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The mediation of science in the age of social media

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Abstract

Science communication is changing in the age of social media. Gatekeeping is a classic function of quality journalism that influences communication and mediation of science in society. The changing media landscape leads to new phenomena such as filter bubbles, echo chambers, spirals of silence and the rapid spread of fake news on the Internet. This paper analyses the transformation of how science and society are mediated and draws conclusions for learning and education.

The mediation of science and science education

Traditional views of scientific literacy have predominantly focused on scientific content and methods and were aiming at teaching students to think and act like scientists. The idea for active citizenship then roughly spoken means that a competent lay person in science should be sufficiently equipped to make well-informed judgements and decisions about problems concerned with science. Then, scientific knowledge might be very helpful as far as it allows for the generation of a basic understanding of the problem at issue and what constitutes appropriate evidence to support a particular scientific claim. It is crucial, therefore, that informed citizens understand how data are collected and interpreted in a reliable and valid manner and that an interplay exists between theory and evidence in science. It might also be relevant to recognize the tentative character of scientific knowledge or how scientific investigations were conducted and reported might be shaped by human interests or cultural peculiarities. These are all aspects of an established view on nature of science (NOS) as an important domain of learning in science which aims at fostering scientific literacy (e.g. Lederman, 2007; Hodson, 2008; McComas, 1998; Erduran & Dagher, 2014).

Next to the fact that NOS is neither very well implemented in standard documents across the world (Olson, 2018) nor in the practice of teaching (Herman, Clough & Olson, 2013; Höttecke & Silva, 2011), another problem with NOS arises. When people deal with socio-scientific issues (Ratcliff & Grace, 2003; Sadler & Dawson, 2012; Hodson, 2003) like climate change, electromagnetic pollution or vaccination in order to make preferably scientifically well-informed judgments and decisions, content knowledge (e.g. the physics of the greenhouse effect) is often too complex for lay persons. Even a scientific literate person with a basic scientific understanding about climate change or electromagnetic pollution is not an expert in any of these fields. Otherwise he or she should be able to recalculate and check a professional climate model, or should be able to develop a model for estimating patterns of electro-magnetic radiation as well as strength and patterns of magnetic fields around high-voltage wires either transferred below or above ground.

These are highly professionalized activities and beyond the competencies of average lay persons.

Science is a complex endeavour and this is why experts have to put much effort on their education, work hard on earning their degrees and the development of their research capabilities, and this process sometimes even takes decades. Knowing when a scientist should count as a credible 'expert' in a particular field or when his/her intentions, actions or methods should better be questioned is a key element of functional scientific literacy (Allchin, 2011; Höttecke, 2017; Höttecke & Allchin, accepted; Hodson, 2011). As has been discussed elsewhere (Allchin, 2012; Höttecke & Allchin, accepted), science has to be understood as a social and communicative practice within a system of distributed expertise. This system is characterized by epistemic dependence and trust (Hardwig, 1991) on the one hand and a system of checks and balances (e.g. peer-review) on the other.

Socio-scientific issues are usually more concerned with science-in-the-making and less with ready-made-science (Latour, 1987), but only the latter is usually taught at school. A functional scientific literate citizen therefore needs capabilities to deal with science in his or her everyday life (Allchin, 2011). The so-called "informed citizen" should be able to participate in discussions, negotiations, and decision-making about actions to be taken to prevent climate change or to mitigate its outcomes, the adoption of laws and regulations for or against nanotechnology, genetically modified food or the determination of critical values for toxic gases and aerosols in the air in urban areas. School science education may contribute to the preparation of students' present and future lives by promoting basic scientific understanding of core concepts and methods of science, knowledge about NOS as well as capabilities for moral reasoning (e.g. Hodson, 2011, 2013; Dittmer, Gebhardt, Höttecke & Menthe, 2016). However, when citizens are concerned with socio-scientific issues and the appraisal of new technologies during their lives, the science involved is hardly ever communicated to them directly, but via media. From a lay person's perspective, science is inevitably mediated (Höttecke & Allchin, accepted).

In the following, the role of media will be discussed and how they might function or disfunction as gatekeepers of information about socio-scientific issues. I draw upon the example of climate change as one of the most challenging issues of our time where discourses in science, the media, political decision-making and a wider public are intersecting.

The role of journalistic media for the mediation of science

Beginning with the 1930s, a new kind of journalism has been established which was concerned with the popularization of science. Since then, journalism has developed towards its role as a critical observer and commentator of science (Weingart, 2017). In this regard the media play the role of gatekeepers. Gatekeeping in mass media traditionally consists of 2, respectively 3 objectives which can be identified with 'gates' allowing information to be selected, prepared and transformed for feeding public discourse: A first gate describes the process of selecting information from various sources by professional journalists. Here information has to be strongly reduced and focused to the needs and character of a particular newspaper, magazine, radio or TV program. Through a second gate information is prepared and pre-

sented in specific ways and either becomes a news, a report, an editorial comment or any other journalistic text. It is the second gate where news at least in high-quality media undergo certain levels of factual verification, analysis of content, and editorial review. As long as consumers of media are allowed to give feedback (e.g. letters to the editor), a choice of answers and reactions from either readers, listeners or viewers is passing a third gate and will either be published or rejected (Bruns, 2009). Gatekeeping of media in this way are controlling the interface between science and the public.

Next to the parental home and the educational system (most of all schools), journalistic media are of general importance for opinion-making and catching up on scientific information towards active citizenship in democratic societies. Media like newspapers, magazines, books, TV programs and radio stations play a major role in directing attention, setting agendas and trigger alarm if needed. This not only means that information e.g. about climate change or ozone depletion in the upper atmosphere are provided. Moreover, journalistic media are convincing people about the relevance of particular issues, select, control and direct information, reduce complexity and contextualize scientific information (e.g. cumulative climate reports in the context of extreme weather conditions). They mediate between science, policy-making and the wider public by reducing the differences between scientific knowledge of experts and immediate experience (Weber, 2008). They control and criticize political discourse and contribute to and reflect upon public opinion-making (Schweiger, 2017). 40% of American adults agree to the statement that it is a big problem that there are so many findings that it's hard to distinguish between high- and low-quality studies in science (Funk, Gottfried & Mitchell, 2017). It is therefore evident that many people are well aware of the importance of media for connecting science and the public.

Modern societies are deeply characterized by the necessity of identifying and negotiating risks which substantially threatens and even imperils society (Beck, 1986). As a result, societies strongly depend on the advice of experts in science or other professional domains. Beck highlights the peculiar nature of contemporary risks as invisible. It is again the media which help to visualize and symbolize risks and their consequences (Cottle, 1998). Media have established metaphors in public discourse which mediate everyday and scientific discourses (Weingart, 2015). Here is an example: Through the last decades scientists as well as journalists have made wide use of the metaphor of *tipping point* (Hel, Hellsten & Steen, 2018). This metaphor expresses the dramatic and irreversible character of climate change, stresses the need for immediate action, and became a bridge between science and the public. Within the scientific domain, the metaphor is driving empirical and theoretical research. The *tipping point* metaphor turned into a rhetorical device to enhance comprehensibility as well as communicate patterns of risk in terms of "before" and "after". After having passed the *tipping point* in climate change, the earth system has changed beyond human influence. The time before is the time when climate change might still be prevented as long as appropriate actions will be taken. The metaphor of *tipping point* thus allows for a mediation of scientific results from expert climate science to everyday discourse and at the same time is communicating an urgent need for action.

Mass media are depending on economic resources in order serve their purposes. Therefore, they have to acquire and secure resources by maximizing public attention. As a consequence, media are not just mirroring reality. This is even not the case because of their restricted capacities to pick up and transform information through their first and second gate. Moreover, media reports are inherently driven by norms to present narratives as dramatic, personal, emotional, astonishing, new, uncertain, full of conflicts and controversies, balanced, and with a preference for a local focus (Boykoff, 2011; Luhmann, 2017; Schweiger 2017). In this way media are causing a second shaping of science (Feinstein, 2015).

It is the media which ultimately transforms scientific understandings in socio-scientific issues. Climate change for instance is initially turned into an environmental and into a societal crisis thereafter (Weber, 2008). Because people hardly realize how the climate is changing with a naked eye, media are transforming climate change into a sequence of events (Weingart, Engels & Pansegrau, 2000). If the media do not manage well, the transformation of science into socio-political action might be substantially hampered.

The interfaces of science, policy-making and society are mediated by the media. As a consequence, for public debate and opinion-making it is less important, if a scientific idea is regarded as valid and confirmed within science. Instead, it is more important, if and to which extent a wider public agrees on a particular scientific idea as it was mediated by the media (Weingart, 2015: 239). Boykoff (2011) is presenting a good example and summarizes results of two studies about how newspapers and TV programs contributed to a distorted presentation of the scientific consensus about anthropogenic climate change. A first study was based on an analysis of 3,500 articles from high quality US newspapers from 1988 to 2002 and the second study assembled a database of nearly 300 segments that had appeared on US TV 1995–2004. Both studies show that a majority of articles and TV segments followed a balanced reporting approach. This means that independent of an already established wide agreement among scientist about the human impact on the climate, the media payed equal attention to the view that humans contribute to global warming as well as to the view that their role was negligible. This *bias as balance* of the media negatively affected their gatekeeping function and strongly influenced the public discourse as well as political action taking about climate change in substantial ways (see example, fig. 1). Nevertheless, research has indicated that climate journalism has recently moved beyond the norm of balance towards a more interpretive pattern of journalism where most journalists are aware of the broad scientific consensus about an anthropogenic climate change (Brüggemann & Engesser, 2017).

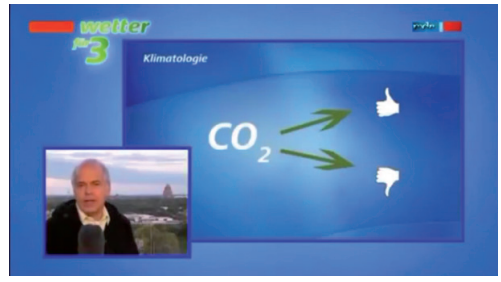

Figure 1: Weather forecast on German television suggests that scientists' opinion on the role of CO_2 in climate change is balanced.
https://youtube.com/watch?v=Ru1S0wauCbY
(Retrieved 2019-12-04)

Because of their gatekeeping function, journalistic media are serving several purposes in democratic societies most of all connecting societal sub-systems like policy-making and science to a wider public. Journalistic media therefore contribute to how society observes itself (Luhmann, 2017). Therefore, it is not surprising that the media are exposed to campaigners and their efforts to influence the interfaces between science, policy-making, the media, and a wider public. Even though a wide agreement among scientists about the human role in climate change has been established for more than a decade (Oreskes, 2005), climate change is the most commonly cited topic among US-Americans when asked for the role of disagreement among scientific experts (Funk, Gottfried & Mitchell, 2017). The way how the public perceives climate science has been strongly affected by campaigning which was driven by economic interests and aiming at an amplification of doubt in climate science (Oreskes & Conway, 2010; Dunlap & McCright, 2011; Hoggan & Littlemore, 2009; Boykoff, 2011). In this respect the "merchants of doubt" (Oreskes & Conway, 2010) have been more effective "educators" of the public than climate science itself (Cooper, 2011) and their effort went pretty well together with the above-mentioned *bias-as-balance-problem* of the media.

Given this, it is evident how vulnerable the interfaces between the media and other societal sub-systems are for being influenced by partisan economic interests. For an informed citizen this might mean that he or she does not only have to understand the basic science behind a socio-scientific issue, but also how science is portrayed, presented, transformed, sometimes distorted or even misused by the media. The gatekeeping function of the media might be helpful to protecting science against distorted presentations, as long as critical journalists dispose sufficient resources to do their jobs and as long a wider public is trusting not only in experts in science, but in how science in portrayed in high quality media in general. As we will see, both is a problem at present and the outstanding role of the media as gatekeepers is generally fading (Höttecke & Allchin, accepted).

Media in many countries are suffering from an economic crisis of decreasing budgets which strongly restricts investigative journalism. Under an increasing economic pressure, time and resources for thorough investigations are limited. This leads to an amplification of how media depend on public relation agencies or the advertising industry (Steindl, Lauerer, & Hanitzsch, 2017). The economic crisis of the media finally contributes to eroding trust in the media, depending on country and political orientation. As an international survey indicates (Newman, et al., 2018), on an aggregate level only 44% of the people express trust in the reliability of media. The situation varies strongly from countries of general high trust (Finland, 62%) to low trust (South Korea, 25%). In strongly polarized countries like the US, trust in media varies from 49%/17% according to a left-wing/right-wing orientation. In the US, Republicans and Democrats are equally likely to be active science news consumers, but Republicans are less likely to be convinced that the media are doing a good job on covering science (Funk, Gottfried & Mitchell, 2017). Hence, the polarization of a society is even mirrored by different ideas about how reliably the media are presenting science.

While traditional journalistic media like newspapers, TV or radio play important roles in mediating science, policy-making and a wider public of citizens, they are at the same time facing an economic crisis and a crisis of vanishing trust. Today, political stake-holders, companies and other organizations can provide citizens directly with their own websites, YouTube and Twitter channels and Facebook pages. As a result, the traditional role of the media as gatekeepers and curators of the mediation of science in society is declining. This process has been generally called 'disintermediation' (e.g. Schweiger, 2017: 16).

The mediation of science in a disintermediated society

The distribution of scientific knowledge and information online seems to be a big achievement. The internet potentially contributes to the emancipation of citizens. Misleading or falls information might quickly be identified and criticized by online communities. However, the actual situation seems to be different. Online discussions are rather conducted among people, which share the same ideas and predominantly agree with each other. Controversial discussions are less common (Schweiger, 2017). While it has been never before so easy to get access to a rich variety of information, positions or opinions, this sheer endlessness of opportunities also bears problems for the communication of science. In the early days of the Internet, it was still hoped that the social media would have a self-correction function, but this hope has largely not been fulfilled. Are internet users essentially prepared and willing to check plausibility and trustworthiness of the information they find? Are they able to realize conflicting evidence and find out which online source should be estimated as more or less trustworthy?

On the internet journalistic media have to increasingly compete against social media, which recently led to a substantial and quick change of adolescents' information and communication practices. A German study about media use of adolescents (Medienpädagogischer Forschungsverbund Südwest, 2017) pointed out that almost all of the 12–19-year-old do have internet access. Smartphones are the most important device for going online and are therefore used intensively by 92% of the 12–13 old people and even 99% of 18–19-year-old. When using media in their free time, being online is at the top. The most popular internet offers for young people are YouTube, WhatsApp, Instagram and Snapchat while the relevance of Facebook is rapidly declining. When asked where adolescents are searching for information at least several times a week, 85% indicate to use Google, 2/3 use YouTube and about half of them use Wikipedia. A quarter of them receives news and up-to-date information via social networks such as Facebook or Twitter or online offers of newspapers. Only a fifth use online offers of news magazines. 1/4 of adolescents and young adults (14–29 years) used the internet as primary source for searching for news, which is a high rate compared to people aged 30+. Overall, the importance of the internet for adolescents for up-to-the-minute information is increasing (Allensbacher Markt- und Werbeträgeranalyse, AWA, 2017). Across eight Western European countries, adults aged 18 to 29 are about twice as likely to get news online than from TV (Matsa, Silver, Shearer & Walker, 2018). It is likely that adolescents are using the internet not only for social purposes — most of all staying

connected to their peers — but for retrieving information with scientific and political relevance.

A German survey about adolescents (Bravo & YouGov, 2017) shows 1/3 being interested in politics on a high and another 1/3 on a medium level. The prejudice of a politically disinterested youth is therefore wrong. School and family are the most important influences for political opinion-making, but only the group of highly interested adolescents is actively engaged in online discussions about political issues. On the other hand, international comparative studies of young people's media literacy show that young people are not well prepared to deal with the information overload of the Internet. Students in class 8 rarely exhibit the highest level of competence (EU: 1.5%, USA: 2.3%), indicating that they cannot securely evaluate and organize information independently. (Eickelman, Bos, Gerick & Labusch, 2019). In a nutshell, young people are interested in politics and public decision-making and increasingly draw on the internet and social networks as primary tool to get informed and participate in public debate while at the same time they are lacking competencies of media use.

Among the distinctive features of the internet is its relative lack of professional gatekeeping. Web-based information is not always subject to the same level of scrutiny as high-quality journalistic media are, which undergo restricted review and gatekeeping processes. Of course, websites of major magazines or broadcast services often invoke the same editorial attention as their traditional counterparts, but these sites constitute a minority among all kinds of internet sources which provide information (Metzger, Flanagin, Eyal, Lemus & Mccann, 2003). As a consequence of the general change in media use in society, traditional journalistic media are increasingly turning form their traditional role as gatekeepers to gatewatchers (Bruns, 2009, 2018). This means that material that passes through the output gates of news outlets online and offline is continuously observed, selected and assemble for publication in the gatewatcher's own site.

Social media on the first sight allow for a better communication of science towards a wider public of lay persons and informed citizens. Citizens might for instance use explanatory YouTube videos, make comments and discuss scientific issues with a wide audience including scientists. On a second sight, social media lead to a blurring of boundaries between public and professional discourses. Lay persons increasingly become informed by social networks, but may allegedly appraise themselves as experts. As a result, the extension of the passive reception of information and active communication in social networks by lay persons exacerbates the crisis of confidence in scientific expertise (Weingart, 2017). In this way, social networks do have the potential to amplify a general crisis of expertise in society (Nichols, 2017).

Searching, selecting and evaluating news on the internet and social media compared to traditional media reveals to quite distinctive features. News aggregators like Google News or Yahoo News became quite popular. They are searching and assembling news and information from several websites including online newspapers, blogs, videos or podcasts. Based on an analysis of a user's interests and attitudes, aggregators provide selected, personalized and tailored information. As a result, the use of non-aggregated offers is declining. The aggregation of news on the

internet leads to a distortion of information because of at least two reasons. First, people predominantly pick up information which already fits to their pre-existing ideas and beliefs, and second the information provided is often decontextualized (Schweiger, 2017). As a result, internet users are more and more trapped in so called *filter bubbles*. There, they are fed with information which meets what they already know, and communicate with people which already share their views and perspectives. Social media often present tailored narratives and are hiding at the same time what they do not tell.

Next to the aggregation effect, members of social networks like Facebook have so called friends which contribute to the amplification of one's beliefs and opinions: The chance that somebody's friends share a wide array of ideas and beliefs about a certain topic together with the chance that friends send and share news and information accordingly is high. As a result, social networks function as so-called *echo chambers* where ideas, beliefs and opinions have a high chance to be confirmed, instead of being challenged. At the same time, the willingness to articulate ideas and opinions against the mainstream in a social network is rather low (e.g. Hampton, et al., 2014). This self-amplifying effect has been called a *spiral of silence* (e.g. Walter, Brüggemann & Engesser, 2018; Schweiger, 2017). The basic mechanism behind these communication pattern in social networks is not only driven by technical algorithms (e.g. by aggregation), but by the psychological trait of humans to avoid cognitive dissonance. This effect initially investigated by Festinger (1957) means that people are basically striving for a reduction of contradictions among knowledge, beliefs, and attitudes towards a certain topic which might lead to feelings of discomfort when confronted with opposing views. Personal cognitive filters are protecting one's identity against otherwise threatening information (Kahan, 2017). As a result, the cognitive architecture of the so-called *cognitive bias* (Nickerson, 1998; Kahneman, 2012) fits very well to the architecture of social media and aggregated news platforms where news and information is recommended in tailored ways (see extended discussion: Höttecke & Allchin, accepted).

What does all this mean to the communication of science? An analysis of comments to online articles about climate change shows that challenging comments which tend to deny the anthropogenic climate change are less likely from Germany, Switzerland, UK, USA to India (Walter, Brüggemann & Engesser, 2018). Sharing skeptical comments is significantly lower and sharing of supporting comments significantly higher in countries that are generally considered to be more doubtful of anthropogenic climate change. It seems to be the case that in countries like Germany, where public opinion widely agrees on the scientific consensus, skeptical voices are marginalized in a broader public debate, but still very active in social media. The public sphere is therefore disintegrated into different spheres representing different communities. Sub-communities either supporting or denying anthropogenic climate change, each evolve into consonant echo chambers, where either supporters or challengers dominate. Due to the above-mentioned effects of filter bubbles, echo chambers and spirals of silence, users of either of the groups tend to an overestimation of the number of people supporting their own views. This effect has been called a *false consensus effect* (ibid.). In our age of

social media we observe several spirals of silence on different levels which are likely to compete with each other (Schulz & Roessler, 2012).

Surprisingly, an analysis of climate skeptical blogosphere let to the identification of only three central blogs (Sharman, 2014). Either they are directly challenging mainstream climate science, or they criticize how the system of climate science is generally conducted. At the same time the blogs present themselves with a scientific appearance, while less explicitly highlighting differences in values, politics, or ideological worldviews. Such central blogs are online key players in de-legitimization and contestation of scientific experts. They do not contribute to a properly working interface between science and the public, but demonstrate themselves as alternative scientific experts for a climate skeptical audience. An analysis of comments on YouTube videos about climate change which either argued for or against the scientific consensus, shows a similar pattern: it is a limited number of key players which strongly influences the public discourse of online-communities and aggregate the power to form opinions in the public (Shapiro & Park, 2018).

Another phenomenon increased by social media is the effectiveness of how *fake news* are travelling through the internet. Fake news is often purposefully launched and aims at affecting public opinion-making and enforcing partisan interests. Among the most cited fake news about climate change is the idea that a wide consensus about anthropogenic climate change has not yet been achieved. The basic problem of fake news is that compared to non-fake news they appear to be more reliable, more interesting and more surprising at least on a first sight. In a recent study about fake news travelling on Twitter (Vosoughi, Roy & Aral, 2018), it turned out that true news needed six times longer to reach the same amount of people compared to fake news. One might conclude that people sharing fake news are more active in sharing internet content, but this actually was not the case. The increased chance of fake news to be shared was due to their novelty and attractiveness only. Even if fake news is revoked after some time, the revocation is reinforcing and stressing the formerly released fake news, because it is less attractive compared to the fake news itself. As a result, revocation of fake news leads to a boomerang-effect, where fake news is amplified even by its own refusal (Wormer, 2017). This is why fake news are such powerful tools for affecting public attention and opinion-making.

Conclusions

As we have seen, the disintermediation of society caused by a growing lack of gatekeepers at the interface between science and the wider public leads to several substantial problems. They have to be considered by science educators: Social media are of increasing importance for adolescents towards being informed about science. Since socio-scientific issues are often concerned with science-in-the-making, the process of science and how it is portrayed in the public do matter for opinion-making. News providers on the internet and social media are characterized by certain traits like the aggregation of news, information bubbles, echo chambers, spirals of silence, false consensus-effect and the effectiveness of fake news. All these traits contribute to the fact that a person's opinion about a socio-scientific issue like climate change, vaccination or air pollution is more likely to be amplified instead of being

challenged. As a consequence, societies at present are increasingly polarized which is among the major side-effects of the disintermediation of society. Without functioning mechanisms of gatekeeping, the quality of information about science will decrease, especially in the age of purposefully launched disinformation (fake news).

As has been argued in the introduction, citizens making informed decisions about socio-scientific issues require more than scientific content knowledge. Even a basic understanding of traditional NOS is not sufficient. We have to consider instead that any simplified model of "dissemination" or "diffusion" of scientific knowledge from science to society is rather limited and is neglecting the fact that scientific knowledge becomes actively transformed and recontextualized as it travels through communication networks (Latour, 1987; Höttecke & Allchin, accepted). Traditional approaches to NOS focus on how science is embedded in society in a rather general sense (e.g. dependence of science from funding) and how scientists justify claims within their own professional discourse. This paper argues instead that from a functional scientific literacy perspective we have to consider not only how science is produced and communicated within science. We have to consider instead the active and transformative practice of the media (gatekeeping!) when science is communicated to the public. Media use is rapidly changing. Social media more and more take up the role of communicating science in society. Here, we have seen that the gatekeeping role of traditional media is in decline and social media instead lead to distorted communicative practices in society (filter bubble, echo chamber, spiral of silence, false-consensus effect, fake news). As has been argued elsewhere (Höttecke & Allchin, accepted), students need to develop *science media literacy* in order to become *scientifically literate* and *media literate* at the same time. Science media literacy bridges the three domains of discourse: science — the media, and the citizen-consumers in their world of social media.

References

Allchin, D. (2011). Evaluating knowledge of the nature of (whole) science. *Science Education*, 95(3), 518-542.

Allchin, D. (2012). Skepticism and the architecture of trust. *The American Biology Teacher*, 74(5), 358-362.

Allensbacher Markt- und Werbeträgeranalyse, AWA (2017). *Anhaltender Transformationsprozess der Mediennutzung*. www.ifd-allensbach.de/fileadmin/AWA/AWA_Praesentationen/2017/AWA_2017_Schneller_Medien.pdf (09.08.2018).

Beck, U. (1986). *Risikogesellschaft. Auf dem Weg in eine andere Moderne*. Frankfurt a.M.: Suhrkamp.

Boykoff, M.T. (2011). *Who speaks for the climate? Making sense of media reporting on climate change*. Cambridge [i.a.]: Cambridge University Press.

Bravo & YouGov (2017). *Politische Jugendstudie*. https://yougov.de/Politik/Jugendstudie (09.08.2018).

Brüggemann, M. & Engesser, S.F. (2017). Beyond false balance: How interpretative journalism shapes media coverage of climate change. *Global Environmental Change*, 42, 58-67.

Bruns, A. (2009). Vom Gatekeeping zum Gatewatching. Modelle der journalistischen Vermittlung im Internet. In C. Neuberger, C. Nuernbergk, M. Rischke (eds.), *Journalismus im Internet* (pp. 107-128). Wiesbaden: VS Verlag für Sozialwissenschaften.

Bruns, A. (2018). *Gatewatching and news curation: journalism, social media, and the public sphere*. New York: Peter Lang.

Cooper, C.B. (2011). Media literacy as a key strategy toward improving public acceptance of climate change science. *Bioscience*, 61(3), 231-237.

Cottle, S. (1998). Ulrich Beck, 'Risk Society' and the media. A catastrophic view?. *European Journal of Communication*, 13(1), 5-32.

Dittmer, A., Gebhard, U., Höttecke, D., & Menthe, J. (2016). Ethisches Bewerten im naturwissenschaftlichen Unterricht: Theoretische Bezugspunkte für Forschung und Lehre [Ethical judgment and decision-making in science teaching: Theoretical reference points for research, teaching, and learning]. *Zeitschrift für Didaktik der Naturwissenschaften*, 22(1), 97-108.

Dunlap, R.E. & McCright, A.M. (2011). Organized climate change denial. In John S. Dryzek, Richard David Schlosberg (eds.), *The Oxford Handbook of Climate Change and Society* (pp.144-160). Oxford: University Press.

Eickelmann, B., Bos, W., Gerick, J., & Labusch, A. (2019). Computer- und informationsbezogene Kompetenzen von Schülerinnen und Schülern der 8. Jahrgangsstufe in Deutschland im internationalen Vergleich. In B. Eickelmann et al. (eds.), *ICILS 2018. Computer- und informationsbezogene Kompetenzen von Schülerinnen und Schülern im zweiten internationalen Vergleich und Kompetenzen im Bereich Computational Thinking* (pp. 113-135). Münster, New York: Waxmann.

Feinstein, N.W. (2015). Education, communication, and science in the public sphere. *Journal of Research in Science Teaching*, 52(2), 145-163.

Festinger, L. (1957). *A Theory of Cognitive Dissonance*. Stanford: Stanford University Press.

Funk, C., Gottfried, J. & Mitchell, A. (2017). *Science News and Information Today*. Pew Research Center, Washington, DC, http://www.journalism.org/wp-content/uploads/sites/8/2017/09/PJ_2017.09.20_Science-and-News_FINAL.pdf (20.04.2019).

Hampton, K.N., Rainie, L., Lu, W., Dwyer, M., Shin, I., & Purcell, K. (2014). *Social Media and the 'Spiral of Silence!* Pew Research Center, Washington, DC, http://www.pewinternet.org/2014/08/26/social-media-and-the-spiral-of-silence/ (26.11.2018).

Hardwig, J. (1991). The role of trust in knowledge. *The Journal of Philosophy*, 88(12), 693-708.

Hel, v.d. S., Hellsten, I., & Steen, G. (2018). Tipping points and climate change: metaphor between science and the media. *Environmental Communication*, 12(5), 605-620.

Herman, B.C., Clough, M.P., & Olson, J.K. (2013). Teachers' nature of science implementation practices 2-5 years after having completed an intensive science education program. *Science Education*, 97(2), 271-309.

Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education*, 25(6), 645-670.

Hodson, D. (2008). *Towards Scientific Literacy: A Teachers' Guide to the History, Philosophy and Sociology of Science*. Rotterdam: Sense Publishes.

Hodson, D. (2011). *Looking to the Future. Building a Curriculum for Social Activism*. Rotterdam: Sense Publishers.

Hodson, D. (2013). Don't be nervous, don't be flustered, don't be scared. Be prepared. *Canadian Journal of Science, Mathematics and Technology Education*, 13(4), 313–33.

Hoggan, J. & Littlemore, R. (2009). *Climate Cover-Up. The Crusade to Deny Global Warming*. Vancouver [i.a.]: Greystone Books.

Höttecke, D. (2017). Die Natur der Naturwissenschaften [The nature of science]. In U. Gebhard, D. Höttecke & M. Rehm (eds.), *Pädagogik der Naturwissenschaften* (pp. 85-105). Berlin: Springer VS.

Höttecke, D. & Allchin, D. (accepted). Re-conceptualizing nature-of-science education in the age of social media. *Science Education*.

Höttecke, D. & Silva, C.C. (2011). Why implementing history and philosophy in school science education is a challenge - An analysis of obstacles, *Science & Education*, 20(3-4), 293-316.

Kahan, D. (2017). Misconceptions, misinformation, and the logic of identity-protective cognition. *SSRN Electronic*

Journal, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2973067 (10.11.2019).
Kahneman, D. (2012). *Thinking Fast and Slow*. London [i.a.]: Penguin Books.
Latour, Bruno (1987). *Science in Action: How to follow Scientists and Engineers through Society*. Cambridge, Massachusetts: Harvard University Press.
Lederman, N. G. (2007). Nature of science: past, present, and future. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 831–879). Mahwah, NJ: Erlbaum.
Luhmann, N. (2017). *Die Realität der Massenmedien*. Wiesbaden: Springer VS.
Matsa, K.E., Silver, L., Shearer, E., & Walker, M. (2018). *Western Europeans Under 30 View News Media Less Positively, Rely More on Digital Platforms Than Older Adults*. Pew Research Center, Washington, DC, www.journalism.org/wp-content/uploads/sites/8/2018/10/PJ_2018.10.30_europe-age_FINAL3.pdf (21.11.2018).
McComas, W. F. (ed.) (1998). *The Nature of Science in Science Education. Rationales and Strategies*. Dordrecht, Boston, London: Kluwer Academic Publishers.
Medienpädagogischer Forschungsverbund Südwest (Eds.) (2017). *JIM-Studie 2017. Jugend, Information, (Multi-) Media. Basisuntersuchung zum Medienumgang 12- bis 19-Jähriger*. https://www.mpfs.de/studien/jim-studie/2017/ (09.08.2018).
Metzger, M.J., Flanagin, A.J., Eyal, K., Lemus, D.R., & Mccann, R.M. (2003). Credibility for the 21st century: integrating perspectives on source, message, and media credibility in the Contemporary Media Environment. *Annals of the International Communication Association*, 27(1), 293-335.
Newman, N., Fletcher, R., Kalogeropoulos, A., Levy, D.A.L., & Nielsen, R.K. (2018). *Reuters Institute Digital News Report 2018*. media.digitalnewsreport.org/wp-content/uploads/2018/06/digital-news-report-2018.pdf?x89475 (21.11.2018).
Nichols, T. (2017). *The Death of Expertise. The Campaign against Established Knowledge and Why it matters*. New York: Oxford University Press.
Nickerson, R.S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology*, 2(2), 175-220.
Olson, J.K. (2018). The inclusion of the nature of science in nine recent international education standards documents. *Science & Education*, 27 (7-8), 637-660.
Oreskes, N. (2005). The scientific consensus on climate change. *Science*, 306(5702), 1686.
Oreskes, N. & Conway, E.M. (2010). *Merchants of Doubt. How a handful of scientists obscured the truth on issues from tobacco smoke to global warming*. New York [i.a.]: Bloomsbury Press.
Ratcliffe, M. & Grace, M. (2003). *Science Education for Citizenship. Teaching Socio-Scientific Issues*. Maidenhead [i.a.]: Open University Press.
Sadler, T. D. & Dawson, V. (2012). Socio-scientific issues in science education: contexts for the promotion of key learning outcomes. In B.J. Fraser, K.G. Tobin & C.J. McRobbie (eds.), *Second International Handbook of Science Education* (pp. 799-809). Dordrecht: Springer.
Schulz, A. & Roessler, P. (2012). The spiral of silence and the internet: selection of online content and the perception of the public opinion climate in computer-mediated communication environments. *International Journal of Public Opinion Research*, 24(3), 346-367.
Schweiger, W. (2017). *Der (des)informierte Bürger im Netz. Wie soziale Medien die Meinungsbildung verändern*. Wiesbaden: Springer.
Shapiro, M.A. & Park, H.W. (2018). Climate change and YouTube: deliberation potential in post video discussions. *Environmental Communication*, 12(1), 115-131.
Sharman, A. (2014). Mapping the climate sceptical blogosphere. *Global Environmental Change*, 26, 159-170.
Steindl, N., Lauerer, C., & Hanitzsch, T. (2017). Journalismus in Deutschland. Aktuelle Befunde zu Kontinuität und Wandel im deutschen Journalismus. *Publizistik*, 62(4), 401-423.

Vosoughi, S., Roy, D., & Aral, S. (2018). The spread of true and false news online. *Science*, 359, 1146-1151.

Walter, S. Brüggemann, M., & Engesser, S. (2018). Echo chambers of denial: explaining user comments on climate change. *Environmental Communication*, 12(2), 2014-217.

Weber, M. (2008). *Alltagsbilder des Klimawandels. Zum Klimabewusstsein in Deutschland*. Wiesbaden: VS Verlag für Sozialwissenschaften.

Weingart, P. (2015). *Die Stunde der Wahrheit? Zum Verhältnis von Wissenschaft zu Politik, Wirtschaft und Medien in der Wissensgesellschaft*. Weilerswist: Velbrück Wissenschaft.

Weingart, P. (2017). Wissenschaftskommunikation unter digitalen Bedingungen. Funktionen, Akteure und Probleme des Vertrauens. In P. Weingart, H. Wormer, A. Wenninger, A., & R.F. Hüttl (eds.), *Perspektiven der Wissenschaftskommunikation im digitalen Zeitalter* (pp. 31-59). Weilerswist-Metternich: Velbrück Wissenschaft.

Weingart, P. Engels, A., & Pansegrau, P. (2000). Risk of communication: discourse on climate change in science, politics, and the mass media. *Public Understanding of Science*, 9, 261-283.

Wormer, H. (2017). Mythos Gatewatching. Die erhoffte Korrektivfunktion von Social Media im Lichte von ‚Dementiforschung' und ‚Fake News'. In P. Weingart, H. Wormer, A. Wenninger, A., & R.F. Hüttl (eds.), *Perspektiven der Wissenschaftskommunikation im digitalen Zeitalter* (pp. 196-213). Weilerswist-Metternich: Velbrück Wissenschaft.