Chemistry Education Research and Practice

Accepted Manuscript

This is an *Accepted Manuscript*, which has been through the Royal Society of Chemistry peer review process and has been accepted for publication.

Accepted Manuscripts are published online shortly after acceptance, before technical editing, formatting and proof reading. Using this free service, authors can make their results available to the community, in citable form, before we publish the edited article. We will replace this *Accepted Manuscript* with the edited and formatted *Advance Article* as soon as it is available.

You can find more information about *Accepted Manuscripts* in the Information for Authors.

Please note that technical editing may introduce minor changes to the text and/or graphics, which may alter content. The journal's standard Terms & Conditions and the Ethical guidelines still apply. In no event shall the Royal Society of Chemistry be held responsible for any errors or omissions in this *Accepted Manuscript* or any consequences arising from the use of any information it contains.

ROYAL SOCIETY OF CHEMISTRY

www.rsc.org/cerp

Chemistry Education Research and Practice RSCPublishing

ARTICLE

Learning with and about advertising in chemistry education with a lesson plan on natural cosmetics – A case study

Cite this: DOI: 10.1039/xoxxoooooox

Received ooth January 2012,
Accepted ooth January 2012

DOI: 10.1039/xoxxoooooox

www.rsc.org/

Nadja Belova[a] and Ingo Eilks[b]

This paper describes a case study on the chemistry behind natural cosmetics in five chemistry learning groups (grades 7-11, age range 13-17) in a German comprehensive school. The lesson plan intends to promote critical media literacy in the chemistry classroom and specifically emphasizes learning with and about advertising. The lessons of four lesson periods encompass several strategies for evaluating and creating advertising. Evaluation was carried out using a questionnaire with both open-ended and Likert-type questions. Classroom observation protocols were also analyzed. The lesson plan proved to be very motivating and it initiated intense discussions about chemistry and science-related information in advertising. The findings of this study indicate that the lessons triggered self-reflection on students' consumer behavior. Most of the younger pupils saw advertising as a suitable and important topic for the science classroom. More advanced students tended to regard such issues as an interesting, but in some cases an unnecessary, part of their science education. Findings from the different groups are compared. Future research directions are also considered.

1. Introduction

Cosmetics play an important role in our everyday lives. However, the variety of different products and brands can appear confusing to consumers. Products vary from basic, indispensable, everyday items such as soaps, shower gels and shampoos to decorative cosmetics and high-end skin creams with specific, 'innovative' ingredients for every skin type imaginable. Cosmetic products create a broad market worldwide, earning roughly 72 billion Euros in European sales revenues and 47 billion Euros in the USA in 2013 alone (Cosmetics Europe, 2014). Just like every other market, the cosmetics industry is impacted by trends. Every now and then, the demand for specific products, product groups or specific ingredients increases. In recent years, one trend has been a shift towards 'natural' cosmetics, whereby a whole range of products is touted as 'natural'. Some of these so-called 'natural' products contain a certain amount of plant-based and/or organically grown ingredients, while others receive their label thanks to a lack of particular chemicals like silicones. In Germany, sales revenues of 'natural' cosmetics (meaning products with any kind of corresponding labels) have increased from 600 million Euros in 2007 to 920 million Euros in 2013 (EHI Retail Institute, 2014). Yet neither the European Union nor the USA has a binding, clearly specified definition for the term 'natural cosmetics'. No national or international definitions of what 'natural' cosmetics are supposed to be exist. Only a few non-obligatory guidelines can be found (Council of Europe, 2000; U.S. Food and Drug Administration, 2010).

There seems to be a public perception that skin and hair products need to be as 'pure' as possible: 'The less chemicals, the better'. Some 'natural' products are even advertised with claims stating they are completely 'chemical-free'. Advertising for 'natural' cosmetics often emphasizes a product's lack of certain potentially harmful ingredients or publicly criticized raw materials, such as silicones, parabens and palm oil. Different labels are used to promote certain products. However, the criteria used to award such labels are often unclear. If criteria are stated, they regularly refer explicitly to chemicals either used or avoided. For this reason, advertising for 'natural' cosmetics often contains chemistry-related information which can only be identified and understood by scientifically literate consumers. This makes advertising in the context of natural cosmetics a fruitful topic for promoting critical scientific media literacy in the chemistry classroom. It also has the potential to make chemistry learning more meaningful to learners and more personally and societally relevant (Stuckey, Mamlok-Naaman, Hofstein & Eilks, 2013). This is because knowing about and understanding the use of chemistry in advertising may directly impact students' consumer behavior.

This paper describes a case study on a teaching and learning module about natural cosmetics which was undertaken in five chemistry learning groups (grades 7-11, age range 13-17) in a German comprehensive school. The module explicitly focuses on cosmetics advertising and aims to reveal the chemistry-related aspects behind advertising, thereby promoting critical scientific media literacy. It encompasses several methods for explicitly structuring learning with and about advertising, while also including subject matter learning on the basic ingredients of cosmetics and their functions.

2. Background and framework

Science education at the primary and secondary schooling level is suggested to make students scientifically literate citizens (Bybee, 1997). Accordingly, chemistry lessons should seek to promote the development of general educational skills via contention with topics selected from science and technology (Holbrook & Rannikmäe, 2007; Sjöström, 2013). Relevant science education should cover a broad range of goals, including preparation to live an individual, responsible, and self-determined life in the society (Elmose & Roth, 2005; Stuckey et al., 2013; Hofstein, Eilks & Bybee, 2011).

Acting and participating in society requires skills for dealing with the media offers surrounding us (Buckingham, 2003). Today, mass media is one of the main channels for students and citizens to access information. This encompasses understanding and reacting to scientific aspects presented by the media (Chang Rundgren & Rundgren, 2014). Usage of for learning in the school context can be performed in different ways. On the one hand, students can learn with or through media (e.g. using newspapers or the Internet as information resources). On the other hand, they can learn about the media, for example about who selects information offerings and how such packages are presented to the public (Eilks, Nielsen & Hofstein, 2014).

Media literacy found its way into curricula and classrooms in many countries around the middle of the 20th century (Holmes, et. al., 1947). This was mainly done to provide students with skills to protect themselves from the influence of the rapidly growing media world (Hobbs & Jensen, 2009). In 1982, nineteen nations officially acknowledged their responsibility to providing media education programs to young people by signing the 'Grunwald Document' at the UNESCO International Symposium on Media Education (UNESCO, 1982). In 2006, two main dimensions of media literacy were outlined by UNESCO: 'reading' media (understanding media communication) and 'writing' media (creating one's own media products). Other media literacy definitions (European Commission, 2007; Scheibe & Rogow, 2012) specify similar dimensions. Four concrete goals of media literacy which can often be found in the literature are accessing, analyzing, evaluating and creating media (Hobbs, 2003).

In line with the growing importance of media literacy in general, 'science in the media' has also become an emerging field in science education research. However, media education coverage in the science subjects still remains limited in scope. So far, most of the research on media in the science classroom focuses on news media (McClune & Jarman, 2012). Researchers have shown that when it comes to everyday media, science teachers mostly use only print-based news media in their lessons (Klosterman, Sadler & Brown, 2012). However, the overall media landscape is much broader and also encompasses entertainment media, public communication, a whole range of digital media and, finally, advertising in connection with all of them. All of these media sources quite frequently have references to science and technology.

When transferring the main goals of 'reading' and 'writing' media literacy to the science classroom, there is a need to provide students with skills which allow them to critically evaluate media offers and gain competence in understanding the socio-scientific issues debated in both the news media and the public arena (McClune & Jarman, 2012; Stuckey et al., 2013). In order to cope with media in the science classroom, Chang Rundgren and Rundgren (2014) suggest the concept of 'scientific media literacy', a combination of scientific literacy and media literacy. One important aspect of scientific media literacy is understanding how media products are created and how scientific knowledge is incorporated into them (Eilks, Nielsen & Hofstein, 2014).

To illustrate how science-related information in the media and advertising is transformed and filtered, Belova and Eilks (2014) recently adopted a model of filtered information in advertising based on Stuckey, Heering, Mamlok-Naaman, Hofstein and Eilks (2015) (see also Eilks et al., 2014). This model describes the information transfer from science into advertising, while at the same time providing justification for the fact that critical perception requires more than just understanding the content behind advertisements. Presenters of science-related information in the public primarily follow the basic principles of journalism, scientific accuracy often lags behind (Hansen, 1994). This is even more the case when they are dealing with advertising. Besides a recognition of content reliability, an understanding of how and by whom the information was transferred into advertising is needed. This claim provides sound justification for implementing learning about advertising in science education programs.

Additional arguments for a more thorough implementation of advertising in the science classroom can be gained from research on media impacts on young peoples' perceptions of science. For instance, Dhingra (2003) has shown that television-mediated science is a 'significant force' (p. 234) and that it influences students' views on the nature of science. She points out that different television programs provide students with different pictures of the nature of science. On the other hand, scientific knowledge has been shown to lead to a more critical, skeptical view of media information (Hove, Paek & Isaacson, 2011). There are good reasons for assuming that the way science is presented in advertising also contributes to these views. Consumer research reveals that even advertising aimed at adults has many effects on the younger generation. Interest in the products advertised and entertainment value belong to this aspect, although children and young people lack in-depth

understanding of the ads (Constandinidou-Semoglou, 2007). For a more detailed analysis of the multifaceted connection between science education and advertising see Belova, Chang Rundgren and Eilks (in print).

Concerning learning about advertising, UNESCO defined the concept of 'advertising literacy' as a part of media literacy (UNESCO, 2011). Different modules were suggested which relate to the development of advertising literacy (UNESCO 2006, 2011). However, reflecting the (scientific) content behind advertising does not play any significant role in these modules. In the extensive UNESCO curricula, buzzwords like 'misleading claims' or 'supporting facts' for advertising do appear, but the issue is not addressed in any detail. Very few teaching ideas can be found in the literature for how to use advertising in the science classroom. Most of these come from American teacher journals (e.g. Burrows, 1997; Hanuscin, 2002). These ideas mostly focus on using advertising for motivational purposes or for contextualizing content knowledge ('learning with advertising'). Aspects of deeper evaluation, including the creation of media ('learning about advertising'), appear only very rarely (e.g. in Stuckey, Lippel & Eilks, 2012).

Advertising research suggests that activities intensively dealing with advertising, thereby increasing student awareness of the corresponding knowledge, can lead to a more critical view of advertising. However, the few advertising-related teaching ideas available in science education rarely focus on such critical media literacy goals as evaluation skills or, especially, media creation and its various sources (Belova et al., under review). Although science education seems to be the only place to bridge the gap between meta-knowledge about ads and the science content knowledge employed by them, a solid connection is seldom created in the science classroom (Belova & Eilks, 2014). Based on an analysis of the relevant literature, Belova and Eilks (2014) recently suggested four potential roles which advertising can play in science education. The roles differ in their complexity and in their potential contributions to scientific media literacy. It was also found that the third and fourth suggested roles have rarely been used in science education:

1) Motivation: Advertising is used as an introduction to a new science topic in the science classroom to create meaning for the students and increase motivation.

2) Contextualization: Advertising is used to contextualize science-related tasks, e. g. science-related calculations or inquiries. Advertising is used to provoke and motivate experimental activities or theoretical tasks.

3) Promotion of critical thinking by reflecting upon the role of science-related information in advertising: Information borrowed from science- or technology-based advertising is reflected upon with respect to its reliability, validity, and manipulative character. This includes factors such as suggestive or misleading advertising, advertising with false or falsified scientific and technical information, etc.

4) Meta-reflection of the interplay between science and advertising: The role of science and technology (specifically science- and technology-related information) in advertising is reflected upon by the learners. Such learning focuses on the question of how science-related information enters into and is employed by advertising.

The available research on students' opinions on using media in the science classroom is generally quite spotty, particularly when discussing advertising. Ten years ago, Lemke (2004) had already noticed that 'there is very little systematic research on students' reactions to science as portrayed in various popular media' (p. 43). Most of the studies of students' cognitive and affective responses to media are based on news media (McClune & Jarman, 2012). Although learning both with and about scientific news strongly differs from working with advertising (e.g. regarding the vested interests behind the media types or the amount of actual debatable content), some findings can be considered to be interesting in an advertising context. For instance, research shows that most pupils have limited capabilities when it comes to interpreting science-based news reports. This is especially true when it comes to evaluating the scientific evidence presented in the reports (e.g. Kolstø, 2001; Ratcliffe, 1999). Students are not adequately prepared by schools to critically read science-based media reports. Another issue which has been disclosed in the context of news reports is that students tend to accept the information given in the report as superior to their prior beliefs, which have in turn been strongly influenced by the media (Murcia, 2009; Phillips & Norris, 1999). More recent studies have, however, shown that young people are not totally naive while absorbing media offerings and are often able to critically interpret scientific content. Christensen (2011) reported that young people between the ages of 18 and 26 were able to provide their own strong arguments for the issue of health risks associated with mobile phones. However, their views on the nature of science were quite simplistic and often ignored such important factors as the roles of underlying theory and data. According to McClune and Jarman (2012) the characteristics of well-founded discussions of scientific information presented in news reports directly depend on both the production circumstances and the nature of the media texts. Positive tendencies as described by Christensen (2011) may be interpreted as the successful implementation of media offerings in science education programs during the last few years (McClune & Jarman, 2012). Because advertisements provide much less, if any, evidence and the evidence supporting a claim is often shortened and falsified, it is our viewpoint that it is important to take this type of media under further consideration.

Findings regarding the affective responses arising from authentic reports in the media show that students consider science-related news both attractive and interesting. Halkia and

Mantzouridis (2005) conducted a study based on questionnaires with 351 Greek secondary school students. They found that these students find authentic news reports much more interesting and comprehensive than the information presented in their textbooks. They are mostly attracted by the more narrative language and the vivid images. Jarman and McClune (2002) and Kachan et al. (2006) focused more on teachers' observations of their students' reactions, but arrived at similar results with regard to motivation and interest. McClune and Jarman (2012) summarize these findings by pointing out that 'students are […] attracted by the relevance of science news in the world around them – it is important to see the usefulness of science' (p. 26).

Despite the identification of a whole range of roles and corresponding purposes which advertising might serve in science education, advertising has not reached prominence in the science education literature to date (Belova & Eilks, 2014). Searches in relevant databases document that advertising has almost exclusively remained a topic in the humanities and in social science subjects, especially language education (Belova et al., under review). Unfortunately, these subjects hardly focus their reflections on the reliability of the scientific information used in advertising (Belova & Eilks, 2014). Therefore the current project aims to develop a teaching and learning module around the four roles described above through a case study. This includes finding out which objectives can be achieved, as well as how students will react to the integration of advertising with chemistry education.

3. Context of research: A lesson plan on natural cosmetics

One of the goals of science education is to prepare students to live in society (Elmose & Roth, 2005; Hofstein et al., 2011) as well as to raise the relevance of science education and students' perception thereof (Lee & Erdogan, 2007; Stuckey et al., 2013). Different theoretical views (Hofstein et al., 2011) have lent support to the need for change, specifically a move toward more societally oriented science education with a more thorough focus on argumentation and decision-making skills. Within this framework one sub-set of innovations has been based on the use of socio-scientific issues (SSI) in the science classroom (Sadler, 2004). SSI-based science education provides motivating contexts to promote meaningful science learning. Simultaneously, SSI-based science education becomes a catalyst which promotes general educational skills, especially argumentation and decision-making (Albe, 2008). SSI-based science education on advertising is special, because in addition to acting as a medium for learning ('learning with advertising'), advertisements themselves can also become SSI ('learning about advertising'). Better still, we can do more than just illustrate certain scientific topics through examples of appropriate advertising. We can also discuss the scientific information used in advertising, exactly how it is presented, what effect it has on the credibility of the ads, whether incorrect and/or misleading information is used, etc.

Within the SSI movement, the socio-critical and problem-oriented approach to science education has been suggested in Germany (e.g. Marks & Eilks, 2009, 2010). This approach attempts to construct a consistent model in which to operate SSI-based science teaching (Marks, Stuckey, Belova & Eilks, 2014). It was developed into a five-step model covering each of the required curriculum units. The introduction to a topic is performed using authentic media artifacts, e.g. newspaper articles or (in our case) advertising items. The topics selected must allow for real decisions to be negotiated by the learners. The activities performed within the lesson plan challenge students to make up their own minds and to verbalize their opinions on the topic in an open forum. Such conditions allow the expression of one's personal point-of-view without the individual being judged, censored or condemned as an outsider by the rest of the group. Reflection upon how society handles SSI is carried out by mimicking an authentic societal practice dealing with science-related information used by the public. The module developed for natural cosmetics is based on the five-step model by Marks and Eilks (2009). It additionally includes all four of the potential roles of advertising in the science classroom as described above.

The issue of natural cosmetics is controversial and rather complex. There are no binding definitions; several label types can also be found on the market. Therefore, the main goal of the module was to encourage students to critically deal with advertising for natural cosmetics. This included both showing the learners how cosmetics advertising employs scientific information to convince potential customers and providing the students with relevant, corresponding chemistry content knowledge which can help them develop a critical stance.

The introduction to natural cosmetics is carried out with the help of authentic claims, which are frequently used for advertising purposes. These include statements and personal claims covering certain beliefs about natural cosmetics. The selection includes such statements as 'The less chemistry in a product, the better', 'Natural cosmetics are better for your skin' and 'Natural cosmetics are chemistry-free'. Each student receives a green card (signalizing agreement) and a red card (signalizing disagreement) and must rate each of the statements with a color.

Before learning the chemistry background of the topic, students receive a worksheet with an activity called 'reflection on advertising slogans' (Belova & Eilks, 2014). The pupils are given ten authentic slogans on the worksheet, which must be rated regarding their attractiveness, scientific background information and credibility. The rating is carried out through three 'thermometers' located next to each slogan. Potential correlations between the three dimensions are also discussed (e.g. scientifically based slogans are more likely to be less attractive). After the discussion the work sheets are collected by the teacher or researcher. A collage with different advertisements for natural cosmetics is then shown to the students. Among the offerings, claims highlighting the absence of certain chemicals (paraben free, silicone free, etc.) as well those emphasizing products which supposedly contain few to

no (synthetic) chemicals prevail. Again, the credibility and scientific background of the slogans is discussed. The students are then asked why they think advertising selects this kind of information and which reactions are provoked by it.

Before the students start exploring the particular ingredients of natural cosmetic products more closely, they learn about the basic components of skin creams and body lotions, which are representative of general cosmetic products. This is followed up with a group activity about particularly controversial ingredients in cosmetics, which are often not contained in explicitly "natural" products. The students mimic a fictional meeting in which representatives of a risk assessment institute evaluate product ingredients and rate their risks. The students act as experts and are divided into six groups. Two groups each receive one of three ingredients (palm oil, parabens, silicones) so that every ingredient is represented by two expert groups. With the help of texts covering the advantages and disadvantages of each of the ingredients, the expert groups have to reach a consensus and give a final recommendation. They are asked if they would recommend the implementation of a given ingredient in the cosmetics industry and, if yes, under which circumstances they would do so. During the presentation of the individual recommendations, the positions of the parallel groups covering identical ingredients are also compared and discussed.

Armed with their foreknowledge of positive and negative opinions of certain body cream components and a generic recipe for a body cream, the students are now able to produce their own product in a guided-inquiry experimental group activity. Each group must decide whether or not to use palm oil-based ingredients or parabens in their cream (silicones were not used in this recipe). They must also justify their decision. Their reasoning is presented to the other groups and then discussed. Each group is also required to create their own advertisement for their specific product. The pupils receive a worksheet giving preselected information about natural cosmetics (Figure 1). They need to sort the arguments into sets of positive and negative information, including scientific, technical and other sorts such as economic info (Belova & Eilks, 2014). Based on their analysis of the information the students create their own ads in small groups. They must select the (potentially) most beneficial set of information to represent their product to a certain target audience. This approach allows the learners win an overview of the various arguments available for natural cosmetics. During the presentation the students reflect upon which ads were the most convincing and why. They also discuss whether an inclusion of science-based information is reasonable when advertising for a specific target group and whether the case might be different for a different product or target group. Figure 2 shows examples of advertisements created by students from 7th grade which illustrate the different approaches for creating advertisements.

After presenting their advertisements the students are given back their completed slogan rating worksheets from the beginning of the unit. They discuss whether their opinions and assessments have changed during the module and whether the correlations they discovered at the beginning of the module are still present. The claims from the initial exercise are rated again to see if their perceptions have changed.

An overview of the lesson plan structure is shown in Table 1. A connection is also made between the different activities and roles which advertising can play in the science classroom (roles 1 to 4, see above). The lessons consist of four 45-minute classroom periods. The versions for different grade levels varied in the lengths of the texts covering the chemistry background.

Table 1. Structure of an advertisement-based module on natural cosmetics. Number of advertising scenario type refers to the outline in section 2 of this paper.

Phase and activity	Number of advertising scenario type
Activation of prior knowledge: The students rate the credibility of different claims such as 'Natural cosmetics are chemistry-free'. Such claims are most frequently used for advertising.	3
Reflection on authentic advertising slogans: The students receive a worksheet with ten authentic slogans, which must be rated regarding their attractiveness, scientific background, and credibility. Possible correlations between these three dimensions are also discussed.	3, 4
Introduction to the issue: The students are shown a collage with different labels and ads for natural cosmetics which are then discussed (also in relation to the previously shown claims).	1, 3
Introduction to subject matter learning: Students work on worksheets presenting the components of a generic skin cream.	
Introduction to risk assessment: The students act as the employees of a fictional institute for risk assessment. They are supposed to formulate recommendations for different controversial cosmetic ingredients based on provided information.	
Creation of the students' own cream: In a guided inquiry-based scenario, the pupils prepare their own skin cream and decide whether or not to use various ingredients during its	2

production.	
Advertising the students' own product: The students receive a summary of positive and negative information about natural cosmetics. They have to select what they consider important and create an ad for their own product. They then present their ads and discuss whether or not they have actually used scientific information.	4
Meta-reflection: The students reflect on the worksheets with the slogan ratings from the beginning of the unit. The claims covered in the beginning exercise are rated again to see if and how pupils' perceptions have changed. The students discuss whether their assessment has changed during the module.	3, 4

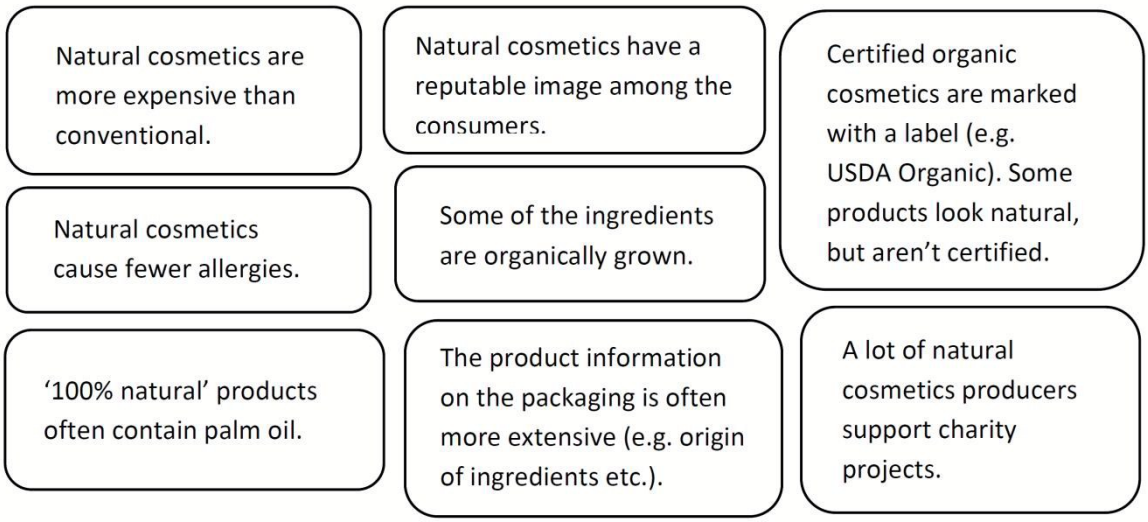

Figure 1. Excerpt from a worksheet used in the module. The students receive different arguments for and against natural cosmetics, which help them to create an advertisement.

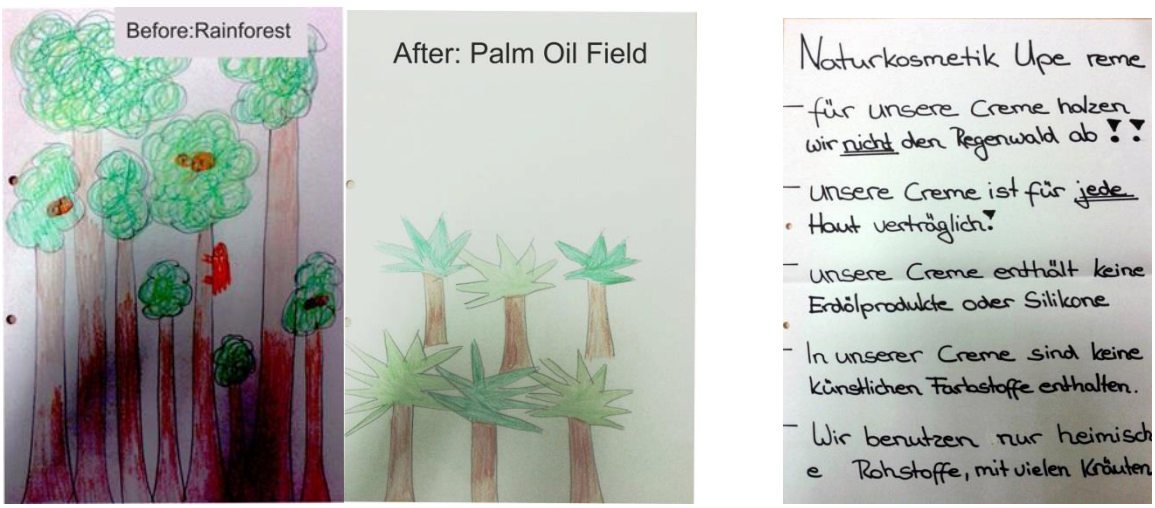

Figure 2. Examples of advertisements designed by students from a 7th grade class. The first two posters were designed by the same group and show no text, only drawings showing the transformation of a rain forest (a habitat for animals) into a mono-culture palm oil field. The third poster contains only text (mainly science-based information). The differences between such approaches were actively discussed.

4. Methods and sample

4.1 Sample and background

The lesson plan was piloted in a 11th grade chemistry class by the first author and then revised according to the feedback provided by the accompanying class teacher. As a case study, the lesson plan was then taught again by the first author in another five learning groups in a German urban comprehensive school in grades 7, 8, 9 and 11 (age ranges 13-17 years). Two of the classes were eighth-grade and the total sample consisted of 102 students (48 female, 54 male). The regular teacher accompanied the lesson and contributed to the study by filling a classroom observation protocol. All participants were informed about the nature of this case study before the intervention started. All students and teachers were given choice to provide anonymous feedback or not to take part in the evaluation.

4.2 Data collection

A student questionnaire containing five open-ended questions and ten Likert items was used for evaluation. The questionnaire was structured based on experiences with other questionnaires used in similar studies (e.g. Marks & Eilks, 2010; Burmeister & Eilks, 2013) and it was checked for comprehensibility by communication within the research group. In the first open-ended question the students had to describe what they perceived to have learned during the lesson. Two further open-ended questions asked the students to name aspects they particularly liked/disliked about the lesson. The last two questions focused specifically on the aspect of advertising. The students were asked whether (and how) they believe that dealing with advertising from a scientific perspective would influence their future consumer decisions. Afterwards, they were asked to rate and justify whether they think advertising is a suitable topic for chemistry lessons.

In the Likert items the students had to rate the attractiveness of the learning environment and their personal interest in advertising in chemistry education on a four-step scale. Another five items focused on their personal consumer behaviour.

In addition, the accompanying class teacher in each learning group was asked to create a classroom observation protocol in an open format. The teachers were asked to focus their attention on the students' discussions in the classroom and on general differences to "normal" chemistry lessons.

4.3 Data analysis

The open ended questions and classroom observation protocols were also analysed by Qualitative Content Analysis (QCA) according to Mayring (2000). The Likert-based part of the questionnaire was analyzed using descriptive statistics. The percentage distributions from the Likert Items were displayed for the different samples in bar chart diagrams and compared. The aim of this part of the questionnaire was to provide first insights into students' affective responses to advertising in the chemistry classroom. It also helped to obtain clues as to whether such lesson activities can effectively lead to better reflection on advertising from a scientific perspective.

5. Results

5.1. Students perception of the lesson plan

The first open-ended question asked pupils about the most substantial issues which they believed they had learned during the lesson. The question intended to reveal whether the aspects mentioned by the students mainly stemmed from the domain of scientific content, or if advertising issues would also be named. Overall, 65% of the statements were solely content matter-based *('I learned a lot about the different ingredients in skin creams and shampoos.'*). A further 15% covered both subject matter and advertising. Only 20% were exclusively related to advertising *('Advertising sometimes presents scientific information in a confusing way and I have to be careful not to fall for wrong things'*).

The students seemed to be more aware of their personal learning outcomes concerning subject matter, but the general, media-focused issues such as advertising strategies were not so clear to them. The answers of younger students (7th and 8th grades) more often focused on certain facts related to environmental protection, which was also the most prominent topic for discussions in these classes (according to the classroom observation protocols). This occurred even though this subtopic constituted only a small fraction of the lesson plan in the context of palm oil use. Typical answers were: *'I learned that even natural products can contain things that are bad for the environment'* or simply *'Many products can be bad for the environment'*. Only few answers of the younger students contained explicitly reflective aspects: *'I learned a lot about the ingredients in cosmetics. It is confusing because advertising presents everything in a positive way, but almost everything seems to have at least one disadvantage, even natural products. Palm oil is also natural and it's bad for the rain forest'*.

Answers of the older students more often focused on advertising aspects and were more general and reflective. This revealed tendencies of a growing awareness of the scientific aspects of advertising and a more critical consumer behaviour. *'What I really learned is: 1) to regard advertising more critically, 2) to think more about the products in the advertisements and what the companies try to sell you, and 3) not to accept advertising without scrutinizing it first.'* Another pupil stated: *'I learned a lot of things that will help me buy the right product, including how advertising works, that expensive isn't always better, and what the ingredients mean.'* Another opinion was: *'I learned a lot about creams and their ingredients. Due to this I now understood that you have to be careful what you buy and that it makes sense to inform yourself before you go to the shop.'*. Only five students mentioned that they learned something about the role and image of science/chemistry in advertising: *'[I learned] which role chemistry plays in cosmetics. It's really not as bad as it sounds in all the ads and it's actually important.'* The classroom observations confirmed that these aspects were intensely discussed by the students.

Two further questions asked participants for their feedback on the module (What did you particularly like/dislike?). The most frequently mentioned aspects were the hands-on design and preparation of skin cream and the student-centered, cooperative work in general *('I liked the fact that we could work in groups*

and make our own cream to take home'). Only 15% of the pupils mentioned the advertising-based activities among the things they had particularly liked (*'I liked the discussions about advertising the most'*). All of these students came from grades 7 and 8. Very few aspects were viewed as negative by the participants. The most frequent criticisms were a noisy classroom atmosphere during the group work phases and a lack of personal interest in the content of natural cosmetics.

The next question asked was whether the students thought that dealing with advertising in the science classroom would affect their purchasing decisions in the future. A total of 54% of the pupils' statements indicated their decisions might be affected. The main reasons given were: 1) the knowledge gained in the unit would help in evaluating the truthfulness of advertising claims in everyday life *('Yes, because you can rate the credibility of advertising better if you know what's actually in the products and what the ingredients are supposed to do.'*) and 2) it would now be easier to connect this knowledge to everyday situations (*'I think so, because now I will look closer at what the advertisement tells me. I will think about the things we did during the lessons and try to regard all pros and cons like on the worksheet'*). Again, younger students frequently named environmental aspects they would consider in the future (*'I think I will try to buy products without palm oil. The rain forest has to stay!'*). Only 28% of the students stated that they would not change their purchasing habits, mainly because they felt that they were more thoroughly influenced by other aspects such as smell, packaging design, etc. The other 17% were uncertain about this issue and regarded it as being too complex: *'I don't know … Although there are some things that are not good I still want to buy more natural products in the future. I still think they are better than something 100% from the lab. It will be hard though, because I also want to try to avoid palm oil. So probably in the end I will keep buying the same stuff I bought before'.*

The final question asked participants whether advertising should be a recurrent topic in the science classroom. This was answered positively by a great majority of the students (83%). The main reasons for this were its proximity to everyday life issues and the fact that advertising aspects can often be connected with school subject matter. Selected statements include: *'It is good to know what some slogans really mean.'*, *'Only a scientific basis makes it possible to talk about advertising in a serious way.'*, *'This topic is a sort of practical test for school chemistry.'*, *'Such knowledge protects us from false advertising. Many people don't really understand what they buy. We should talk about this in all the sciences!'*, *'You need these things more than the other stuff you have to learn.'* A small number of older students at the upper secondary level (grade 11) did not regard this issue as a necessary part of their science lessons. They find content knowledge to be more important. One student stated that, in his opinion, *'science is about "bigger" things, about nature and so on, and not about this [advertising]'*. Overall, only five students explicitly stated that advertising should remain a part of other subjects only, such as German language education.

5.2. Students' feedback to given statements

The findings from the Likert items show that advertising is regarded positively (Figure 3). We can see that even in the science classroom, most students prefer to discuss topics which are not purely science-related. Most learners stated that the lessons affected their personal opinions on cosmetics in particular and advertising in general. However, these two items also showed the largest levels of disagreement among the participants. Generally, younger students from grades 7 and 8 showed higher agreement rates in most of the items of the Likert questionnaire compared to students from grade 9-11. For example, 85% of the students from grade seven fully agreed to the statement: 'I liked talking about advertising in the science classroom', while only 54% of the students from grade nine and 70% from grade 11 did so. A potential reason might be that older students might perceive themselves more settled and mature in consumer behaviour so that learning about advertising has less to offer to them compared to younger students.

The results from the items focusing on scientific aspects of advertising ('I understand which role science can plan in advertising', 'I understand that scientific information used in advertising is often shortened and falsified') show very similar distributions of answers in the Likert scales among the different age groups. Interestingly, boys showed higher agreement rates on all of the items. One possible explanation might be the choice of the topic. Teenage girls may be more involved with aspects of cosmetics in their everyday lives. They have often already selected preferred products and brands, which they chose according to smell or certain other trends. Therefore, it is much more difficult to change these perceptions and to achieve a more critical view on cosmetics in general. Boys, who claim that they do not to buy cosmetics, are probably more open to such activities promoting a more critical view of advertising for such products.

Chemistry Education Research and Practice RSCPublishing

ARTICLE

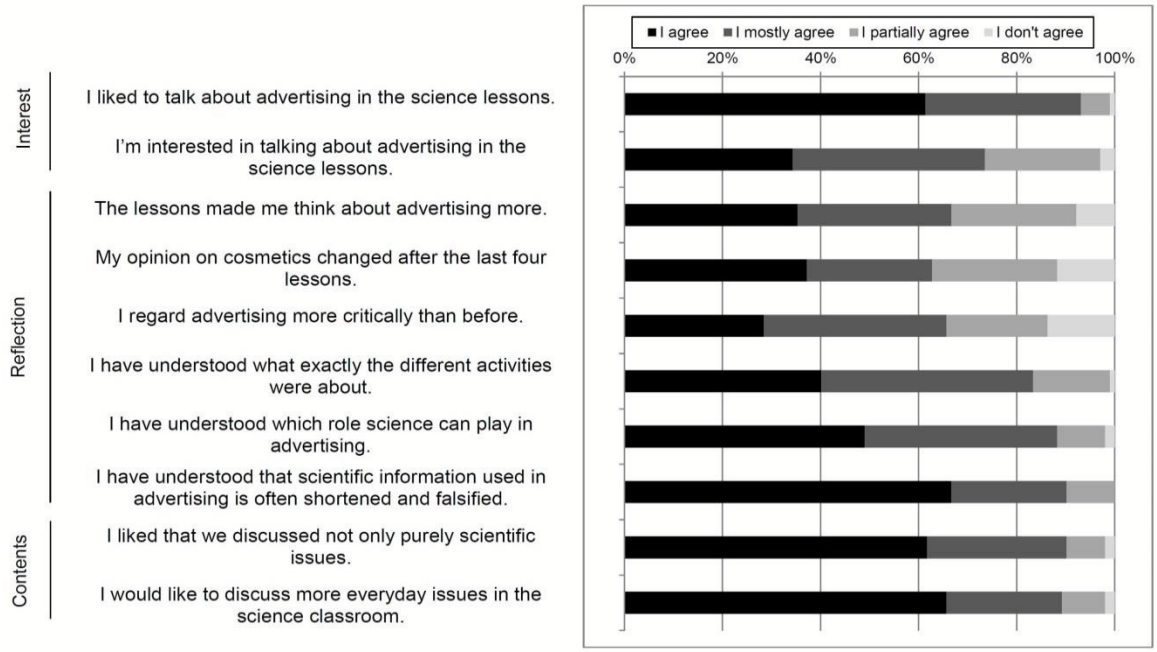

Figure 3: Results from the Likert questionnaire (N=102; 48 female, 54 male)

The last question asked students to rate the query "How much have you learned during the last four lessons?" on a scale from zero ('I haven't learned anything') to ten ('I have learned a lot'). The final mean score was 7.2, with no major differences among the different grades.

5.3. Teachers' observations

In the classroom observation protocols all of the accompanying teachers mentioned that during the lessons, the students were engaged in very lively discussions. These debates continued after the lessons were over and were more intense than the discussions in previous chemistry lessons. Especially in grade 7 and 8 classes the teachers pointed out that the students regularly have difficulties making up their own minds on controversial SSIs and in finding compromises. This was also the case in some of the groups tested here. One teacher from grade 8 wrote: *'During the group work: Huge confusion in the palm oil group about the criteria for the recommendation. Decide based on environmental issues or on the impact on skin? Even slight frustration. Similar difficulties in the other groups'.* Apparently, this was a totally new situation for the students in science lessons. In the upper grades the teachers noted that they could practically see how the information on advertising and consumer aspects started to influence the students: *'It is obvious that something is happening in their heads. […] The views they previously had are already strongly impacted by the input and the activities. Especially obvious in the case of silicones'.*

From the classroom observations it also became apparent that students possess a large amount of foreknowledge about advertising types and strategies. Most probably this comes from other, non-science subjects and everyday life *('Students are able to discuss advertising strategies; must have heard about these issues before'*). However, most learners had difficulties if they were asked to evaluate advertisements from a scientific perspective. In the classroom discussions pupils tended to fall back on analysis strategies learned from other domains, including the evaluation of language phenomena. This was especially true at the very beginning of the lesson plan (*'Students always tend to talk about language phenomena, etc., although [the researcher] tries to focus their attention on other, science-related things'*). This was also the case during the final discussion of the advertisements created by the students. While they worked to develop their own advertisements, students' creativity (especially in younger pupils) was strongly affected by their foreknowledge of advertising slogans. They tended to think up slogans clearly inspired by previously known advertisements, instead of creating their own.

What was also positively mentioned in the observations was the authenticity of the teaching and learning materials (*'As soon as the kids saw the real slogans they were instantly much more motivated'*). It was also pointed out that the activities provided a good balance between the different issues of the pedagogy.

6. Conclusions

In this case study a teaching module focusing on chemistry-related aspects in advertising was developed for the context of natural cosmetics. The lesson was inspired by the socio-critical and problem-oriented curriculum model by Marks and Eilks (2009). It included four different roles that advertising can play in the science classroom (Belova & Eilks, 2014). The module was implemented in five learning groups in different grade levels and received a generally positive feedback. This exploratory study gives first insights into students' responses to using advertising on the chemistry classroom and can therefore be characterized as a 'discovery study' (Biddle & Anderson, 1986).

Advertising directly influences students' consumption behavior and can simultaneously influence their perception of science (Davies, Spencer, Quinn & Gerhardstein, 2002; Dixon, Scully, Wakefield, White & Crawford, 2007). McSharry and Jones (2002) point out that 'advertisements could prove to be extremely useful in increasing the relevance of science education to children' (p. 496). However, such ideas remain largely neglected and underdeveloped in the science education literature. This is true for learning both through advertising and about advertising. This case study is one of the first studies to help bridge this gap.

The current study suggests that teaching using advertising as both a tool and as a topic in the science classroom has potential to enrich the curriculum and pedagogy in science education. Learning both with and about advertising in chemistry education can increase chemistry's contribution to the development of scientific media literacy. This will contribute to the development of skills for students to become critical consumers in the future. Advertising was characterized as a highly authentic medium by the participants and proved to be motivating. Dealing with advertising in chemistry education may open up new opportunities for the social contextualization of science learning. The innovative pedagogy described in this paper can help to counteract the perceived lack of relevance which many students express with regard to the sciences (Stuckey et al., 2013).

The student feedback received shows that most pupils have a positive attitude towards the integration of learning through and about advertising in science education. Students regarded advertising as a well-justified, suitable topic in the science classroom. Classroom observations revealed that most students are not used to media education activities in science education. Moreover, some of the older students seem to hold to an overarching, clinical image of science, which often does not include (or even allow) societal aspects (Marks & Eilks, 2010). One conclusion seems to be that students need to be more thoroughly shown that relevant science education includes its societal dimension (Hofstein et al., 2011). These results corroborate findings in news media research in the sciences with regard to the affective responses towards news reports (Halkia & Mantzouridis, 2005; Jarman & McClune, 2002; Kachan et al., 2006).

Although using advertising is generally very uncommon in science education, the students found that working with such types of media proved to be highly authentic, attractive and interesting to them. This parallels other findings about learning with news media in the science classroom. In that domain McClune and Jarman (2012) point out '[…] it was noted that students are attracted to science that is sensational in some way' (p. 26). Although most advertising contains much less content than a news report, there is a great deal of sensation and (false) promises behind the claims, which can act as a challenge to investigation and spark debate, too. Whether this is also the case for advertising presenting other product groups is beyond the scope of the current study. Cosmetics may be a very motivating topic, but there is need for further research in other product areas.

Not all of the students in our case study were equally attracted by learning with and about advertising in the chemistry classroom. But as other studies of affective responses to news media have already shown, the less-engaged students in our sample proved to be 'ambivalent rather than negative' (McSharry & Jones, 2012, p. 26). The varying activities in the module also provided a trigger for the students to activate their prior ideas about and foreknowledge of cosmetics and advertising. They opened strategies to the participants which made them more aware of their own critical thoughts on advertising. According to Rozendaal, Buizen and Falkenburg (2012) this may reduce advertising susceptibility.

There is a great need for more evidence stemming from further research. This is particularly true in the area measuring the effects of including advertising in science classes. This includes evaluating the concrete effects on student learning and cognitive and attitudinal outcomes in detail. There is need for further research on the influence of advertising on students' beliefs, including their ability to interpret science in advertising. Another important aspect of research needs to be the image of science after learners have experienced the advertising learning units. Some of the initial findings have shown a tendency for students' consumer behavior to be affected by such teaching units. However, this needs to be better researched on a long-term timescale. In conducting more specific research we anticipate that advertising in science education will reveal itself to be an important teaching and learning approach. We believe that new, exciting, and innovative pedagogies will result and that critical scientific media literacy will be promoted in the learners.

Notes and references

[a] University of Bremen, Biology/Chemistry, Bremen, Germany. E-mail: n.belova@uni-bremen.de; Tel: +4942121863287.

[b] University of Bremen, Biology/Chemistry, Bremen, Germany. E-mail: ingo.eilks@uni-bremen.de; Tel: +4942121863280.

Albe V., (2008), When scientific knowledge, daily life experience, epistemological and social considerations intersect: students' argumentation in group discussions on a socio-scientific issue, *Res. Sci. Educ.*, **38**(1), 67–90.

Belova N. and Eilks I., (2014), Promoting societal-oriented communication and decision making skills by learning about advertising in science education, *Centre Educ. Pol. Stud. J.*, **4**(1), 32-49.

Belova, N., Chang Rundgren S.-N. and Eilks I., (in print), Advertising and science education – A multi-perspective review of the literature, *Stud. Sc. Educ.*

Biddle B.J. and Anderson D.S., (1986). Theory, methods, knowledge and research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 230–252), New York, NY: Macmillan.

Buckingham D., (2003), *Media education: Literacy, learning and contemporary culture*, Cambridge: Polity.

Burmeister M. and Eilks I., (2012), An example of learning about plastics and their evaluation as a contribution to Education for Sustainable Development in secondary school chemistry teaching. *Chem. Educ. Res. Pract.*, **13** (2), 93-102.

Burrows, W. R., (1997). The great paper towel race, *Sci. Act.*, **34**(3), 32-37.

Bybee R. W., (1997), Toward an understanding of scientific literacy. In W. Gräber & C. Bolte (eds.), *Scientific literacy – an international symposium* (pp. 37-68), Kiel: IPN.

Chang Rundgren S.-N. and Rundgren C.-J. (2014), SSI pedagogic discourse: embracing scientific media literacy and ESD to face the multimedia world. In I. Eilks, S. Markic & B. Ralle (Eds.), *Science education research and education for sustainable development* (pp. 157-168). Aachen, Germany: Shaker.

Christensen C. K., (2011), Young adults' accounts of scientific knowledge when responding to a television news report of contested science, *Int. J. Sci. Educ.*, Part B, **1**(2), 115-145.

Constandinidou-Semoglou O., (2007), Early childhood education and adult-oriented advertising discourse, *Eur. Early Childh. Educ. Res. J.*, **15**(3), 329-341.

Cosmetics Europe (2014), Umsatz mit Kosmetik in Europa, den USA, China und Japan im Jahr 2013 (in Milliarden Euro) [Sales revenues with cosmetics in Europe, the USA, China and Japan in 2013 (in billion euro)]. Retrieved from http://de.statista.com/statistik/daten/studie/312422/umfrage/umsatz-mit-kosmetik-in-europa-den-usa-china-und-japan/

Council of Europe (2000), Natural cosmetic products. Retrieved from http://www.coe.int/T/E/Social_Cohesion/soc-sp/natcosE.pdf

Davies, P.G., Spencer, S. J., Quinn, D.M. and Gerhardstein, R. (2002). Consuming images: How television commercials that elicit stereotype threat can restrain women academically and professionally. *Pers. Soc. Psych. Bull.*, **28**(12), 1615-1628.

Dhingra K., (2003), Thinking about television science: How students understand the nature of science from different program genres, *J. Res. Sci. Teach.*, **40**(2), 234-256.

Dixon, H.G., Scully, M.L., Wakefield, M.A., White, V.M. and Crawford, D.A., (2007), The effects of television advertisements for junk food versus nutritious food on children's food attitudes and preferences, *Soc. Sci. & Med.*, **65**(7), 1311-1323.

EHI Retail Institute (2014), Umsatz mit Naturkosmetik in Deutschland in den Jahren 2007 bis 2013 (in Millionen Euro) [Sales revenues with natural cosmetics in Germany between 2007 and 2013 (in million euro)]. Retrieved from http://de.statista.com/statistik/daten/studie/201220/umfrage/umsatz-mit-naturkosmetik-in-deutschland/

Eilks I., Nielsen J. A., and Hofstein, A., (2014), Learning about the role of science in public debate as an essential component of scientific literacy. In A. Tiberghien, C. Bruguière, P. Clément (Eds.), *Topics and trends in current science education* (pp. 85-100), Dordrecht, The Netherlands: Springer.

Elmose S. and Roth, W.-M., (2005), Allgemeinbildung: Readiness for living in a risk society, *J. Curr. Stud.*, **37**(1), 11-34.

European Commission (2007), Media literacy. Active citizenship in today's information society. Retrieved from http://ec.europa.eu/culture/media/media-literacy/index_en.htm

Halkia K. and Mantzouridis, D., (2005), Students' views and attitudes towards the communication code used in press articles about science, *Int. J. Sci. Educ.*, **27**(12), 1395–1411.

Hansen A., (1994), Journalistic practices and science reporting in the British press, *Public Understanding of Science*, **3**(2), 111–134.

Hanuscin D., (2002), Names & Claims: Is it science or spin? *Sci. Scope*, **25**(6), 36-38.

Hobbs R. (2003). Understanding teachers' experiences with media literacy in the classroom. In B. Duncan and K. Tyner (Eds.), *Visions/revisions: Moving forward with media education* (pp. 100–108). Madison, WI: National Telemedia Council.

Hobbs R. and Jensen A. (2009), The past, present, and future of media literacy education, *Journal of Media Literacy Education*, **1**(1), 1-11.

Hofstein A., Eilks I. and Bybee R., (2011), Societal issues and their importance for contemporary science education: a pedagogical justification and the state of the art in Israel, Germany and the USA, *Int. J. Sci. Math. Educ.*, **9**(6), 1459-1483.

Holbrook J. and Rannikmäe M., (2007),. The nature of science education for enhancing scientific literacy, *Int. J. Sci. Educ.*, **29**(11), 1347-1362.

Holmes H. W. et. al. (eds.) (1947). *Fundamental education, common ground for all peoples. Report of a special committee to the preparatory commission of the United Nations Educational, Scientific and Cultural Organization, Paris, 1946*. New York, NY: Macmillan.

Hove T., Paek H.-J. and Isaacson T., (2011), Using adolescent eHealth literacy to weigh trust in commercial web sites: The more children know, the tougher they are to persuade, *J. Advert. Res*, **51**(3), 524-537.

Jarman R. and McClune B., (2002), A survey of the use of newspapers in science instruction by secondary teachers in Northern Ireland, *Int. J. Sci. Educ.*, **24**(10), 997–1020.

Kachan M.R., Guilbert S.M. and Bisanz, G.L., (2006), Do teachers ask students to read news in secondary science? Evidence from the Canadian context, *Sci. Educ.*, **90**(3), 496–521.

Klosterman M. L., Sadler T.D. and Brown J., (2012), Science teachers' use of mass media to address socio-scientific and sustainability issues, *Res. Sci. Educ.*, **42**(1), 51-74.

Kolstø S.D., (2001), 'To trust or not to trust …': Pupils' ways of judging information encountered in a socio-scientific issue, *Int. J. Sci. Educ.*, **23**(9), 877–901.

Lee M.-K. and Erdogan I., (2007), The effect of Science–Technology–Society teaching on students' attitudes toward science and certain aspects of creativity, *Int. J. Sci. Educ.*, **29**(11), 1315-1328.

Lemke J., (2004), The literacies of science. In E.W. Saul (Ed.), *Crossing borders in literacy and science instruction: Perspectives on theory and practice* (pp. 33–47). Newark/Arlington, NJ: International Reading Association/National Science Teachers Association.

Marks R. and Eilks I., (2009), Promoting scientific literacy using a socio-critical and problem-oriented approach to chemistry teaching: concept, examples, experiences, *Int. J. Environ. Sci. Educ.*, **4**(3), 231-245.

Marks R. and Eilks I., (2010), Research-based development of a lesson plan on shower gels and musk fragrances following a socio-critical and problem-oriented approach to chemistry teaching, *Chem. Educ. Res. Pract.*, **11**(2), 129-141.

Marks R., Stuckey M., Belova N. and Eilks I., (2014), The societal dimension in German science education – From the tradition to selected cases and recent developments, *Eurasia J. Math. Sci. Techn. Educ.*, **10**(4), 285-296.

Mayring P., (2000), Qualitative content analysis, *Forum Qualitative Social Research*, **1**(2). Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/1089/2386

McClune B. and Jarman R., (2012), Encouraging and equipping students to engage critically with science in the news: what can we learn from the literature? *Stud. Sci. Educ.*, **48**(1), 1-49.

McSharry G. and Jones S., (2002), Television programming and advertisements: Help or hindrance to effective science education? *Int. J. Sci. Educ.*, **24**(5), 487–497.

Murcia K., (2005), Science in the newspaper: A strategy for developing scientific literacy, *Teach. Sci.*, **51**(1), 40–42.

Phillips L.M. and Norris S.P., (1999), Interpreting popular reports of science. What happens when the reader's world meets the world on paper? *Int. J. Sci. Educ.*, **21**(3), 317–327.

Ratcliffe M., (1999), Evaluation of abilities in interpreting media reports of scientific research, *Int. J. Sci. Educ.*, **21**(10), 1085–1099.

Rozendaal E., Buijzen M. and Valkenburg P. M. (2012), Think-aloud process superior to thought-listing in increasing children's critical processing of advertising, *Human Comm. Res.*, **38**(2), 199-221.

Sadler T. D., (2004), Informal reasoning regarding socioscientific issues: A critical review of research, *J. Res. Sci. Teach.*, **41**(5), 513–536.

Scheibe, C. and Rogow, F. (2012). *The teacher's guide to media literacy*. Thousand Oaks, CA: Corwin.

Sjöström J., (2013), Towards Bildung-oriented science education, *Sci. & Educ.*, **22**(7), 1873-1890.

Stuckey M., Heering P., Mamlok-Naaman R., Hofstein A. and Eilks I., (2015), The philosophy of Ludwik Fleck and its potential meaning for the teaching and learning of science, *Sci. & Educ.*, 24, 281-298.

Stuckey M., Lippel M. and Eilks, I., (2012), Sweet chemistry: Learning about natural and artificial sweetening substances and advertising in chemistry lessons, *Chem. Act.*, **98**, 36-43.

Stuckey M., Mamlok-Naaman R., Hofstein A. and Eilks I., (2013), The meaning of 'relevance' in science education and its implications for the science curriculum, *Stud. Sci. Educ.*, **49**(1), 1-34.

U.S. Food and Drug Administration (2010). "Organic" cosmetics. Retrieved from http://www.fda.gov/Cosmetics/Labeling/Claims/ucm203078.htm

UNESCO (1982). Challenge of media education (The Grunwald Document). Retrieved from http://www.medialit.org/reading-room/challenge-media-education-grunwald-document

UNESCO (2006). Media education. A kit for teachers, students, parents and professionals. Retrieved from http://unesdoc.unesco.org/images/0014/001492/149278e.pdf

UNESCO (2011). Media and information literacy. Curriculum for teachers. Retrieved from http://unesdoc.unesco.org/images/0019/001929/192971e.pdf