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Between scientism and relativism: epistemic competence as an important aim in science and philosophy education

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Abstract

There is an ongoing cultural struggle regarding the reach and boundaries of science. Central questions discussed in this debate are for example: what is the essence of natural science? Is its claim for epistemic superiority justified?

As the dispute is not only academic but lies behind several life-world relevant issues as well, we believe that it is essential both to science education and philosophy education. As the topic is inherently interdisciplinary, we claim that the didactics of science and philosophy should work jointly to establish a model of epistemic competence and develop concepts that facilitate such a model. We make a proposal for the structure of epistemic competence as a basis for discussion.

Keywords

Epistemic Competence; Science Education; Philosophical Education; NOS; Scientism; Relativism

1 Introduction: why the current dispute over science is relevant for education

Two weeks before the term "post-factual" was chosen as the word of the year of 2016 in the culture section of the leading German newspaper FAZ, the journalist Joachim Müller-Jung (2016) demanded an "outcry" from scientists against the populist gibberish of a *zeitgeist*, euphemistically declared as post-factual. In his article, Joachim Müller-Jung criticizes the "tragedy of civilization", which in his view, is constituted by the marginalization of science. He mentions the sluggishness of scientists and their institutions, who would agree with this proclaimed decline if funding remained untouched. As examples of the continuous erosion of the societal status of the (natural) sciences, Müller-Jung mentions the increasing presence and acceptance of intelligent-design adherents, big-data skeptics and climate-change deniers. As a cause of this development, he identifies a loss of trust in scientific thought that is constituted by a "systematical investigation of the world through experiment and observation, the utilization of so acquired knowledge and by challenging it repeatedly". Science's promise of progress could no longer convince the people. Instead, particularly in the educated middle-class, concerns regarding technological risks prevail since the complex, abstract and often speculative attempts of science take a backseat to the "appearance of relevance and simpleness, the radical problem awareness of populists".

The worrisome analysis articulated by Müller-Jung did not suddenly emerge in 2016 and is not restricted to Germany. In the "Süddeutsche Zeitung", which is another German newspaper, the influential American policy adviser Benjamin Barber (2010) laments an "epistemological deficit" of the populace that threatens democracy and leads to a

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situation where “truth, objectivity, science, facts and reason are not being sufficiently differentiated from opinion, subjectivity, prejudice, emotion and irrationality”. Even Bruno Latour (2004), who is arguably one of the internationally most prominent critics of the idea of objective and rational science, expresses concern regarding the idea of scientific fact as a social construction (which was partially established by his own work) currently being “misused by dangerous extremists to fuel mistrust about scientific evidence” (p. 227).

The erosion of the ability to judge and act by means of indifference toward concepts, such as “truth”, “fact” and “objectivity”, has been long discussed. As early as 2005, the philosopher Harry G. Frankfurt (2006) warned against the commonly held position of “Bullshit”, according to which the search for objective, and above all scientific, truth was supposed to be irrelevant and futile. Instead, what mattered most in all aspects of life was to make a trustworthy impression on others. Bullshit differs from lying in that the pursuit of truth becomes irrelevant. Those who lie must know the truth to be able to create a lie, whereas those who Bullshit do not care about the truth. According to Frankfurt, the current prevalence of Bullshit in public discourse and the media is rooted in various forms of skepticism that deny the possibility of reliable access to an objective reality and claims that we are always unable to understand the real world. Bullshit is the aftermath of pressure experienced by premier opinion leaders, particularly in democracies, to present an opinion regarding any arbitrary topic in the mass media, even without a sufficient reason. From current experiences, the pervasiveness of the Bullshit-position may be strengthened by the extensive use of digital media due to everyone uttering opinions and asserting facts anonymously without providing verification (Fake News). According to Frankfurt “these ‘anti-realist’ doctrines undermine our trust in the value of an unbiased endeavor to clarify the question of what is true and what is false, and even our trust in the concept of objective research” (p. 72).

Thus, this skeptical attitude prevents one from incorporating the following essential attitudes — one might even say virtues — that have been cherished as important ideals by both philosophers and scientists: sincerity, patience, accuracy, curiosity, reliability, and striving for increasingly better explanations. In addition to these theoretical and societal considerations, practical consequences also play a role. In her book about the life-world science-oriented didactic of philosophy, Bettina Bussmann (2014, p. 116) systematically investigates the relationship among science, pseudo-science and esotericism. She suggests that educational systems that do not adequately analyze and legitimize scientific standards and cannot differentiate these processes from pseudoscientific approaches run the risk that graduates are deceived by dangerous, expensive and useless products, services and institutions, such as an ineffective or damaging medicine, therapy or training programs that do not concord with scientific standards (for example, see Graf & Lammers, 2016 regarding several approaches of so-called alternative medicine). However, this damage is not restricted to the economic or health sectors. This damage leads to a general loss of trust in the possibility of obtaining knowledge regarding the nature of the world through scientific inquiry, which is the same concern stressed by Barber, Latour and Frankfurt and is emphasized by Joachim Müller-Jung.

Müller-Jung´s appeal appears to revitalize the dispute regarding the foundation and scope of natural science known as the *Science Wars,* which occurred in the 1990s*.* If one

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follows Müller-Jung´s demand, not only scientists and their institutions but also the didactics of science and philosophy should feel obligated to oppose the societal marginalization of their respective disciplines and promote the development of a scientific worldview. Thus, if a new version of the *Science Wars* existed, which position should the didactics of science and philosophy occupy? We approach this question by first sketching the backgrounds and frontiers of the fundamental conflicts regarding nature and reach of natural science. Subsequently, we provide a brief summary of the didactics of science and philosophy. In the final section, we outline recommendations at the curricular level to meet the posed problems. Finally, we present a description of interdisciplinary competence that we designate epistemic competence.

2 Dispute over the scope of science

The exact frontlines of the dispute over the scope of science are complex and nebulous. Detailed expositions are beyond the scope of this paper, particularly those regarding the respective political relationships. However, Mario Kötter and Marcus Hammann (2017) suggest simplifying the assessment of the scope of the natural sciences by characterizing the following two main camps: science optimism, which is the stance that in contemporary Western culture, science is the epistemic superior source of knowledge, and science pessimism, which is the stance that science optimism is unjustified because the alleged superiority is a myth, and therefore, science should be treated as any other societal institution. Although these camps are not homogeneous groups, they can be characterized by certain epistemological standpoints and different methodological perspectives of natural science. Certainly, many unifying positions exist in these two camps. However, we largely ignore these unifying positions because our aim is to draw attention to the *disputes* regarding the epistemological and societal reach of the natural sciences.

Several insights have been revealed during the previous century regarding the sociology, philosophy and history of science that provide a more authentic picture of science and its possibilities of gaining knowledge. However, these insights have been continuously used to support very "pessimistic" views regarding the scope of science, and, in certain cases, these insights have been used to support various outright anti-scientific (and anti-rationalistic and anti-intellectual) stances. Scientists (and other groups, such as philosophers of science) have publicly argued against the growing distrust of science, which has become known as the *Science Wars* in the final decades of the previous century. We believe that this situation currently is at least analogous because the perpetrators of anti-science views use the very same arguments developed by sociologists and others in the previous century, while the protagonists have mostly changed. The following section introduces the two camps.

2.1 Science pessimism

Regarding the *Science Wars,* philosopher of science Noretta Koertge (2000) establishes that throughout the 1990s, approaches from the sociology of knowledge, feminist philosophy of science and postmodern cultural criticism have gained importance due to their reflection upon science[1]. According to Koertge, these "new age commentaries on science" share a relationship with post-positivistic arguments, such as the theory-ladenness of observation and the underdetermination of theory. These arguments have long been discussed in the philosophy of science, but in the 1990s, these discussions were used to justify the radical claim that no essential difference exists between scientific knowledge and other belief systems, such as indigenous knowledge and religion. This position leads to a rejection of the normative project of the philosophy of science and concentrates on the purely descriptive perspective. The knowledge gained through science studies regarding how science occurs was used as an argument against the claim that the epistemic nature of the natural science is superior. For example, findings related to the history of science in terms of changing scientific methodology were considered sufficient evidence in a thesis stating that determining the criteria of scientific quality is impossible. According to critics, scientific norms are not timeless, objective or epistemically necessary; instead, these norms are simply based on the consensus of those involved in the work of knowledge production.

Babette Babich (2015) argues that the established natural sciences oppose approaches, such as cold fusion, AIDS denialism and homeopathy, due a dogmatic oppression of their underlying ways of thinking rather than due to deficient knowledge. For instance, dogmatic oppression occurs when mainstream experts refuse to cite publications or publish their work. In this context, accusations of pseudoscience arbitrarily discredit deviants. According to Babich, philosophy of science functions as an ally to the science establishment, providing criteria for demarcating science from pseudoscience, which consequently, can be used by the establishment as an instrument of power.

The "facts" of science — as reflected by Müller-Jung in his lament regarding the post-factual *zeitgeist* — are merely *social constructs*. If this view is accepted, the political and economic elites (often white Western males) can exert prevailing influence on scientific insights and misuse these insights as opportunistic arguments to enforce their political goals and ultimately maintain the existing balance of power. According to the science-pessimists, science and its claim to objectivity and rationality cannot be trusted as the core method, at least not more than other explanatory models of reality.

2.2 Science optimism

In the 1990s, the postmodern-relativistic conceptions of science were initially opposed by scientists, followed by philosophers of science (e.g., Gross & Levitt, 1998; Gross, 1996; Brown, 2001). Although the descriptive disciplines of sociology and history have provided insights they nevertheless claim that normative evaluation remains necessary.

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[1] Reflecting upon science can be performed in various ways. For example, the analysis of terms used in scientific theories is an issue typically pursued in the philosophy of science, while reflecting upon power structures in science laboratories is an issue typically pursued in the sociology of science. If reflection upon science is performed in an academic, institutionalized manner, this reflection refers to a "science-reflective discipline". We use this term as an umbrella representing the entirety of all domains of inquiry that have science as their research subject (philosophy, history, sociology, anthropology, psychology of science etc.). Thus, we differentiate the realm of the *philosophy of science,* which also investigates normative questions from the realm of s*cience research,* which is exclusively restricted to the empirical-descriptive disciplines, such as the sociology of science and science studies.

The *demarcation problem* is a classical task in this respect that is also considered by many contemporary philosophers (e.g., Hansson, 2014; Mahner, 2007; Schurz, 2014). The demarcation problem can be described as the (partially normative) problem of defining science (Resnik, 2000), i.e., how to distinguish between science and pseudoscience. This question does not imply that the demarcation problem is necessarily solvable, but the authors state that the natural sciences exhibit a special status regarding its insights into the fundamental processes of nature and that certain basic differences exist between science and other less epistemically justified declarative systems. The basic attitude of philosophers working in the normative tradition of reflection upon science can be commonly designated science optimistic. This position is currently advocated by Gerhard Schurz (2014, pp. 26–29) and others. According to Schurz, the aims of science are “approximately true statements about a subject in question”, which are at least partially achieved by assuming a “minimal epistemological model” and applying “common methodological criteria”. Consequently, Schurz considers the demarcation problem a central concern in the philosophy of science; the clarification of this problem is highly important to the abovementioned quest for a methodological and epistemic foundation.

Amidst all controversy, many experts believe that descriptive and normative perspectives should be considered complementary rather than contradictory and that social and epistemic factors exert an influence on science (Carrier, 2007, p. 18; Carrier, 2008, pp. 9–10). The clash of perspectives must be considered a topic for reflected discourse. In education, emphasizing the presence of both domains, i.e., history of science, sociology and psychology as well as the philosophy of science and epistemology is necessary. The two distinct questions — how, in fact, does science proceed? how *ought* science proceed to foster knowledge? — are in the center of attention. One-sidedness could result in radically science-optimistic or science-pessimistic positions. Both cases of one-sidedness should be criticized as fallacious alternatives.

3 The scope of science and education

As described in section 2.1, the science-pessimistic camp generally pursues societal-emancipatory goals. In the educational context, they claim that students should first and foremost develop a *critical* attitude toward science. However, certain philosophers are skeptical because they doubt that radical criticism of science can lead to the intended emancipation. In the context of multiculturalism, the philosopher of science Paul Boghossian (2013, p. 134) mentions that constructivist (pessimistic) approaches to science are often used to defend the beliefs of oppressed minorities. If taken seriously, these arguments lead to the paradox situation in which the powerful cannot criticize the oppressed minorities and the oppressed cannot criticize the powerful. Thus, denying the existence of independent and intersubjective knowledge can deprive the oppressed of their mightiest tool to criticize the powerful.

The philosopher Michael Hampe noted a similar argument in an essay published in the leading German weekly newspaper *Die Zeit (2016),* where he called attention to the danger of the so-called *political correctness* that could undermine our educational system. He states that the proponents of a relativist or social-constructivist conception of knowledge politically dispraise social conditions while simultaneously — due to the lack of reasonable and comprehensible definitions of truth, fact and knowledge — are unable to convey *why* certain statements are racist, discriminating or wrong. To accomplish this, a theory beyond a politically correct education is needed. Schools are places of enlightenment; thus, the search for truth is relevant. Philosophy education is indebted to the educational goal of nurturing rationality. Therefore, controversial topics must not be immunized by means of political correctness; this could amount to an erosion of the educational system. The everyday loss of trust in the concept of objective research also undermines science education's task of conveying an understanding of the importance of the methodological groundwork in natural science's knowledge claims to students. Instead of promoting an attitude of “everybody should know for themselves”, which is increasingly transferred from the students' private and sociopolitical environment into classroom discourse, a critical attitude toward knowledge claims should be systematically promoted.

This diagnosis calls for an explicit treatment of epistemic questions in schooling. Without the possibility of and the obligation toward criteria of truth and knowledge, while on the political stage, there is nothing one can offer in reply, e.g., to a populist who simply cannot be bothered about the truth. Michael Matthews (2004, p. 104) argues that the notion that scientific practice is influenced by many social and psychological aspects is simply trivial. The search for the methodological aspects of science and knowledge that are *independent* of these influences (e.g., logic, probability theory, etc.) are important. Consequently, if normative and descriptive perspectives were jumbled, every claim of knowledge (such as Nazi-, Pseudo-, and Islamic science) would have to be accepted.

According to our view, the authors cited in the introduction are certainly correct in their claim that a plethora of intensely charged debates relevant to everyday life exist in which the question of what distinguishes (natural) science is currently contested, and its claim to epistemic leadership is in many cases fundamentally disputed. The list of arguments compiled by Müller-Jung could be expanded by adding the long-lasting controversy regarding so-called alternative medicine, notably homeopathy (e.g., see the opposing positions of Bettina Schöne-Seifert et al. (2015) and Friedrich Dellmour (2009)) or the current debate regarding the status of gender studies and their relationship to biology (e.g., Kutschera 2016). In our perspective, the didactics of science and philosophy that claim to be relevant to everyday life must contribute to a basic understanding of the debates concerning the societal and epistemic role of science. In the following sections, we inquire whether and how the posed socially and ideologically relevant problems are currently discussed in the didactics of science and philosophy.

4 Reflection upon science in science education

Science education should not merely convey scientific knowledge and procedural abilities but also convey knowledge of the so-called *nature of science (NOS*) (e.g., Kampourakis, 2016). In the German context, an “understanding of science” (Wissenschaftsverständnis) is usually mentioned as a fundamental goal of science education. However, in practice, the topic of reflection upon science is likely only met with limited interest. Calls for placing greater value on reflection upon science in the science classroom are not new; proposals date at least to the 1980s, when Elisabeth von Falkenhausen (1985) argued for “Wissenschaftspropädeutik” (science-propaedeutic) as

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a central component of school biology. In this century, proposals to "teach about NOS" (über die Natur der Naturwissenschaften lehren) in physics education and promote "competence in philosophy of science" (Wissenschaftsphilosophische Kompetenz) in biology education have been offered by Ernst Kircher (2009) and Arne Dittmer (2006), respectively.

However, Arne Dittmer (2010, p. 36) criticizes that reflection upon science usually only occurs in "programmatic introductory talks and in the preface of subject-specific didactics publications". Many colleagues consider reflection upon science a foreign element in science education, as reported by his interview study conducted with teachers from Hamburg (Dittmer, 2010); to date, competence in philosophy of science has not become a component of the biology curricula. Strikingly, the number of publications in relevant German-speaking journals for science education (MNU-Journal and Zeitschrift für Didaktik der Naturwissenschaften, ZfDN) is extremely low. A superficial examination of MNU-Journal issues between 2002 and 2016 and ZfDN issues between 1995 and 2016 revealed only 15 papers on the topic of reflection upon science (from approximately 300 papers in the ZfDN and more than 1000 in the MNU, except for papers on the topics evaluation competence / ethical reflection), and most papers belonged to a special issue of the MNU published in 2002 devoted to the topic. Reflection upon science is also underrepresented at a curricular level; for example, in the educational standards approved by the KMK for the subject biology (KMK, 2004), although one of the four key competences is *acquisition of knowledge*, this competence is primarily concerned with the communication of procedural aspects (e.g., how does one conduct an experiment?), while genuinely epistemic questions (e.g., what role does an experiment play in the acquisition of knowledge?) remain largely untouched. The key competence *evaluation,* particularly in the subject biology, focuses solely on an ethical evaluation of the consequences of scientific inquiry, while an epistemic evaluation of its claim to knowledge is only scarcely mentioned (Hostenbach, 2011, p. 881). Finally, a chemistry schoolbook analysis performed by Marniok and Reiners in 2016 investigated how much text was devoted to questions related to NOS, and the conclusion was "that the results of the analysis are rather sobering "(p. 69). These results should spur publishers and authors to assign topics related to NOS a higher value than the current value.

Therefore, students are unlikely to engage in epistemic reflection upon science in the science classroom. Not explicitly reflecting on science does not mean that students will not develop their own positions. Many science teachers are essentially disciples of science and hold rather unelaborated views, which likely leads to an optimistic image of science, although in a rather naïve and un-reflected way.

The lack of reflection upon science in the science classroom applies even more to explicitly reflecting upon the abovementioned controversies regarding the scope and limits of science. Such approaches are almost absent in the German-speaking science education community (Hammann et al., 2016 and Zeyer, 2005 are exceptions of the general disinterestedness in the topic). Internationally, science education has been and continues to be an arena for the larger societal debate over the scope of science referred to as the Science Wars in section 2 (e.g., Matthews, 2002, p. 122; Good, 2001, p. 180; Allchin, 2004, pp. 935–936). Moreover, there are lively discourses concerning the relation between science and religion (see, for example, science & education, 1996, 5/2) and science and worldviews (science & education, 2009, 18/6–7) or multicultural science education (e.g., Cobern, 2001; El-Hani, 2007), which are related to our contribution.

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However, to date, these discourses have not resulted in approved curricular solutions, and the persistent discourse regarding questions concerning the scope of science has thus far rarely led to the conclusion that the conflict and underlying epistemic discourses could be important subjects of discussion in the classroom (e.g., Matthews, 2012). In contrast, many scholars in science education appear to be skeptical about the practicability and value of teaching NOS in the sense of addressing conflict over the ultimate goals and scope of science. For example, John Rudolph (2000, p. 413ff) criticizes the science education community for their lasting engagement with what he calls the "legitimation project" of science. In his view, students should learn and reflect upon how science works, such as by simulating scientific inquiry in the classroom, whereas the "philosophical issues" mentioned above should be left to the philosophy classroom. Similarly, Richard Duschl and Richard Grandy (2013, p. 2109) propose developing critical epistemic cognitive and social practices (used in science) by allowing learners to experience scientific practices (building and refining model-based scientific claims).

Insofar as philosophical issues are considered important, the so-called consensus view (e.g., Lederman, 2007) has prevailed for more than 15 years. Irene Neumann and Kerstin Kremer (2013, p. 213) attest "that with its relevance for school in mind, there is largely a consensus on which aspects of the philosophy of science should be communicated in science education". The consensus view summarizes valid insights regarding the capacity and limits of science and human understanding in general, which are uncontroversial in the philosophy of science. However, by focusing on the boundaries and limitations of the possibilities of scientific inquiry (as mentioned in section 2.1., e.g., theory-ladenness of observation, subjectivity, and anti-realism), this approach focuses on the same arguments used to support science-pessimistic positions. As mentioned in section 2.1., these insights can be and have been interpreted in radical, anti-scientific ways when they are not negotiated to a certain degree. Our concern is that teaching the consensus view, which remains by far the most influential approach in science education (see, for example Kampourakis 2016), as an unintended side-effect, may easily support rather pessimistic images of science (such as mistrust of science and naïve epistemic relativism; for example, see Abd-El-Khalik, 2001, p. 229; Clough, 2007, p. 35).

Accordingly, Müller-Jung calls for trust in the scientific method and its technological promises that is currently mediated implicitly and can lead to unwarranted and naïve beliefs in science, or views on science are advocated that may lead to an equally unwarranted and naïve distrust. To avoid the problems of naïve optimism regarding the scope of science, we propose that *explicit* reflection upon science should be a mandatory element of the science curricula (particularly in Germany). Furthermore, the consensus view on NOS in its current condition appears inappropriate for reaching the goal of enabling students to develop reasoned opinions over the scope and limits of science.

5 Reflection upon science in philosophy education

In the didactics of philosophy, the transition from a historical-hermeneutical approach to a problem-oriented paradigm that is relevant to everyday life has occurred only gradually (Martens, 1979; Tiedemann, 2013; Thein, 2017). Before the invention of the term "science" in the 19th century, which focused on knowledge tied to experiments

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and physics (Hagner, 2008, p. 24), to a great extent, philosophers were also scientists, particularly in the field of the natural sciences. Historically, the term "philosophy" did not refer to the current definition of philosophy. In the old days, to a great degree, a philosopher was either a scientist or a person who pondered questions that could be viewed as precursors to scientific methods or research, e.g., David Humes' reflections on the human mind, which are currently widely respected by psychologists. However, due to the specialization of the sciences in the 19th century and reformations of institutions, the discipline of philosophy fell into the category of "humanities" (for detailed explanations, see Mittelstraß, 2005, p. 455). Epistemology and philosophy of science, which were the core fields of philosophy since Plato first reflected on the questions of what we know, what we can know and what we know about knowledge (Platon Theätet), have developed into the highly specialized field of the *theory* of science, which is a rather formal approach to questions of knowledge in the individual sciences, from the 20th century to present. Unsurprisingly, philosophers of science typically study a second subject in the natural sciences and often consider themselves as philosophers and scientists. The gap between theoretical philosophy, which also addresses specific problems in the sciences, and the hermeneutic tradition has become considerably large. Nevertheless, even the hermeneutic tradition of philosophy has expanded into a wide range of interdisciplinary research fields within the last 20 years. In his article "The Philosophy of Philosophy", Eugen Fischer states that all philosophical debates of the last two decades indicate "clear signs for an increasing development of metaphilosophy turning into an empirical discipline". This development will ultimately lead to a fundamental transformation of philosophy that is comparable to the triumph of analytic philosophy in the 20th century (Fischer, 2017, p.77).

The hermeneutic orientation continues to prevail in the didactics of philosophy. Any science orientation is often observed with great skepticism due to the fear of losing the philosophical "proprium" and that questions of normativity and philosophical thoughtfulness would return to the background once they are addressed by the realm of the descriptive. Although units from epistemology and the philosophy of science traditionally belong to the canon of topics covered in class, the treatment of the topic of "science" is the consensual approach, which has been dubbed the *hermeneutics of science* by Volker Steenblock and is oriented toward a historical classification of science. Science is "subjected to the conditions of its emergence and the improvability of human accomplishment"; one must insist on "the primate of history" instead of a historically unenlightened ontologism (Steenblock, 1999, p. 290). The "historically unenlightened ontologism" referenced by Steenblock can be compared to the science-pessimistic view outlined above. This ontologism claims that all scientific statements about objects, processes, representations and explanations of the world must be assessed in the light of history. Otherwise, scientism, positivism or naturalism, all of which promote unreflective and dangerous beliefs about the power of scientific inquiry, could be justified. But this approach alone also leads to trouble: it cements the dichotomy between the scientific method (*explanation*) and the humanistic method (*understanding*) as two separate pathways of inquiry established by Wilhelm Dilthey. This schism was advanced and developed into "the two cultures of science" by C.P. Snow (Snow 1961). Admittedly, Snow emphasized that both approaches are relevant to both domains of science in different ways, but to date, the main purpose of philosophy

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education consisted of distinguishing between these different approaches instead of the interdisciplinary analyses that are currently common to academia. Thus, education fails to integrate and reflect upon new scientific methods, problems and insights that current philosophers are addressing, and students are usually quite well informed of these issues through popular scientific magazines, TV or internet discussions.

The recently published and award-winning textbook *Philo. Qualifikationsphase* (Rolf & Peters, 2015) provides insight into the contemporary treatment of the topic of "science". The subject area "science and knowledge", along with anthropology, ethics and political philosophy, receives equal and extensive coverage, in which the epistemological foundation of science, the question concerning the objectivity of the natural sciences and the humanities and the claims and boundaries of scientific inquiry are investigated. Classic authors, such as Carnap, Popper and Kuhn, are listed. Strikingly, the entire discourse after Kuhn is lacking, particularly constructivism, evolutionary epistemology, post-modernism and the *Science Wars.* The analysis and reflection of the scientific method exhaust themselves in the criteria of logical empiricism and critical rationalism and, thus, cannot be linked to problems of everyday life or to the debates regarding academic philosophy. Pressing philosophical issues, such as the value of empirical and scientific-methodological knowledge for normative and ethical deliberations, are not addressed. However, this knowledge appears to be important for many questions that are discussed in a classroom following the paradigm of problem orientation; for example, ethical questions regarding migration, climate change and climate policy, gender issues, and animal treatments all rely on empirical knowledge (studies, experiments, interviews, etc.) that must be included and should be reflected upon. Questions of scientific inquiry enter philosophical discourse to a much greater extent than in the past (see Bussmann, 2017). If one is eager to expand the curriculum with new studies from academic philosophy, one must consider that many philosophers work jointly with, for example, psychologists and neuroscientists, and rely on their scientific methods and results. The new discipline *Experimental Philosophy* has emerged due to this cooperation, and although this field is heavily debated among philosophers in terms of whether this area is fruitful and will have a successful philosophical future, the intensified interdisciplinary approach in philosophy requires an integrated reflection upon the scientific foundation of philosophical inquiry.

While ethical competence is a widely acknowledged and established competence not only in philosophy but also in the areas of professional training and educational research (see Rösch, 2009; Benner & Nikolova, 2016; Eichler & Moritz, 2016), until recently, *epistemic* competence has not been a field of interest in the didactics of philosophy (see Bussmann, 2014). Interestingly, intensified studies have investigated epistemic abilities in the academic field of epistemology. Philosophers claim that epistemic normativity should be described as a set of specific abilities one must have to display knowledge (see Abel & Conant, 2012). The relationship between ethical and epistemic norms and the role played by education in this relationship are currently pressing problems in epistemology according to Günther Abel in his talk at the DGPhil conference in 2017. Since *scientific* knowledge is an increasing section of knowledge addressed even in everyday life, we must develop competences to responsibly use that knowledge for social and personal aims.

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An analysis of the philosophy curricula of the 16 federal states of Germany provides interesting insights into the discussed problem area; while the orientation toward life-world-problems is rather well established in all curricula, science orientation is either not mentioned or is integrated only unsystematically. For example, Lower Saxony requires *interdisciplinary discussions with the other sciences*; Bremen requires the *integration of empirical views* within the topic anthropology; Bavaria explicitly names psychology, sociology, physics and neuroscience as the respected disciplines in discussion of the problem of free will; and only Hessen uses the term "science orientation" as one of the aims of the subject of philosophy. The fact that certain states have recently integrated science specific topics can be considered an indicator that an interdisciplinary orientation is emerging. Nevertheless, currently, a systematic didactical concept is lacking. Conversations with philosophy teachers over the years have shown that the integration of and reflection upon science topics appear to be highly challenging if not an overextension.

According to the *Philo* textbook, the guiding principles of science are criticized rather than substantiated. "A scientifically literate culture should take the ideal of self-reflection much more seriously than is presently the case", suggests Holm Tetens in the volume at hand, who urges the philosophy of science to "put science-superstition in its place" (p. 394), although it remains unclear what constitutes the problematic "superstition". While at least the boundaries and the dangers of natural science or scientism are discussed, its accomplishments and possibilities and the dangers of relativism are largely ignored. This inconsistency is manifested in homework assignments (p. 385) in which the scientific *guiding principles* are presupposed to the natural sciences, and the humanities are considered committed in equal measure but have not been introduced and discussed beforehand.

6 Epistemic competence as an interdisciplinary approach

In the following discussion, we refer to the German context in which the current curricula are competence oriented; thus, the curricula do not specify the subject matter in detail but rather describe the competencies that should be developed in grappling with content-related problems[2].

As previously noted, important social and educational reasons exist for systematically developing a didactical concept that addresses the scope and limits of science. The aspects of epistemology and philosophy of science discussed here have not received adequate representation in the established scope of competency to date, neither in the science subjects nor in philosophy. As a paradigm of problem orientation, the relationship to everyday life problems and the orientation toward research and discourse in the academic discipline are essential paradigms of the didactics of both the natural sciences and philosophy; there is a strong need for action to consistently integrate scientific knowledge into philosophy class and incorporate a philosophical-

2 There is no room for a detailed characterization of the competence paradigm here. In Germany, this paradigm dates to Franz Weinert (2001). Structure models of the competences describe the abilities, knowledge and attitudes that learners must develop to be classified as competent in a special field of application.

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reflective perspective in science classes to broaden the discourse of the epistemic reach of natural science. Based on the unsatisfactory treatment of science topics in schoolbooks and curricula and given that the science orientation is also legitimized by a concept of philosophical education that can be rooted in both philosophy and educational concepts, Bettina Bussmann (2015) urges the didactics of philosophy to systematically develop curricular topics based on the following three main areas that are relevant for philosophical reflection: life-world, philosophy and the knowledge and methods of the empirical sciences. This interrelationship, which similarly applies to science education, relates to integration and critical reflection and can be illustrated by the *triangle of philosophy-didactics.*

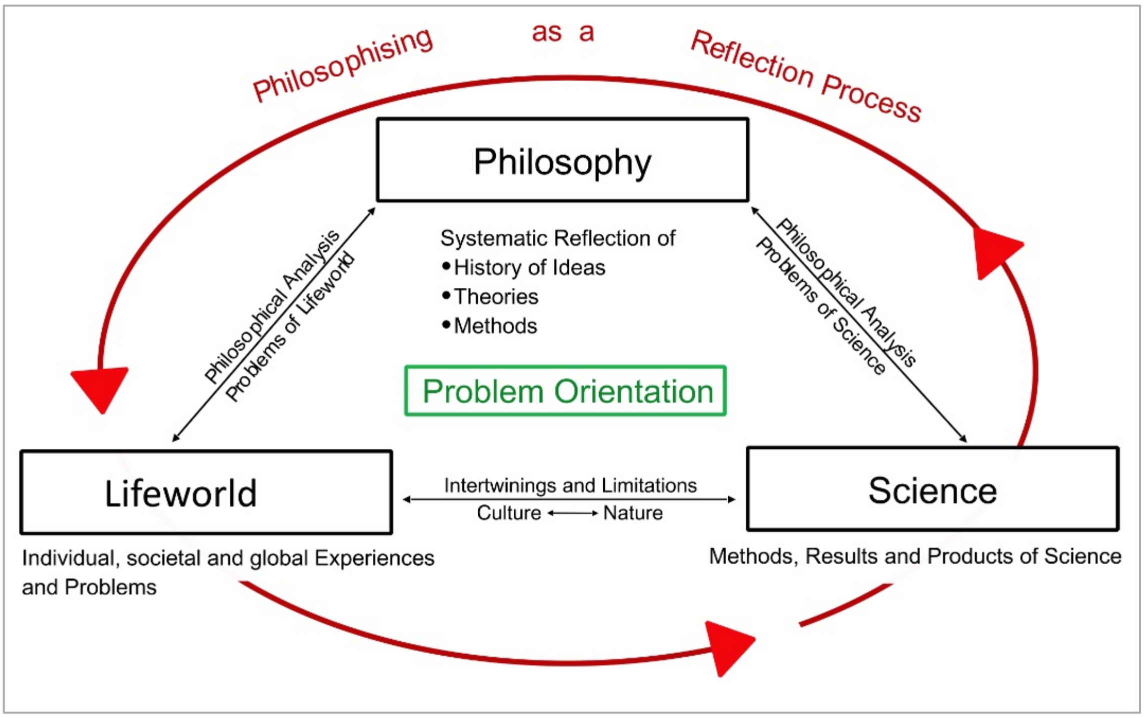

Fig. 1: Triangle of philosophy-didactics (Bussmann, 2015)

Knowledge in the sense of historical, methodical and systematical insight has admittedly always played a role in philosophy and everyday life. However, in empirical science, additional familiarity with *scientific* knowledge and the ability to reflect upon scientific evidence become necessary. Therefore, we propose that students should develop an *epistemic competency*, which we define as “the ability to understand and critically reflect upon aspects of the methods, results, history and relevance of scientific knowledge in relation to other forms of knowledge.”

Thus, first, the didactics of science and philosophy must *jointly* approach this topic and advocate an informed *discourse* about the NOS while considering the possibilities and limitations of its communication. In Germany, cooperation between science education and philosophy has existed for many years but is restricted to ethical questions, such as genetic engineering (e.g., Runtenberg, 1997). This approach remains a new frontier for epistemic questions and the didactics of philosophy.

Although epistemic competence is primarily relevant for NOS and philosophy, this competence should become an *interdisciplinary competence* in the future. Various subjects can contribute to its differentiation and focus on topics from their specific field.

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Thus, other didactics, such as religious education (e.g., Weiß et al, 2016), might already have established fruitful interdisciplinary concepts that can serve as a role model. At the theoretical level, science education has profited from the work of theologians in the analysis of scientism (e.g., Stenmark, 1997). An example of interdisciplinary collaboration between religious and science education is the context of creation and evolution. The relationship between creation and religion has been and remains an area of tension. In this context, the didactics of biology and religious education worked jointly to reach guidelines for addressing intelligent-design creationism (e.g., Bayrhuber, 2009; 2011). Biology educator Christiane Konnemann (2016), in cooperation with religious educators, investigated attitudes toward evolution and creation, scientific and creationistic beliefs, knowledge about NOS and NOTh (Nature of Theology), and examples of teaching approaches (e.g., Löber & Rothgangel, 2008) that explicitly consider the relationship between science and religion. Notably, the debate regarding the worldview implications of evolutionary theory is also an example of the live-world relevance of reflection upon the scope and limits of science proposed in this text.

For these issues to be adequately addressed in the classroom, it is first necessary to implement the respective topics in teacher education. Thus, prospective teachers in the field of natural science should develop the understanding that reflection upon science is not a “fringe topic” (Dittmer, 2006) and is highly important. For philosophy education, similarly, prospective teachers should develop an understanding that empirical considerations do not mean the end of philosophy.

Second, appropriate curricular implementation at the university and school level should occur. In Germany, proposals to expand the range of competences in the science subjects are rare, but there are exceptions. For example, Arne Dittmer (2010, p. 53) describes “wissenschaftsphilosophische Kompetenz” (competence in philosophy of science) as “the ability to understand, evaluate and communicate the nature, concepts and significance of biology”. The proposal for competence in the philosophy of science certainly bears resemblance to epistemic competence, and obviously, we are very sympathetic toward his approach. However, there are differences. First, Dittmer’s approach explicitly refers to the biology context and the philosophy of biology, while we intend to offer a general proposal for science education. Second, Dittmer calls for more philosophy in the science classroom. We additionally include the demand for more science in the philosophy classroom and — which is a crucial difference — propose to reach both goals through the interdisciplinary cooperation of science and philosophy education at the following levels: the conceptual, institutional and classroom levels. Finally, Dittmer´s and our approaches differ only in the details because there are obvious overlaps, as shown in our table of epistemic competence (Fig. 2).

Epistemic competence consists of several dimensions (Bussmann, 2014; Kötter, 2017). It is beyond the scope of this text to provide a detailed description of all dimensions. Furthermore, we do not claim that our approach is complete — additional theoretical knowledge, application fields, abilities and attitudes may be relevant. Fig. 2 provides an overview of the dimensions of epistemic competence as a first approximation and proposal for further discussion. Our framework of theoretical *knowledge* focuses on the interplay between the *normative* and *descriptive* perspectives. The philosopher of science Gerhard Schurz (2014, p. 24) characterizes this interplay as the rational reconstruction of science. A rational reconstruction aims to develop generalized models

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of scientific knowledge that must be empirically adequate, i.e., consistent with descriptive results and concur with normative guidelines for scientific investigations. Thus, we are endued with two controlling authorities, i.e., one normative and one descriptive, that continually reconstruct the joint object of interest — science.

Epistemic competence: *The ability to understand and critically reflect aspects of the methods, results, history and relevance of scientific knowledge in relation to other forms of knowledge*	
Dimensions of content	
Theoretical knowledge	**Special areas of application**
Epistemology and philosophy of science • Theories / positions (realism, scepticism, scientism etc.) and central arguments • Essential questions in epistemology and philosophy of science (Are scientific entities real? Is there scientific progress? What distinguishes science from non-science?) • Methodologies (experiments, interviews, evidence-based trials, expert know how, explanation models) • Quality criteria of scientific work and justification of scientific knowledge claims (reproducibility, objectivity, reliability, validity) • Nature and role of rationality, emotion, intuition in knowledge formation processes • **Ultimate limits and scope of scientific knowledge production** Normative questions and science, relation between science and religion, relation to common sense, superiority of scientific knowledge **Science as a human enterprise** • Science as a social institution (scientific communities, role of peer-review, expertise, authorities, journals, scientific ethos, norms, rationality) • External influences on science (economic, religious, political influences) • Live-world implications of scientific research (ethical implications of technology)	**Pseudosciences** (homeopathy, quantum healing, astrology) **Current mistrust in science** (vaccination criticism, climate change denial, fake news) **Science wars** (postmodernism, multiculturalism, feminism) **Science & religion** (scientific creationism, new atheism, naturalism) **Gender issues** (social and biological perspectives) **Transhumanism** (transformation of humanity by means of technology)
Dimensions of ability	
Argumentation skills and critical thinking **Epistemic virtues**: • Willingness to engage in critical evaluation and judgment, commitment to rational discourse) • Awareness that reflection on science requires tolerance of ambiguity and acceptance of aporia, principle of controversy) **Appropriate use of technical terminology** **Ability to identify individual, social and global implications, as well as ethical implications of scientific practices** **Recognition and awareness of one's attitudes toward the object of reflection**	

Fig. 2: Table of Epistemic Competence

In the following sections, we provide a brief description of the two core dimensions of epistemic competence that we consider both essential and underrepresented in recent discourse in science (section 6.1) and philosophy (section 6.2) education.

6.1 Reflection upon science

Technical qualifications, particularly the conveyance of *epistemic virtues,* should be considered, which appears to be a primary task because the discourses in science and philosophy didactics fundamentally differ from one another. Typically, content taught in the science classroom is not controversial in science. Philosophy didactics must consider that a similar consensus in philosophy is not in place. Therefore, teaching content in an uncontroversial way is deemed inappropriate in the philosophy classroom. To the contrary, teaching should generally involve reflection *about* the controversial approaches to various questions asked in academic philosophy.

In this context, Kötter & Hammann (2017) suggest that NOS education is concerned with science-reflective disciplines as its referent, and thus, their communication standards, particularly principles, such as controversy, reflection, and acceptance of aporia, also should be applied to these portions of science education. These principles have been firmly embedded as core principles of philosophy and ethics education, and since 2016, these principles have also been approved by means of the *Dresdner Konsens* between the professional associations for philosophy and ethics, the forum for the didactics of philosophy, and the German association of philosophy (Tiedemann 2016). This standard document stresses that the *criteria of controversy* are guiding principles that guarantee the practice of argumentation skills to defy suggestiveness, dogmatism and manipulation. Argumentation competence is a core skill that has been implemented in nearly all subjects and curricula (e.g., Weiß et al 2016, p. 206). These already established concepts should be further applied to the weak spot of "reflection upon science" at the curricular level.

6.2 Quality criteria of scientific work

As demonstrated by our brief discussion of the schoolbook *Philo* (section 5), a discussion of the nature and scope of scientific knowledge is mostly restricted to historical and theoretical approaches that do not start with concrete problems (and only rarely integrate life-world problems) but rather cover overarching topics, such as “What is the truth?“ or “Empiricism *versus* Rationalism?” Introductions into the work of important thinkers and schools are predominant. These topics are indeed essential for philosophy education since these programs are tasked with teaching fundamental questions and thereby reaching increasingly higher levels of abstract thinking. However, these fundamental philosophical questions should be supported by the other two foundations of the triangle shown in Fig. 1, namely, life-world and modern science. Since many curricula and books integrate empirical results — such as psychological studies and neurological experiments — there is a need to analyze questions such as the following: how are studies and experiments designed? Why are randomized control studies considered the gold standard of scientific research? What do these studies measure and what mistakes can occur? Are these studies relevant to our philosophical problem? If a thorough reflection upon such questions is lacking, it is highly likely that naïve scientific attitudes, mistrust and indifference are fueled. Therefore, the quality criteria of scientific work should become an integral component of all philosophical disciplines and topics that rely on empirical knowledge. Interesting contemporary cases should be found to obtain a basic understanding of the following three well-known principles: objectivity, reliability and validity. Certain steps in this direction have already been taken in the special issue “Pseudowissenschaft” of the philosophy education journal ZDPE (1/2007), in which historical and contemporary problem cases are analyzed.

7 Concluding remarks

The facilitation of epistemic competence could serve as an answer to the initially posed question of how science education can address concerns regarding the social consequences of the leveling and trivialization of natural science and its claim to knowledge without cultivating naïve impressions of science and encouraging a problematic scientism. Members of an enlightened society whose conception of the world is mainly created and formed by science should be enabled to recognize controversies regarding the scope of natural science, reflect on these controversies and reach a justified point of view. The debates regarding the scientific status of potential pseudosciences could serve as an authentic context for NOS and philosophy education that is relevant to everyday life. According to Bettina Bussmann (2014), in philosophy education, the engagement with pseudoscience could serve as a model of treating issues relevant to everyday life with a scientific mind without ignoring the variety of facts that

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constantly change and challenge scientific methods and explanations. This education could sensitize people not only to the epistemic advantages of scientific norms but also, according to Mario Kötter & Marcus Hammann (2016), to the *difficulties* concerning the demarcation of science and the limits of its explanatory power. Therefore, it may be a suitable starting point to oppose scientific and relativistic belief systems.

References

Abd-El-Khalick, F. (2001). Embedding Nature of Science Instruction in Preservice Elementary Science Courses: Abandoning Scientism, But… . *Journal of Science Teacher Education*, *12*(3), 215–233. doi:10.1023/A:1016720417219

Allchin, D. (2004). Should the sociology of science be rated X? *Science Education*, *88*(6), 934–946. doi:10.1002/sce.20026

Allchin, D. (2011). Evaluating Knowledge of the Nature of (Whole) Science. *Science Education*, *95*(3), 518–542. doi:10.1002/sce.20432

Babich, B. (2015). Calling Science Pseudoscience: Fleck's Archaeologies of Fact and Latour's 'Biography of an Investigation' in AIDS Denialism and Homeopathy. *International Studies in the Philosophy of Science*, *29*(1), 1–39. doi:10.1080/02698595.2015.1071550

Barber, B. (2010, December 4/5). Amerika, du hasst (sic!) es besser. *Süddeutsche Zeitung*, p. 14.

Bayrhuber, H. (Ed.). (2011). *Darwin und kein Ende? Kontroversen zu Evolution und Schöpfung*. Seelze: Kallmeyer.

Benner, D., & Nikolova, R. (2016). *Ethisch-moralische Kompetenz als Teil öffentlicher Bildung*. Paderborn: Ferdinand Schöningh Verlag.

Boghossian, P. A. (2013). *Angst vor der Wahrheit: Ein Plädoyer gegen Relativismus und Konstruktivismus* (1st ed., Vol. 2059). Berlin: Suhrkamp.

Brown, J. R. (2001). *Who rules in science? An opinionated guide to the wars*. Cambridge, MA: Harvard University Press.

Bussmann, B. (2014). *Was heißt: sich an der Wissenschaft orientieren? Untersuchungen zu einer lebensweltlich-wissenschaftbasierten Philosophiedidaktik am Beispiel des Themas ‚Wissenschaft, Esoterik und Pseudowissenschaft'*. Berlin: LIT.

Bussmann, B. (2015). Wissenschaftsorientierung. In J. Nida-Rümelin, I. Spiegel & M. Tiedemann (Eds.), *Handbuch Philosophie und Ethik. Vol. 1* (pp. 125–130). Paderborn: Schöningh.

Bussmann, B. (2018). Wieviel Empirie benötigt die praktische Philosophie? Grundsatzüberlegungen und didaktische Konsequenzen am Beispiel der Migrationsproblematik. In M. Tiedemann (Ed.), *Ethische Fragen der Migration: Theoretische Reflexion und unterrichtspraktische Aufarbeitung*. Stuttgart: Kohlhammer Verlag.

Carrier, M. (2007). Wege der Wissenschaftsphilosophie im 20. Jahrhundert. In A. Bartels & M. Stöckler (Eds.), *Wissenschaftstheorie. Ein Studienbuch* (pp. 15–45). Paderborn: Mentis.

Carrier, M. (2008). *Wissenschaftstheorie zur Einführung* (2nd ed., Vol. 353). Hamburg: Junius.

Clough, M. P. (2007). Teaching the Nature of Science to Secondary and Post-Secondary Students: Questions Rather Than Tenets. *The Pantaneto Forum*, *25*(Januar), 31–40.

Cobern, W. W., & Loving, C. C. (2001). Defining 'science' in a multicultural world: Implications for science education. *Science Education*, *85*(1), 50–67.

Dellmour, F. (2009). Argumentarium Teil 3. *Homöopathie in Österreich (HIOe)*. Vol. 4. Retrieved from http://www.homoeopathie.at/wissenschaft/diskussion/

Dittmer, A. (2006). Wissenschaftsphilosophie am Rande des Fachs? *MNU*, *59*(7), 432–439.

Dittmer, A. (2010). *Nachdenken über Biologie: Über den Bildungswert der Wissenschaftsphilosophie in der akademischen Biologielehrerbildung* (1st ed.). Wiesbaden: VS, Verl. für Sozialwiss.

Duschl, R. A., & Grandy, R. (2012). Two Views About Explicitly Teaching Nature of Science. *Science & Education.* Advance online publication. doi:10.1007/s11191-012-9539-4

El-Hani, C. N., & Mortimer, E. F. (2007). Multicultural education, pragmatism, and the goals of science teaching. *Cultural Studies of Science Education*, *2*(3), 657–702. doi:10.1007/s11422-007-9064-y

Fischer, E. (2017). Philosophie der Philosophie. In S. Lohse & T. Reydon (Eds.), *Grundriss Wissenschaftsphilosophie. Die Philosophien der Einzelwissenschaften* (pp. 77–104). Hamburg: Meiner Verlag.

Frankfurt, H. G. (2006). *Bullshit.* Frankfurt: Suhrkamp.

Good, R., & Shymansky, J. (2001). Nature-of-Science Literacy in Benchmarks and Standards: Post-Modern/Relativist or Modern/Realist? *Science and Education*, *10*(1/2), 173–185. doi: 10.1023/A:1008789610357

Graf, D., & Lammers, C. (Eds.). (2015). *Anders heilen? Wo die Alternativmedizin irrt* (1st ed.). Aschaffenburg: Alibri.

Gross, P. R. (Ed.). (1996). *Annals of the New York Academy of Sciences: Vol. 775*. *The flight from science and reason*. New York, NY: New York Academy of Sciences.

Gross, P. R., & Levitt, N. (1998). *Higher superstition: The academic left and its quarrels with science* (Paperback ed.). Baltimore, MD: Johns Hopkins University Press.

Hagner, M. (2008). Bye-bye science, welcome pseudo-science? Reflexionen über einen beschädigten Status. In D. Rupnow, V. Lipphardt, J. Thiel & C. Wessely (Eds.), *Pseudowissenschaft*. Frankfurt am Main: Suhrkamp Verlag.

Hampe, M. (2016, December 15). Katerstimmung bei den pubertären Theoretikern. *DIE ZEIT*. Retrieved from http://www.zeit.de/2016/52/kulturwissenschaft-theorie-die-linke-donald-trump-postfaktisch-rechtspopulismus

Hansson, S. O. (2014). Science and Pseudo-Science. *The Stanford Encyclopedia of Philosophy*. Retrieved from https://plato.stanford.edu/entries/pseudo-science/

Hostenbach, J., Fischer, H. E., Kauertz, A., Mayer, J., Sumfleth, E., & Walpuski, M. (2011). Modellierung der Bewertungskompetenz in den Naturwissenschaften zur Evaluation der Nationalen Bildungsstandards. *ZfDN*, *17*, 261–288.

Kampourakis, K. (2016). The “general aspects” conceptualization as a pragmatic and effective means to introducing students to nature of science. *Journal of Research in Science Teaching*, n/a-n/a. doi:10.1002/tea.21305

KMK (2004). Bildungsstandards im Fach Biologie für den Mittleren Schulabschluss. Retrieved from https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2004/2004_12_16-Bildungsstandards-Biologie.pdf

Koertge, N. (2000). 'New Age' Philosophies of Science: Constructivism, Feminism and Postmodernism. *The British Journal for the Philosophy of Science*, *51*, 667–683.

Konnemann, C., Asshoff, R., & Hammann, M. (2016). Insights into the Diversity of Attitudes Concerning Evolution and Creation: A Multidimensional Approach. *Science Education*, *100*(4), 673–705. doi:10.1002/sce.21226

Kötter, M., & Hammann, M. (2016). Pseudowissenschaft? Ein Kontext für Reflexionen über Wissenschaft. In U. Gebhard & M. Hammann (Eds.), *Lehr- und Lernforschung in der Biologiedidaktik. Vol. 7. Bildung durch Biologie* (pp. 41–55). Innsbruck: Studienverlag.

Kötter, M., & Hammann, M. (2017). Controversy as a blind spot in teaching NOS. Why the range of different positions concerning NOS should be an issue in the science classroom. *Science & Education*, *26*(5), 451–482. doi:10.1007/s11191-017-9913-3

Kutschera, U. (2016). *Das Gender-Paradoxon: Mann und Frau als evolvierte Menschentypen*. *Naturwissenschaft und Glaube: Vol. 13*. Berlin: LIT.

Lakatos, I. (1974). Falsifikation und die Methodologie wissenschaftlicher Forschungsprogramme. In I. Lakatos & A. Musgrave (Eds.), *Kritik und Erkenntnisfortschritt. Abhandlungen des 4. Internationalen Kolloquiums über die Philosophie der Wissenschaft, London 1965* (Wissenschaftstheorie Wissenschaft und Philosophie, Vol. 9, pp. 89–190). Braunschweig: Vieweg.

Latour, B. (2004). Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern. *Critical Inquiry*, *30*(2), 225–248.

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. 831–880). Mahwah, NJ: Lawrence Erlbaum Associates.

Mahner, M. (2007). Demarcating Science from Non-Science. In T. A. F. Kuipers (Ed.), *Handbook of the philosophy of science. General philosophy of science. Focal issues* (pp. 515–575). Amsterdam: North Holland.

Marniok, K., & Reiners C. (2016). Die Repräsentation der Natur der Naturwissenschaften in Schulbüchern. *ChemKon, 23*(2), 65–70.

Martens, E. (1979). *Dialogisch-pragmatische Philosophiedidaktik*. Hannover: Schroedel.

Matthews, M. R. (2002). Constructivism and Science Education: A Further Appraisal. *Journal of Science Education and Technology*, *11*(2), 121–134. doi:10.1023/A:1014661312550

Matthews, M. R. (2004). Thomas Kuhn's impact on science education: What lessons can be learned? *Science Education*, *88*(1), 90–118. doi:10.1002/sce.10111

Matthews, M. R. (2012). Changing the Focus: From Nature of Science (NOS) to Features of Science (FOS). In M. S. Khine (Ed.), *Advances in nature of science research. Concepts and methodologies* (pp. 3–26). Dordrecht: Springer.

Mittelstraß, J. (Ed.). (2005). *Enzyklopädie Philosophie und Wissenschaftstheorie. Vol. 2: C-F*. Stuttgart: Verlag J.B. Metzler.

Müller-Jung, J. (2016, November 26). Wo bleibt der Aufschrei gegen den billigen Populismus? *FAZ*. Retrieved from http://www.faz.net/-gwz-8nr8o

Neumann, I., & Kremer, K. (2013). Nature of Science und epistemologische Überzeugungen – Ähnlichkeiten und Unterschiede. *ZfDN*, *19*, 211–234.

Resnik, D. B. (2000). A pragmatic approach to the demarcation problem. *Studies in History and Philosophy of Science Part A*, *31*(2), 249–267. doi:10.1016/S0039-3681(00)00004-2

Rolf, B., & Peters, J. (Ed.). (2015). *Philo. Qualifikationsphase*. Bamberg: C.C. Buchner Verlag.

Rösch, A. (2009). *Kompetenzorientierung im Philosophie- und Ethikunterricht. Entwicklung eines Kompetenzmodells für die Fächergruppe Philosophie, Praktische Philosophie, Ethik, Werte und Normen, LER*. Zürich: LIT.

Rudolph, J. L. (2000). Reconsidering the 'nature of science' as a curriculum component. *Journal of Curriculum Studies*, *32*(3), 403–419. doi:10.1080/002202700182628

Runtenberg, C. (1997). Leitideen eines Unterrichts über ethische Probleme der Gentechnik aus der Sicht der Philosophie. In H. Bayrhuber (Ed.), *IPN: Vol. 150. Biologieunterricht und Lebenswirklichkeit. Vom 18.9. bis 22.9.1995 in Weilburg* (pp. 291–295). Kiel: IPN.

Schöne-Seifert, B., Reichardt, J.-O., Friedrich, D. R., & Hucklenbroich, P. (2015). Komplementar- und Alternativmedizin: der Begriff im Licht wissenschaftstheoretischer und -ethischer Überlegungen [The concept of complementary and alternative medicine from the perspective of the philosophy of science and bioethics]. *Zeitschrift für Evidenz, Fortbildung und Qualität im Gesundheitswesen*, *109*(3), 236–244. doi:10.1016/j.zefq.2015.01.015.

Schurz, G. (2014). *Einführung in die Wissenschaftstheorie* (4th ed.). Darmstadt: Wiss. Buchges.

DOI: https://doi.org/10.23770/rt1813

Snow, C. P. (1961). *The two cultures and the scientific revolution. The red lecture 1959*. Cambridge.

Steenblock, V. (1999). *Theorie der kulturellen Bildung. Zur Philosophie der Didaktik der Geisteswissenschaften.* München: Wilhelm Fink Verlag.

Thein, C. (2017). *Verstehen und Urteilen im Philosophieunterricht*. Opladen: Verlag Barbara Budrich.

Tiedemann, M. (2007). Pseudowissenschaften als Gegenstand des Philosophie- und Ethikunterrichts. Zwei Beispiele. *Zeitschrift für Didaktik der Philosophie und Ethik, 1*, 39–45.

Tiedemann, M. (2011). *Philosophiedidaktik und empirische Bildungsforschung*. Münster: LIT Verlag.

Tiedemann, M. (2013). Problemorientierte Philosophiedidaktik. *ZDPE, 35*(1), 85–96.

Tiedemann, M. (2016). Dresdner Konsens für den Philosophie- und Ethikunterricht. *ZDPE*, *38*(3), 106.

Tolksdorf, S. (Ed.). (2011). Conceptions of Knowledge (Berlin Studies of Knowledge Research, Vol. 4). Berlin: De Gruyter.

Weinert, F. E. (2002). Vergleichende Leistungsmessung in Schulen – eine umstrittene Selbstverständlichkeit. In F. E. Weinert (Ed.), *Leistungsmessungen in Schulen* (2nd ed., pp. 17–32). Weinheim: Beltz-Verl.

Weiß, T., Basel, N., Harms, U., Prechtl, H., & Rothgangel, M. (2016). Fächerübergreifende Kompetenzen im Unterricht. In U. Harms, B. Schotter & B. Klüh, (Eds.), *Entwicklung kompetenzorientierten Unterrichts in Zusammenarbeit von Forschung und Schulpraxis* (pp. 205–224). Münster: Waxmann Verlag.

Zeyer, A. (2005). Szientismus im naturwissenschaftlichen Unterricht? Konsequenzen aus der politischen Philosophie von John Rawls. Retrieved from ftp://ftp.rz.uni-kiel.de/pub/ipn/zfdn/2005/13.Zeyer_193-206.pdf

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