Art and Science

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Definition

In addition to the branches of science that are usually discussed in the context of inter- and transdisciplinarity, art also plays a key role. The interplay between art and science that takes place here is neither about making creative practices scientific nor about making scientific practices artistic, but rather about exchange and dialogue among equals. The most highly varied artistic disciplines – for instance, visual arts, film, design, literature, music and theater – encounter the natural and social sciences and the humanities in these sorts of partnerships, which elude a clear definition. This form of collaboration has particularly great potential in transdisciplinary projects (i.e. projects that address specific social problems and problems of the lifeworld and aim to find concrete and comprehensive solutions). Art and artists can reveal additional levels of knowledge and experience (Tröndle and Warmers 2012), contribute to the development of specific methods (Tröndle et. al. 2011) and take on integrated "design tasks" (Krohn 2011), thus paving the way for obtaining new knowledge by way of self-reflection, innovation and communication (Schnugg 2019). Science and art are increasingly finding one another precisely in confronting multi-layered problems (e.g. climate change) that are distinguished by an intertwining of problems from different subsectors of society (Sleigh and Craske 2017).

The Background to the Problem

The differentiation of the artistic disciplines as it is to be found today first occurred in the age of the Enlightenment, when the so-called "fine arts" – the visual arts, music, literature and the performing arts (Guery

2014) – broke off from the humanities and natural sciences, which at the time still went hand in hand. Barely another hundred years went by before Wilhelm Dilthey inspired the separation between the latter two fields, which is still so strongly reflected in the structures of higher education today (Dilthey 2002).

The discussion of a – renewed – linkage of art and science that took place in the USA in the 1930s can only be understood on this backdrop. This discussion was stimulated by John Dewey, who called for the inclusion of art in scientific education as a basic component of a comprehensive educational experience. For Dewey, art is a vehicle of aesthetic experiences that can broaden the perception and perspectives of the learning subject (Dewey 1934). This approach also underlies the educational policy initiatives promoting a transition from STEM to STEAM (Science, Technology, Engineering, Arts, Mathematics): The additional A stands for "arts." The arguments for integrating the arts are similar to those of Dewey and are based on the assumption that artistic approaches increase the capacity for creative thinking and that problem identification and problem solving are learned by way of critical reflection and divergent and convergent ways of thinking (Haley et al. 2016).

In his widely discussed text *The Two Cultures* (1959), Charles P. Snow argued that the combination between art and science is, nonetheless, not without its difficulties. Snow recognizes the potential for creative moments when different disciplines collide, but also sees difficulties in the exchange between them, "because those in the two cultures can't talk to each other" (ibid.: 17). Voices are to be heard in the meanwhile that, drawing on Snow, proclaim a "third culture" in which the boundaries between the disciplines disappear entirely (Miller 2014).

Apart from theoretical discussion of the exchange between art and science in the context of academic research, attempts have also been made at practical implementation. The founding in 1967 of the

Experiments in Art and Technology (E.A.T.) group at the Bell Telephone Laboratories especially stands out, since it is regarded as a pioneer of this form of collaboration (Miller 2014). The founding members of the E.A.T included both engineers like Billy Klüver and Fred Waldhauer and the artists Robert Rauschenberg and Robert Whitman. In 1966, they launched their first large-scale collaboration, together with a number of other artists, engineers and scientists, in the form of a performance series titled *The 9 Evenings: Theatre and Engineering*.

The founding in 1968 of the journal *Leonardo: Journal for the International Society for the Arts, Sciences and Technology* also helped to bring about a broader discussion of combining art, sciences and technology, and the journal continues to have a strong influence on the field today.

The dialogue between art and science also takes place in the form of "artistic research," which is done by artists using artistic practices. Its goal consists of "expanding our knowledge and understanding by conducting an original investigation in and by means of art objects and creative processes" (Borgdorff 2012). The knowledge in question is obtained by way of sensory and emotional perception and cannot to be separated from the latter (Klein 2011). Artistic research creates the conditions for a transformation (Bippus 2015), which can, however, take different forms. This is reflected in academia by the great heterogeneity of the programs of art schools and of their contents, learning and research processes (Buck et al. 2015).

These different, sometimes historical, debates on and approaches to the interaction between disciplines and between art and science also have an influence on ideas about the value of such a combination.

Debate and Criticism

The academic canon on the interaction between art and science in the research and teaching contexts is currently still coming into being. But the discussion is becoming more and more prominent, and the field of methodological and theoretical knowledge on the issue can be expected to gain considerably greater depth in the years to come.

Bringing art and science together should allow for the reciprocal transfer and integration of knowledge and experience, foster the emergence of new knowledge cultures and promote synergies between the disciplines (Tröndle and Warmers 2012). In particular, the aspects of (1) self-reflection, (2) dissonance and irritation, and (3) communication are discussed in the research as decisive, productive moments of the collaboration.

(1) First and foremost, the moment in which self-reflection comes into being by way of the contrast between different theoretical and work cultures is significant in trans- and interdisciplinary exchange. The dialogue stimulated by the artists' questions and by artists' and scientists' observation of one another in their respective works spaces – for instance, the laboratory or the studio – encourage reflection on one's own scientific practice and basic understanding. Exchange about methods, modes of work and disciplinary or institutional paradigms can provide new ideas for one's own way of functioning, call into question routines and enable mutual learning. This gives rise to questions about ethical guidelines, personal motivation and the embedding of the results in the broader society, and these questions provide the impetus for further reflection in turn (Schnugg 2019; Berthoin Antal 2014).

(2) Moments of surprise, irritation and friction, which give rise to innovation and stimulate change, are viewed as even more important by many scholars (Ball 2017; Gengnagel and Warmers 2017; Horstmann and Landbrecht 2019). Art-science partnerships are, as Jens Hauser puts

it, “fruitful misunderstandings” (in Horstmann, Landbrecht 2019: 10). It is, however, precisely these misunderstandings that cause the collaboration to fail, if they are not transformed into a productive moment of joint knowledge production. Philip Ball even credits art with the ability to bring about a “destabilization of comfortable convictions about science and technology” (Ball 2017: 395).

(3) In addition, the dialogue between art and science is supposed to help scientists to communicate the results of their research more effectively. On the one hand, the content of one’s own research has to be communicated to the artists in an understandable way. On the other hand, the artists possess an arsenal of ideas and possibilities for presenting the results to the public in a different form than the usual articles in scholarly journals or conference papers. This aspect of the collaboration, however, also entails the widespread danger that scientists will primarily consider the artists’ role to be that of aesthetically valorizing their results (Ball 2017; Tröndle et. al 2011). If this conception does not change, the collaboration is likely to fail, since no exchange between equals is taking place, but only a job assignment.

According to Tröndle et al. (2011), the particular benefit of including artistic approaches is to be found in the research methods whose development can occur especially successfully in the collaboration, since the artists involved do not carry any disciplinary baggage. Similarly, Krohn regards the joint development of methods of knowledge integration by artists and scientists as a “key epistemic quality of transdisciplinary research” (Krohn 2008: 46). In the course of transdisciplinary research projects, gaps in knowledge are not only closed by way of complex and challenging parameters, but design tasks also emerge, which do not only allow for “building bridges between artistic research and scientific research,” but even demand it (Krohn 2011: 5). Moreover, addressing transdisciplinary issues requires science “to deal with skewed quantities, resistance and surprises in its modeling

and interventions." Science is thus made more like artistic research and can "learn from and cooperate with it" (Krohn 2012: 9).

In order to do justice to both the scientific and the artistic contributions and outcomes in the course of a partnership, the latter have to be subject to robust evaluation in keeping with their respective natures. It is still largely unclear, however, which criteria and indicators and what evaluations methods should be used to assess the processes, results and impact (Schnugg 2019; Ball and Ede 2017; Sleight and Craske 2017). Individual elements of art-science projects can be evaluated according to criteria that are commonly used in the respective disciplines: say, the participants' subsequent career development or the number of publications and patents. But from the science side, the effectiveness of arts-science collaboration is often seen in the fact that "scientific communication" takes place thanks to the artists' collaboration and an assessment criterion of funders is thus fulfilled (Sleight and Craske 2017). The recording of results and the assessment of the degree to which they can be linked up to disciplinary tradition, as is well known from transdisciplinary research, also poses a challenge (Warmers and Gengnagel 2017). This requires a form of assessing arts-science projects that goes beyond noting that exchange is valuable in itself. Otherwise, "the very venture of trying to link these two spheres of human creativity" may be "regarded by advocates as intrinsically worthy, so that Sciart risks being received like a school play: it is the effort, not the execution, that matters" (Ball 2017: 396). The need for this also becomes clear in the presentation of examples of arts-science partnerships: It is often only what the artists have produced that is made visible, whereas the impact on the scientific process or research questions remains hidden.

Forms of Implementation in Teaching

Both in the research context and in pedagogical practice, partnerships between art and science take place without any established foundational and methodological knowledge. Participants draw on knowledge from a variety of sources: among others, from artistic research, curatorial activities and innovation and organizational research. In such a situation of uncertainty about how to proceed, the question of creating appropriate framework conditions for fruitful inter- or transdisciplinary exchange acquires greater relevance.

In research projects, in particular, it is first necessary to go beyond the undisputed, but often vague, ideas of increased creativity and inspiration and to clarify the concrete expectations of all the participants. Determining a (possibly provisional) common goal is helpful here, since it can directly bring to light initial incompatibilities in expectations and allow them to be thematized. It should be ensured, moreover, that interpersonal factors like genuine mutual interest and the recognition of participants' respective expertise are secured. It is also key that both funders and participants accept the conducting of research without predetermined results. Sufficient time and appropriate premises for the exchange are decisive external factors (Warmer and Gengnagel 2017; Horstmann and Landbrecht 2019; Schnugg 2019).

Over the course of the collaboration, moments of tension can arise that are crucial for innovation: the developing of new methods, new contents, new ideas, etc. At the same time, these moments of tension, in particular, have the potential to cause the exchange to fail. In order to channel these unavoidable clashes in a productive direction, it is recommended to obtain support in the form of professional mediators, who are active – to varying degrees – in each stage of the cooperation (Warmer and Gengnagel 2017; Schnugg 2019). These border-crossing intermediaries are – depending on the context – curators, coordinators

or project managers, and they combine numerous roles and qualities in their position. Their significance for the project consists of their ability to recognize the artistic and scientific relevance of the particular moments of exchange and to explain them both within the project and in the broader institutional and social framework (ibid.; Tröndle et al. 2011).

In the academic teaching context, there are only occasionally projects that aim at creating a balanced exchange of equals between students from artistic and scientific disciplines. What is much more commonly found in the teaching field is discussion of creative methods in the scientific enterprise and, vice versa, of scientific methods in artistic training. Types of art-science interaction also serve here to promote the formation of new styles of thought, experiences and skills. Their positive effect has been repeatedly demonstrated by studies (Buck et al. 2015; Goldman et al. 2016; Root-Bernstein et al. 2017). Related programs – like the Center for Art, Science & Technology (CAST) at MIT – offer students from a wide variety of disciplines the opportunity to take courses and workshops led by artists, for example. Programs in which (mandatory) courses are offered for students in the subject that is not their own (art courses for students in STEM disciplines or vice versa) are based on a similar idea: e.g. the "University-Wide Art Studies" at Aalto University in Finland and the course in "Creative Expression" that is required for all undergraduates at Stanford University, while "Foundations of Electron Microscopy" is taught as an interdisciplinary course at the University of Applied Arts in Vienna. The Hybrid Platform, a project of the Technical University of Berlin and the Berlin University of the Arts that was founded in 2010, also promotes the interaction between art, science and technology by way of joint teaching and research projects of the two universities and exchange between the disciplines. The *artsprogram* at Friedrichshafen's Zeppelin University and the *Kunstraum* at the Leuphana University Lüneburg create similar formats and spaces for exchange.

Apart from the acquisition of new intellectual skills and gains in knowledge, ideally interdisciplinary interaction also promotes the capacity for teamwork and innovation (Root-Bernstein et al. 2017; Goldman et al. 2016) – and thus skills that are be regarded as economically valuable in the context of management activities and programs (Miller 2014; LaMore et al. 2013). However, many artists regard such forms of appropriation of artistic practices to meet economic goals as a sort of violation (Sleigh and Craske 2017; Mareis 2012).

Many collaborations initiated by artists also exhibit the characteristics of transdisciplinary research. These collaborations are not usually referred to as transdisciplinary, however, since the term is hardly used in the context of creative design (Gengnagel and Warmers, 2017).

In teaching and research, field trips (Jacobson et al. 2016), Socratic-style dialogues and mini-hackathons promote the exchange of ideas, approaches and methods. Especially in the early stages of the exchange of ideas between scientists and artists, it is beneficial to use methods and approaches that are not strongly attached to a particular disciplinary tradition. In terms of content, it is also advisable to address topics that are situated somewhat uncomfortably between several academic fields and that offer room for new perspectives (Arnold et al. 2019: 55).

In higher education, moreover, we find an increasing number of models for the exchange between art and science, some of which draw on the STEAM agenda, whereas others draw on approaches in scientific communication – often inspired by the pioneering program SymbioticA (2000, University of Western Australia) and the Arts/Sci Center (2006, University of California).

Interaction between art and sciences offers participants the potential to leave behind their habitual intellectual and work processes, to acquire new ideas and to be confronted with other perspectives. These are

qualities that, precisely in the transdisciplinary context, help to meet complex circumstances and social challenges using multidimensional perspectives and new research approaches. Whether this potential gets fully exploited and further used in the context of transdisciplinary research projects and academic teaching depends on the development of related methods.

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