Elmose & Roth, 2005, Fensham, 2004, Hofstein et al., 2011, Krageskov Eriksen, 2002; Marks & Eilks, 2009; Mogensen & Schnack, 2010; Sjöström, 2013).

Allgemeinbildung inseparably bounds education to a democratic understanding of society. It defines all objectives of education under consideration of a societal perspective, for education in general but also for all school educational domains in particular – among them science education (Hofstein et al., 2011).

Within Allgemeinbildung, one part of the word, Allgemein (which can be translated as 'general') has two dimensions. The first dimension means to achieve Bildung as a specific set of skills for all citizens in a society independent from their ethnic, cultural, or socio-economic backgrounds. The second dimension aims at Bildung in all human capacities under inclusion especially of those skills necessary for coping with life in the society the students live and operate (Klafki, 2000a).

The part of the word Bildung is a more complex construct and not easy to explain without understanding its genesis. Until today there is debate which abilities Bildung should encompass and which orientation it should take. The first ideas of understanding Bildung refer back to the works of the German philosopher Wilhelm von Humboldt (von Humboldt, 2000, published originally in German 1793). These works stem from the late 18th century and thus encompass a tradition of more than 200 years.

Over the years, various scholars contributed to clarifying the concept of Bildung. The most important works for our contemporary theory of Bildung stem from the 1950s to the 1970s. In the 1950s and 1960s it was especially the works by the German scholar Wolfgang Klafki who tried to define and conceptualize a modern understanding of Bildung in the means of Allgemeinbildung. He suggested understanding Allgemeinbildung as the preparation of the young generation to live a self-determined life in a democratic society (Klafki, 2000a). Klafki described the overarching goal for any education that the young generation becomes able to recognize and follow their own interests in society and to behave within society as responsible citizens. Klafki conceptualizes this aim as development of capabilities for self-determination, participation, and solidarity within society. Because Bildung is more of a concept of achieving capacity and skills than a set of facts and theories to be learned, Bildung is viewed more as a process of activating potential than just a process of rote learning (Weninger, 2000, published originally in German 1952).

For operation in the curriculum or classroom, Klafki and others developed a tool called Didactical Analysis. This tool reflects upon whether a topic or issue is relevant enough to be taught in formal educational settings (Klafki, 2000b, published originally in German 1958). Didactical Analysis consists of a set of questions. It is suggested that the questions reflect whether a topic has relevance or personal meaning for the learner at present or in the future. This means that any topic selected for science education has to be relevant to the students' life now or in future as a means of raising their capacity for self-determination, participation in society, and solidarity with others.

The theoretical framework of Allgemeinbildung gives a strong justification for an inclusion of societal questions and issues in contemporary science education (Elmose & Roth, 2005; Hofstein et al., 2011; Sjöström, 2013). Dealing with societally relevant issues which are actually discussed is of importance to the lives of students in present society. Moreover, skills developed along these lines also will be important for societal debates and decisions concerning the development of students' future participation as responsible citizens (Roth & Lee, 2004). For this case, Klafki (2000b) raised the question of identifying key problems important to the individual and society. These key problems change throughout time. For example, one of our contemporary key problems is the question of climate change. Understanding climate change has the potential to enhance students' knowledge about an issue that is definitely relevant to and essential for their future. But this topic also has the potential to learn about how such an issue is handled within society and one can learn about the interplay of science with ecology, economics, politics, cultural beliefs and values (e.g. Feierabend & Eilks, 2010) and thus contribute towards Education for Sustainable Development (ESD), as e.g. definded by De Haan (2006).

Allgemeinbildung suggests an organizer on which topics are relevant for education (Klafki, 2000b). Many topics and contexts in science curricula are important for the domain from which they stem. For example, learning about specific laws governing thermodynamics can be helpful in later studying physics, chemistry, or engaging in an engineering career. However, taking the viewpoint of Allgemeinbildung, learning science with recognizing thoroughly the societal dimension will enable students to act better as responsible citizens in a modern society (Roth & Lee, 2004; Hofstein et al., 2011). This concerns all students whether they opt for a career in science and engineering – or not. In this means the theory of Allgemeinbildung supports the point of view of a Scientific Literacy for All instead of science learning only for selecting and preparing future scientists and engineers (Hofstein et al., 2011) as it also can be derived from similar frameworks, e.g. Activity Theory (van Aalsvoort, 2004).

German science curricula and the societal perspective

The roots of a thorough societal orientation of science teaching in Germany date back to the 1970s. Gerda Freise from Hamburg and the group SOZNAT (Naturwissenschaften sozial: science social) tried to promote a political perspective on science and technology as the driver for learning science (Ewers, Kremer & Stäudel, 1990; Freise, 1994). In this approach, the teaching of science was connected to the large political debates of the 1970s in Germany, e.g. the importance of more ecological consciousness, concerns about growing armament in central Europe, or the use of nuclear technology in military and non-military applications. However, this approach felt into a politically stressed atmosphere and was to a large extent quite ideologically based. Therefore a lot of resentment and animosity was provoked. As a result, there was a strong contra-movement not to politicize science education in general, and chemistry and physics education in particular (Ewers et al., 1990). As a result in most of the curriculum initiatives in the 1980s and 1990s a societal focus about chemistry and physics played only a minor role (Schenk, 2007), with less rejection in biology. In Germany in curriculum reform in biology ecological and societal questions were implemented, e.g., environmental protection. Anyhow, even in biology education reform did not lead to a full integration of a societal perspective in the means of socio-scientific issues at large (Ewers et al., 1990).

The debate of the 1970s promoted in the 1980s and 1990s a position in chemistry and physics teaching whereby more everyday life questions were suggested to be included (Behrendt & Just, 1997). However this was not accompanied by a thorough change in the focus and emphasis of the curricula. Science curricula and textbooks, at least in chemistry and physics, remained according to the structure of the discipline (Parchmann, Ralle & Demuth, 2000) and applications from everyday life and society were used only for illustration and motivation purposes (Schenk, 2007). Bigger debates from society played only a very minor role (Ewers et al., 1990). Learning about the interplay among science, the economy, ecology, and society did not find a prominent place in most of Germany's science classes or textbooks until today (Burmeister, Rauch & Eilks, 2012).

Following the German results in TIMSS and PISA around the year 2000, another wave of reforms was initiated. For the first time, Germany in 2004 set nationwide standards for science education (KMK, 2004). These standards are structured by four domains: scientific knowledge, the generation of knowledge in science, communication, and evaluation. The last two domains of standards explicitly ask for a stronger inclusion of societal perspectives in science education. E.g., level three in the domain 'evaluation' asks for the ability to "weigh arguments for the evaluation of an issue from different perspectives and to reflect upon decision making processes". More specific in the chemistry domain, e.g. one standard suggests "The pupils discuss and evaluate societal relevant statements from different perspectives".

What is the status today? Until today, science teaching in Germany in general and in chemistry and physics in particular is still criticized as being too strongly focused toward the structure of discipline approach, and with too low connection to the students' lifeworld and the society they live and operate in (Fischer et al., 2005; Ostermeier & Prenzel, 2005). Although there have been ideas published in teacher journals which aimed at promoting a stronger orientation toward everyday life topics, technical applications, or societal issues, the application in science classrooms is still rare (Hofstein et al., 2011; Schenk, 2007).

However, some indication of change can be found. These changes which were driven by a wide recognition of projects and classroom materials based on context-based science education having been suggested in parallel to the post-PISA reforms. Many of the contexts and exemplary units, e.g. suggested by the project Chemie im Kontext (Nentwig et al., 2007), include societally relevant questions and issues, some of which even begin with a societal point of view. Similar projects were also conducted in biology and physics education. A related approach was also driven by the German parts of the PARSEL and PROFILES projects (Gräber & Lindner, 2008; Bolte et al., 2012). Both projects aim at raising the perception of relevance of science education by including a societal perspective. The maybe most thorough societal approach in recent years was the framework of a socio-critical and problem-oriented approach to science teaching suggested since 2000 by Eilks et al. (e.g. Eilks 2002; Feierabend & Eilks, 2011; Marks, Bertram & Eilks, 2008; Marks & Eilks, 2009; 2010). This approach tries to implement science teaching according to the international movement of socio-scientific issues-based science education as discussed e.g. by Sadler (2011).

Socio-critical and problem-oriented science education in Germany

Based on the development of a lesson plan on learning about Biodiesel usage from a chemical and societal perspective about fifteen years ago Eilks (2000, 2002) described a new conceptual approach to teaching chemistry in Germany. It was entitled "A socio-critical and problem-oriented approach to chemistry teaching". The approach itself fits into the SSI-based science education movement (Sadler, 2004; 2011). The objective was promoting students' attitudes to chemistry and chemistry teaching, and fostering a broad range of domain-specific and general educational goals. The educational intention was to promote chemistry education thoroughly in the sense of "Allgemeinbildung" as described above (Marks & Eilks, 2009).

The core objectives of the socio-critical and problem-oriented approach to science teaching were suggested to be, as cited from Eilks, Marks and Feierabend (2008):

"to increase students' interest in science and technology, and to display the relevance of science in societal discussions and decision-making,
to make the students aware of their own interests, to motivate students to develop self-interest (either as consumers or within political decision-making), and to stimulate individual decision-making processes,
to promote students' competency in the critical use of information and in their reflection upon why, when and how science-related information is used by affected groups or for public purposes, and
to promote student-active science learning motivated through relevant and contentious socio-scientific issues."

Various examples were developed and researched in the classroom based on the model of Participatory Action Research in science education (Eilks & Ralle, 2002). From reflecting different cases, e.g. on Biodiesel usage (Eilks, 2002), low-fat- and low-carb-diets (Marks et al., 2008), or musk fragrances in shower gels (Marks & Eilks, 2010), a coherent conceptual framework was derived leading to a coherent model for SSI-based science education in Germany (Marks & Eilks, 2009; Figure 1).

The framework sets the focus in Allgemeinbildung and Scientific Literacy for All to broaden up the general educational goals approached by the teaching. Aside the learning of some essential science knowledge and skills, a special emphasis is suggested for focusing multidimensional evaluation and communication skills. The aim is contributing preparing the students in the future to participate on societal debate and decision making processes. It is suggested that all the lessons plans centre round authentic and relevant topics being controversially discussed in society. The topics need to be undetermined in a socio-scientific respect. It is suggested to be necessary that authentic differences of opinion can be expressed during debate in the classroom. These differing perspectives are suggested to provoke questions and open discussions among pupils.

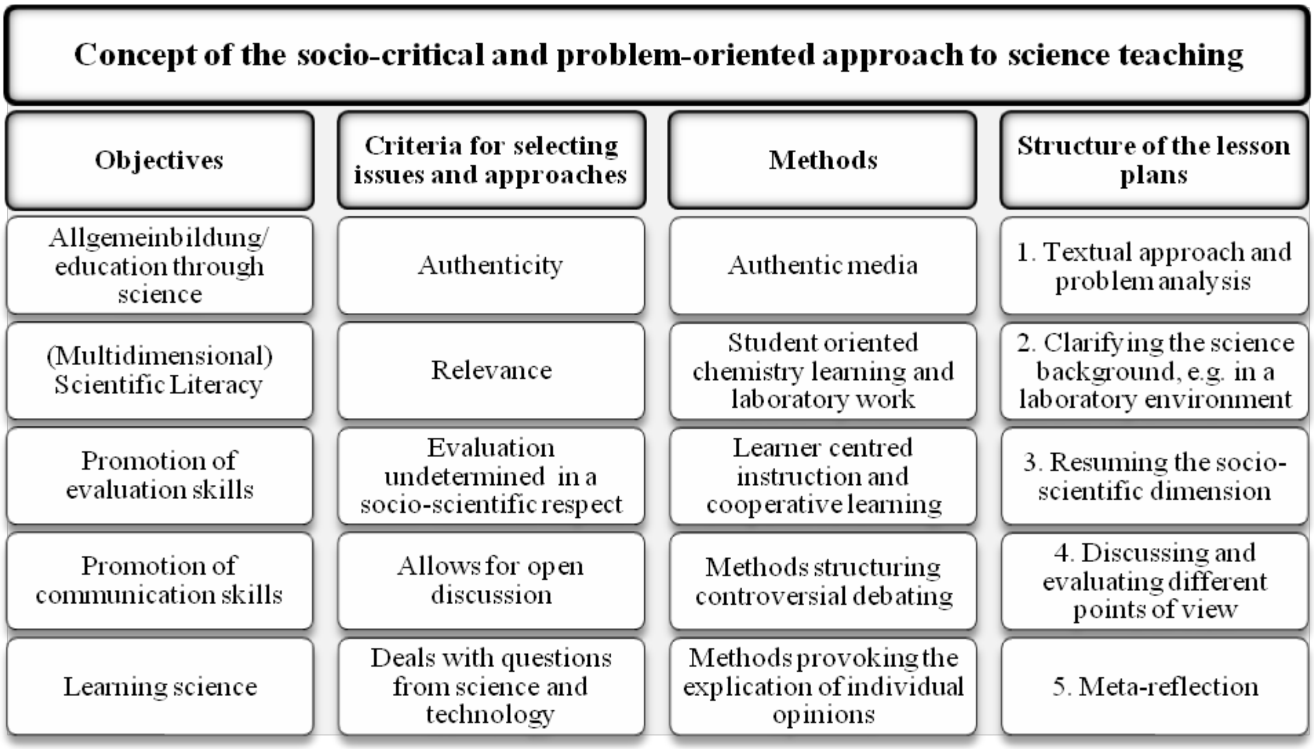

Figure 1. Conceptual framework of the socio-critical and problem-oriented approach to science teaching

The approach towards the topic is structured along media artefacts to derive questions on the scientific background as well as on the societal dimension of the issue, e.g., newspaper articles, brochures printed by pressure groups, or reports broadcasted by TV stations. Lesson plans are structured using methods of open, learner-centred instruction, e.g. forms of cooperative learning. Discussion techniques are implemented to draw out and encourage different points-of-view, to recognize exactly how contrary various opinions can be, and to see how such points-of-view are presented, promoted and manipulated within society at large. Pedagogies are applied that challenge the students to make up their own minds and express their opinions on the topic in an open forum. Such conditions make it possible to express one's personal point-of-view without being judged, censored or condemned as an outsider by the rest of the group.

In the end a five step model is suggested: (I) The lesson plan starts with a textual approach and problem analysis to derive questions on the topic that encompass a scientific perspective as well as questions from the individual and societal domain. (II) In a second phase the science background is clarified with respect to the level of student understanding and if possible under inclusion of practical work. (III) The socio-scientific dimension is resumed in the means of a reflection to which extend scientific information can support individual or societal decisions. (IV) The way towards individual decisions is mimicked by explicating, evaluating and comparing various points of view and different perspectives on the issue. Finally, (V) a meta-reflection is done on the way how information and different points of view are presented, discussed and used in the public.

One example may illustrate the model. In 2008, Marks et al. reported about a case study on a lesson plan focusing the chemistry of fats and carbohydrates from a chemical and societal perspective. The public debate about low-fat and low-carb-diets was the socio-scientific issue driving the lesson plan. In the life-world of the students, books and journal reports are present for both diets, and products containing less fat and less carbohydrates are advertised accordingly. Nevertheless, there is no clear proof as to whether these diets work and work well. The lessons start from authentic advertisements for light potato crisps and conventional crisps. Students are asked to reflect what the advertising is about, and whether the arguments are reliable from a scientific point of view (e.g. concerning the caloric value). The students learn about the nature of fats and carbohydrates and measure the fat and carb content of different sorts of potato crisps in the laboratory. Calculations about the calorie value are done and the advertisings are reflected. The lesson continues to examine how the issue is handled in a societal debate. A role play mimicking a TV-talk show on low-fat- and low-carbohydrate-diets is implemented. The students learn how different stakeholders (producers of crisps, producers of light products, nutrition experts, or marketing experts) are arguing about their position towards the issue. The students learn that in order to understand the issue background knowledge in science is necessary. They learn that arguments from science can be the basis for understanding a topic, but that decision about such an issue always is also influenced by information and interests of different stakeholder groups. The students also recognize that a socio-scientific decision, on e.g. the consumption of light or regular potato crisps, is multidimensional including different individual and societal perspectives.

Many case studies were published inspired by this framework. Aside those mentioned above further examples e.g. focused bioethanol usage (Feierabend & Eilks, 2010), teaching climate change (Feierabend & Eilks, 2011), bioplastics (Burmeister & Eilks, 2012), or tattooing (Stuckey & Eilks, 2014). In all of the cases the highly motivational character of socio-scientific issues in the science classroom was described. In many examples indicators were found that such an approach contributes to students' skills in communication and evaluation about socio-scientific issues. It was suggested that socio-scientific issues operated under this framework have great potential contributing the development of students' critical thinking skills. However, the development didn't stop with the model. The model inspired further research, e.g. into the characteristics of socio-scientific issues (Stolz et al., 2013) or the question of relevance in science education (Stuckey et al., 2013). Some of these aspects will be discussed below.

Selected contributions to theory development in societal-oriented science education

Criteria for reflecting socio-scientific issues for science education classroom use

The question of how to select and operate suitable contexts for context-based science curricula is still an issue of debate (De Jong, 2006; Gilbert, 2006). However, the question which issues are the most promising to promote SSI-based science learning is also not fully operationalized (Sadler, 2004; 2011). In 2009, Marks and Eilks suggested five criteria: 1) authenticity, 2) relevance, 3) open-endedness with respect to societal questioning, 4) being openly discussable in a public forum, and 5) having a clear-cut relationship to science and technology. Originally these five criteria were thought to guide the teacher or curriculum designer in selecting potential topics to be used as a socio-scientific context for science education.

However, in the practice of curriculum development and classroom teaching it became clear that it would be of value to extend the initial outline of the criteria with a clear and testable description to avoid post-hoc justifications for unsuitable topics. Along the development of a new lesson plan aimed at operating doping as a controversial SSI to frame the learning about doping substances and analytical chemistry (Stolz et al., 2013) the development of respective criteria were put into focus.

In reflection on the case of doping as a driver for societal oriented science education – together with an analysis of all the previous examples - the criteria suggested by Marks and Eilks (2009) were refined and operationalized into provable criteria. Table 1 summarizes this discussion of all the five criteria and gives a clear description for all of them including a testable criterion (Stolz et al., 2013). In the resulting framework it was suggested that the authenticity of a topic for society and the life-world of the students can be tested whether it is broadly available in those media mirroring the mindset of society. The question of relevance was operationalized in analyzing potential individual and public decisions by scenarios to whether they impact the present or future lives of the students, e.g. by legal restrictions. The question to whether an issue is undetermined in a socio-scientific respect can again be answered by analysis of the mass media. The analysis will show whether different points of view are available and substantially supported by relevant groups in society. However, debate in classroom only will come up if the topic can be openly discussed. Thus an analysis of all available arguments from the media is made whether their use within the classroom discussion will insult individual students, religious or ethnic groups. Finally, whether a question is related to science and technology can be tested by looking on the public debate in the media whether scientific facts, techniques, or arguments are used to support any of the points of view. Table 1 gives an overview about the criteria and how they can be operated on the above described example about low-fat- and low-carb-diets.

The societal component in a multi-perspective view on relevance in science education

The model presented in Figure 2 (Marks & Eilks, 2009) suggests the relevance of a topic for the life of the students and the society she or he is living in as a selection criterion for a societal issue. Using and reflecting this criterion within the given framework inspired the search for clarifying what is meant by the term 'relevance' in the case of societal-oriented science education in particular and science education in general.

Based on a review of the literature (Stuckey et al., 2013) and connected to a lesson plan development on tattooing (Stuckey & Eilks, 2014) theoretical contributions to the understanding of the concept of relevance in science education were developed. Stuckey et al. (2013) suggest understanding relevance in the means of consequences. Such consequences of learning science (or not) can lie in the students' present life or in the future. It was also found that the understanding of

Table 1. Reflecting potential topics for SSI-based science education as suggested by Stolz et al (2013) and illustrated by the example "Low-fat- and low-carb-diets" as discussed above

Criterion	Description and testing	Example: " Low-fat- and low-carb-diets "
Authenticity	The topic is authentic, when it is currently being discussed by society. Test: Common media is checked for presence of the topic, e.g. newspapers, magazines, TV, advertising, ...	At the time the lesson plan was developed debate about the effects of low-fat- and low-carb-diets was present in magazines or talk-shows on TV. Many magazine covers took titles such as "Does fat really make fat" or "The diet-revolution".
Relevance	The topic is relevant, if respective decisions will affect the current or future lives of our students. Test: Scenarios on potential decisions are tested to see which impact they will have e.g. consumer behavior or behavioral choices.	Healthy nutrition and whether to opt for a diet has direct consequences to the human body as well as the perception of a person by others. Opting for a diet has direct impact on eating and consumer behavior of a person. Nutrition also has long term effects on health and the attitude to life.
Evaluation undetermined in a socio-scientific respect	The evaluation allows for different points-of-view. Test: Media is analyzed whether controversial viewpoints are represented (by interest groups, the media, politicians, scientists, etc.).	Reports in the media discuss successes, miss-successes and risks of diets. Several opinions are available which diet one should to take or whether to take any at all. Advertisers, nutrition experts, or authors of diet-books use many different pints of view.
Allows for open discussions	This topic is able to be discussed in an open forum. Test: Thought experiments test arguments to make sure that no individuals, religious or ethnic groups would feel themselves to be insulted or pushed to the fringes of society by their use.	As debate about the use of different diets is open it is the question which weight (e.g. in the body-mass-index) a person should have. One can have different points of view what a healthy weight for a person is about if it does not fall into extremes. As long there are students in class with diseases like anorexia, debate in the classroom will be possible.
Deals with an issue based on science and technology	This topic concerns itself with a techno-scientific query. Test: Discourse in the media is analyzed. The question is raised, whether scientific facts and concepts are addressed and either explicitly or implicitly used for argumentation.	The composition of fats and carbohydrates are questions of chemistry, as nutrition is a question of biology and medicine. References to the caloric value and the ingestion of different sorts of food are used as arguments for certain sorts of diets.

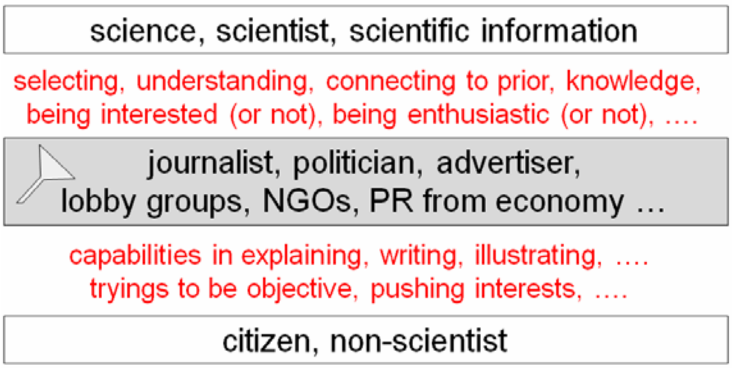

Figure 2. *The doubled filtering process of scientific information transfer*

relevance can be operated in three dimensions: individual, societal, and vocational relevance. It is also suggested that many consequences might be beyond the students' actual interest and understanding. This leads to extrinsic aspects of the relevance of science education, e.g. the parents' interest that students take a wide range of courses to have the broadest possible chances in future to continue good education and having different career options. The suggested model implies that relevance has a broader meaning than just contributing to meaningfulness or orienting science education along the present interests of the students. The model can be used as a tool to reflect whether science teaching, curricula, or textbooks come up with all the potential dimensions of relevance in a balanced way and according specific groups of students and their grade level. Hope was expressed that some lesson plans might even contribute all the three dimensions in a balanced way (Stuckey et al., 2013).

Topics explicitly dealing with all the three dimensions encompassing a view on students' present life and their future might be the most promising ones for raising the perception of relevance of science education among students. A case with potential for touching all the three dimensions of relevance was seen in the issue of tattooing practices in modern Western societies (Stuckey & Eilks, 2014). Tattooing is an issue encompassing all the three dimensions both in a present and future meaning. Also intrinsic and extrinsic aspects construct the three dimensions. In the personal domain the students are confronted with decisions whether to get a tattoo or how to react to tattoos of others in their today's and future life. Tattoos can represent a visible social statement which, in turn, can influence individual circumstances where others do not support the same views. It is also controversial in society under which conditions (from which age) tattooing should be allowed or whether health costs caused by tattooing should be covered by society. And finally, tattoos have present and future vocational implications. It can offering career chances as tattoo artist or in the medical arena, but tattoos can also limit career chances in some areas (e.g. bank assistant, insurance agent etc.) where employers do not hire people with visible tattoos. Also the above described example on low-fat- and low-carb-diets is connected to all the three dimensions. Nutrition and its effects on the human body are individually relevant for present life and future health. Food products and advertising is discussed in society and the perception of the individual in society is not independent from eating behavior and body shape. Food supply and industry offers a lot of career chances as the personal fitness will impact chances to get and operate certain professions.

Concerning the issue of tattooing, a lesson plan was developed by Participatory Action Research (Eilks & Ralle, 2002). The lesson plan deals with inquiry-based learning into tattoo inks of various origin and quality according to the model of socio-critical and problem-oriented science education (Marks & Eilks, 2009) and focusing a multi-dimensional view on relevance (Stuckey et al., 2013). A case study was performed in grade-9 (age range 14-15) compulsory science education. After implementation of the teaching unit on tattooing the focus of the study was to investigate into the perception of relevance of this kind of lesson plans networking the societal dimension of science education with individual and vocational relevance and to whether this lesson plan is especially motivating to the students. The data gathered in this case study together with the classroom observations showed a highly motivating lesson plan. The data showed a significant change in students' motivation. This change was mainly caused by the perception of relevance of the topic (Stuckey & Eilks, 2014).

Modelling society's use of scientific information in societal debates

Coming from the use of role play to understand the use of science-related information in societal debates (e.g., Eilks 2002; Marks et al., 2008) the search for a model was started to better understand and explain how information from science comes into its use in society. This development was driven along different cases of curriculum development under the here described framework and it was inspired by the development of new pedagogies to be operated (e.g. Marks et al., 2010).

The central idea for the development of the model was that most science-related information the vast majority of our students will come into contact with are not directly taken from the domain of authentic science. In consuming popular science magazines or newspapers the reader is no longer dealing with original scientific information; sometimes, e.g. in local newspapers, the information is not even processed by scientists who are experts in the particular area in question (Eilks et al., 2014). At the same time, mass media in general or e.g. advertising in particular have a strong impact on young peoples' lifestyle, behavior and view on science (Villani, 2001, Halford et al., 2003; McClune & Jarman, 2012).

Based on the philosophical works of Ludwik Fleck (1935) and as discussed in Bauer (2009) scientific information can be understood as a marked-off field of science activity surrounded by domains starting with academic books, via a public understanding of science media, towards society. There are gradients of concreteness, simplification, certainty of judgment, and controversial reception coming from one of the domains to another (Eilks et al., 2014). To become skillful in contributing societal debate on SSIs the learner needs some understanding of the basic science behind the issue. However, the responsible citizen also needs knowledge and understanding about how the information comes into societal discussions. In the public, scientific information is mainly presented by special interest groups, politicians, journalists or any other societal player. Every citizen is confronted with this kind of information that was named in Hofstein et al. (2011) as filtered information. To value the respective information one needs to understand who were the individuals or groups that processed the selecting, simplifying, and interpreting of the information from the science to the public. Frequently, it is just as – if not more - important to understand which pathway the information followed and which interests have played a role in the transfer of this information.

For educational purposes, a model of a double-filter mechanism was suggested for understanding information transfer in society and to teach about it as it is represented in Figure 2 (Eilks et al., 2014). Understanding this double-filtration is directly related to understanding how to (re)act towards such information. This is true, for example, in the case of determining the credibility of an information source. This includes working out various strategies like, e.g. self-consciously contrasting different pieces of information quite possibly stemming from sources with diametrically opposed interests.

In the example on low-fat- and low-carb-diets discussed earlier in this paper the lesson plan (Marks et al., 2008) started with advertisings about different sorts of potato crisps. "Light crisps" are advertised, e.g. by slogans like 30% less fat. This slogans led into investigations of different sorts of potato crisps, however also reflecting that 30% less fat does not mean 30% less calories. The students started reflecting that advertisers on purpose prefer using "30% less fat" than using "10% less calories" of which both claims are true. The use of scientific claims in advertisings for both various sorts of potato crisps as well as different diets is reflected during the lesson plan as it is the way how such information is used and operated by different actors in society.

Connecting the model in Figure 2 and the socio-critical and problem-oriented approach to science teaching suggested the mimicking of authentic societal practices of socio-scientific information handling and transfer to become a part of science lessons (Marks & Eilks, 2010). From different societal practices of information handling various alternative pedagogies were derived. Such methods were inspired, e.g. by the working of a journalist where the students are asked to write a news report on the controversial topic, as if they were working in the editorial pool of newspaper or TV news magazine (Marks et al., 2010). Other recently developed examples mimic e.g. the work of consumer test agencies (Burmeister & Eilks, 2012) or advertisers (Stuckey, Lippel & Eilks, 2012; Belova & Eilks, 2014). Also analyzing dialogues from everyday life or puzzling them based on given quotes of different potential persons involved (students, parents, salesman, consultant) proofed to be very appropriate for reflecting information use in public communication (Eilks et al., 2012).

In respective evaluation case studies (e.g. Burmeister & Eilks, 2012; Marks & Eilks 2010), these instructional techniques proved to be very motivating. The lesson plans allowed the students to learn about different examples of socio-scientific information handling by individuals and society at large, a meta-reflection on the model of information filtering helped them to better understand the mechanism behind. The students' feedback gives initial evidence that they became more reflective and critical about them (Eilks, 2002, Burmeister & Eilks, 2012). Some of the students explicitly recognized having learned that the knowledge about the information transfer can have a bigger influence on how the information appears to the reader/listener than the information itself might have (Eilks, 2002).

CONCLUSION

This paper reflects the societal dimension of science education from a German perspective. In the international literature it is clear that a societal component is a necessary element of science education relevant to all students (Holbrook & Rannikmae, 2007; Stuckey et al., 2013). This point of view is supported by several theoretical frameworks, e.g. Scientific Literacy for all students (Osborne & Dillon, 2008) or Activity Theory (van Aalsvoort, 2004). However there is also a unique central European tradition to support a more thorough societal view in science education: Allgemeinbildung (Klafki, 2000a). This theory supports the international perspective (Hofstein et al., 2011) and contributes step by step the international debate about the role of a societal perspective for contemporary and relevant science education (Hofstein et al. 2011, Roth & Lee, 2005; Sjöström, 2013; Stuckey et al, 2013).

This paper discusses that there are some unique Central European traditions in societal oriented science education. However, application in the classroom is neglected in Germany, as it is in many other countries (Hofstein et al., 2011). Nevertheless, there are recent contributions to strengthen societal perspectives in science education in Germany from a context-based point of view (Nentwig et al., 2007) or in the means of SSI-based science education (Marks & Eilks, 2009). Research-based curriculum design following the later concept based on many different cases of Participatory Action Research (e.g. Marks & Eilks, 2010; Eilks & Feierabend, 2013) led to a coherent framework for SSI-based science education in Germany (Marks & Eilks, 2009).

This framework and the respective curriculum model was operated in different schooling levels as well as different science subjects and proved to be of potential to raise motivation and the perception of relevance of science education (e.g. Feierabend & Eilks, 2010; Stuckey & Eilks, 2014). The focus of this curriculum model is suggested of particular importance for the lower secondary schooling level before students might get the choice to withdraw from science courses. In nearly all cases of curriculum development insoired by the described curriculum framework connections were made to the official school curriculum and governmental syllabi to allow the teachers for integrating a thorough societal perspective on science into their regular classes. However, currently the framework is also adopted for projects of educational innovations by linking the non-formal and formal educational sectors (Garner, de Lourdes Lischke, Siol & Eilks, 2014). However, this paper also shows how such Action Research triggered innovation can help to further develop theoretical models to support curriculum design and classroom development e.g. concerning understanding the character of SSI's for the classroom, a concept of relevance in science education, or the learning about the role of science related information for public purposes (Eilks et al., 2014; Stuckey et al., 2013).

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