Interdisciplinary Research and Transdisciplinary Validity Claims

Extract of the same-named study at the EA European Academy GmbH, Bad Neuenahr-Ahrweiler (Germany)

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edited by

Carl Friedrich Gethmann, Martin Carrier, Gerd Hanekamp, Matthias Kaiser, Georg Kamp, Stephan Lingner, Michael Quante, and Felix Thiele


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Foreword

The modus of interdisciplinarity has become a familiar feature in modern research despite of the ongoing specialisation of disciplines in science and humanities. Today, many questions addressing the science system are of complex nature and are thus directed towards a diversity of relevant disciplines. Hence, these disciplines have to organise themselves within interdisciplinary research frameworks in order to introduce their specific perspectives to these problems and their reflection appropriately. However, crossing disciplinary borders in this way is not trivial, especially with regard to the epistemic and procedural restrictions of such endeavours. Moreover, the topics of interdisciplinary research are often societally relevant, either simply in form of explicit research mandates from the addressees or implicitly by problems of uncertainty, incompleteness and ambiguity of modern scientific knowledge with respect to their impact on and utility for society. Hence, the extra-scientific dimensions of interdisciplinary deliberations might challenge the results and validity claims of these efforts.

From this background, the present study aims at critical reflections of the practise of interdisciplinary research and at its validity conditions within and beyond the scientific system. It is not a manual or recipe book for meaningful or best-practise interdisciplinary research but a basis for further discussion and improvement of interdisciplinary endeavours – no more, no less. The content of this volume is the result of a more than three years’ exercise by a working group, which has been established at the European Academy GmbH. The group met fifteen times to discuss and frame the topic and to reflect relevant initial theses and papers, which were finally developed to the chapters and conclusions of this present study by iterative refinement in the course of the whole project.

The working group consists on experts who are renowned in the fields of epistemology, practical philosophy, technology assessment and scientific policy advice. Namely, the members and authors of this study are: Martin Carrier (Bielefeld), Carl Friedrich Gethmann (Siegen), Gerd Hanekamp (Bonn), Matthias Kaiser (Bergen/NO), Georg Kamp (Bad Neuenahr-Ahrweiler), Stephan Lingner (Bad Neuenahr-Ahrweiler), Michael Quante (Münster) and Felix Thiele (Bad Neuenahr-Ahrweiler). Most of the authors contributed already to other relevant publications within the academy’s book series “Ethics of Science and Technology Assessment” such as to the volumes on rational technology assessment (1999), ethics in technology governance (1999), “Interdisciplinarity in Technology Assessment” (2001), “Enabling Social Europe” (2006) and “Business Ethics of Innovation” (2007) among others.

Additionally, two events with the incorporation of external experts improved the formation of the findings of this study: In an early phase of the study, a public symposium on interdisciplinary research was held in October 2010 in Mainz. The conference aimed at exploring the tension between scientific validity claims of interdisciplinarity and societal expectances thereupon. Besides members of the working group, the following invited speakers contributed to the fruitful discussion with the audience: Professor Dr. Claudius Geisler (Mainz), Professor Dr. Bernward Gesang (Mannheim), Professor Dr. Armin Grunwald (Karlsruhe), Professor Dr. Eberhard Knobloch (Berlin), Professor Dr. Klaus Mainzer (Munich) and Professor Dr. Jan C. Schmidt (Darmstadt). Central papers of the conference were published in the Springer journal
Poiesis & Praxis. International Journal of Ethics of Science and Technology Assessment, Vol. 7(4) in June 2011. In September 2013 a more focused workshop was held at the premises of the European Academy. The workshop aimed at the review and discussion of the working group’s interim results with those external researchers which have specific competences in methodology of interdisciplinarity and in scientific policy advice. We would like to thank Professor Dr. Hanne Andersen (Aarhus/DK), Professor Dr. Armin Grunwald (Karlsruhe) and Professor Dr. Harry van der Laan (Wyk/NL) for their evaluation efforts.

For careful editing the “References” section of this volume we also express our gratitude to Bettina Schwab (Bayreuth) as well as to the academy’s receptionists for their helpful meeting support.

Siegen and Bad Neuenahr-Ahrweiler, Carl Friedrich Gethmann
November 2014 Stephan Lingner
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1 Introduction

1.1 Background

Today, interdisciplinarity seems to become a matter of course and a promising answer for dealing with contemporary questions of science and/or society within a complex, uncertain and confusing world. Proponents of this idea would argue that this world appears to be much better accessible to interdisciplinary reflection than to ordinary disciplinary analysis. In this way, interdisciplinarity seems to become a “repair measure” against the specialisation paradigm of modern science (Mittelstraß 1992). Aligned to these conceptions, interdisciplinarity is often acclaimed by numerous public funding and research schemes in Europe and abroad. Consequently, modern research is frequently guided by the idea of interdisciplinarity. A simple “Google” search\(^1\) gives a ratio of 796,000 to 185,000 hits for the term “interdisciplinarity” compared to “disciplinarity”, which might reflect the above mentioned expectations and observations in some way.

On the other hand, interdisciplinarity might risk to become a fashionable buzz word for upgrading any, even poor analysis beyond well-established disciplinary practices. But interdisciplinarity is not a universal tool for every scientific question. Therefore, it seems to be neither necessary nor even appropriate in every case or for each aim of modern research. For instance in Löffler’s article on the shortcomings of a still promising research conception (German title: “Vom Schlechten des Guten”), the author examines cases of ignorant interdisciplinarity. One might be concerned that the notion of interdisciplinarity could lose its meaning by careless use (cf. Grunwald 2013). Similar experiences from other terminological hypes like those of “sustainability” and “innovation” might give an idea what could be at stake. The same holds true for the term trans-disciplinarity which is yet at the advent of its terminological career and which is sometimes even used as synonym or variant of interdisciplinarity. Nevertheless, recent societal challenges often need rational scientific decision support, which frequently relies also on appropriate interdisciplinary knowhow, thus expanding its utility beyond the science system. Corresponding expectations and advisory offers from a trans-disciplinary perspective challenge the sensitive relation between society at whole and the mainly publicly funded science subsystem within that society.

At first, the study at hand will thus contribute to the clarification of the relation between interdisciplinarity and disciplinarity as well as to their specific objectives and practices. Corresponding efforts should reflect the state-of-the-art of the empirical and methodological knowledge from all relevant disciplines. Secondly, their outcome should be also acceptable and useful – in the trans-disciplinary arena and beyond the scientific perspective. The exchange of scientific and practical knowledge between these spheres will therefore also be an issue here. Within this, the demands from the society for sound advice as well as the prospects and conditions for its effective provision by the science system are considered. This encompasses also the comparative reflection of different operational trans-disciplinary approaches with regard to their different contexts, practical aims and theoretical foundations.

\(^1\) Search on 17 June 2013.
The notion of inter-disciplinarity is applied in this report. The apparent current plurality of scientific disciplines might be seen as a consequence of different and changing cognitive interests of researchers and practical challenges from their milieus over historical times, among others. This differentiation along emerging topics and appropriate theories, terminologies and methods to deal with, as well as specific societal needs for action might have led to the distinction of disciplinary object domains. In modern democratic societies, choices are often difficult, ambivalent and uncertain with regard to their consequences and their acceptability – especially over long time periods. Therefore, tailored scientific advice will not necessarily fit into the pre-established disciplinary landscape, which means to create cross-disciplinary frameworks, while securing the complementarity and coherence of the relevant multi-disciplinary expertise. Societal relevance and complexity of scientific questions will hence determine the adequate setting of related research. Depending upon this, four research types might be generally distinguished (see Table 1.1).

<table>
<thead>
<tr>
<th>1. Disciplinary &amp; Epistemic</th>
<th>4. Disciplinary &amp; Trans-disciplinary</th>
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<tbody>
<tr>
<td>e.g. field theory formulation and deduction</td>
<td>e.g. design and construction of tunnels and bridges</td>
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<table>
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<tr>
<th>2. Interdisciplinary &amp; Epistemic</th>
<th>3. Interdisciplinary &amp; Trans-disciplinary</th>
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</thead>
<tbody>
<tr>
<td>e.g. investigations in planetary evolution</td>
<td>e.g. climate impact and policy assessment</td>
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**Table 1.1: The general modes of research.**

The matrix above visualizes that research might be either conducted *disciplinarily* or *inter-disciplinarily*, depending upon the complexity of the respective scientific tasks. Within this framework, the perspective might be either *epistemic* – and therefore directed towards the enhancement of understanding – or it might be societal resp. *trans-disciplinary*, thus aiming at the solution of practical problems. Examples for the epistemic, cognition-driven types might – in the case of type 1 – encompass fundamental research from mathematics, philosophical logics, theoretical physics etc. In case of the epistemic type 2, research might e.g. be represented by investigations of complex and past processes of planetary evolution, which need in contrast to type 1 joint effort of astrophysics, chemistry and geology (type 2) in order
to understand the present planetary dynamics, material distribution and radiation patterns in the solar system. Another trans-disciplinary type (type 3) however, might be represented by climate impact and policy analyses, which are conducted with respect to serious public concerns on the future habitability of the planet Earth. This type of research needs even more extensive and broad interdisciplinary approaches regarding quite different knowledge types and disciplines involving meteorology, ecology, epistemology, economy, jurisprudence, practical ethics and political science. Moreover, this research type is confronted with uncertain and conditioned scenarios of the future and with normative ambiguity with regard to intra- and intergenerational justice of proposed strategies to cope with the climate problem, thus making corresponding efforts so ambitious. Finally, trans-disciplinary research must not necessarily be rather complex or ambivalent with regard to its results (type 4). For instance, the construction of bridges is clearly an application oriented disciplinary task of engineering, only including the consideration of technical guidelines, which are still parts of contemporary engineering knowledge despite their normative aspirations.

In this way, research with trans-disciplinary perspective aims at the development of sound, relevant and – especially with regard to the complex type 3 research – acceptable advice for the solution of societal problems, or of those, which are brought forward by the public or other stakeholders. Trans-disciplinary efforts address therefore the competent actors and institutions as well as the affected parties. In this respect they have to be compatible to the orientation needs of the addressees. Within the context of type 3 research, interdisciplinarity will not establish itself as an on-going universal scientific endeavour but rather as targeted and topical cross-disciplinary discourses with limited lifetimes. Corresponding research processes will therefore be organised as temporary projects rather than as long-term programmes. Figure 1.1 below gives an impression of this idea in terms of the case of climate impact and policy evaluation:

![Figure 1.1: Multi-disciplinary structure of a climate impact and policy assessment](image-url)
This example encompasses many and partially distant scholarly branches, thus establishing an extended interdisciplinary framework. Within this framework, meteorology is naturally a relevant discipline, which represents the knowledge on the object – the climate system – including its subsystems, their dynamics and their simulation as well as their stochastic characterisation. Ecology and economy are the central impact dimensions of climate change with clear societal relevance. Philosophy of science adds here, especially with regard to the assessment of the knowledge status of modelled climate data. Acting under conditions of incomplete knowledge is clearly an issue for moral philosophy, which aims at finding universal rules for dealing with long-term problems of the future and corresponding sustainability conceptions. Finally, binding normative claims from jurisprudence as well as the social reality of emerging climate regimes as domain of political science are central issues here. All these disciplines will have to be represented within such a climate project. The problem dimension of climate change is partially based on common knowledge, which feeds into the interdisciplinary assessment trans-disciplinarily from outside. Then again, the scientific appraisal might in the end work out practical recommendations, providing feedback towards society.

Figure 1.1 might serve also as point of departure for the description of the relevant scientific activities over time: The disciplinary circles still represent here permanent research programmes. The normal mode of disciplinary research makes them “high-end tools” with definite competences already at hand for specific purposes. The system of disciplines thus can be seen as a toolbox, which supports the solution of complex interdisciplinary questions. Interdisciplinary research can thus be made to measure to the cognitive demands from specific problem cases without the need for new de-disciplinised scholarly programmes. This tool-box approach of interdisciplinarity and the problem-oriented nature of this kind of research indicate corresponding projects with limited life-time. In the following chapters of this study, it is worked out inter alia on what theoretical basis and in which way interdisciplinarity can be organised à la carte as well as which socially relevant validity claims can be derived from the corresponding research.

1.3 Overview of the Major Aspects of this Study

The main body of the study is built up by three consecutive chapters starting with a description of the constitution of science as point of departure for the following discussions on knowledge and acting as well as on trans-disciplinary deliberation. The results of this exercise lead to reasonable conclusions, which aim at informing researchers and research politics.

1.3.1 Science in Society

The validity of scientific research – whether disciplinary or interdisciplinary – relies upon its compliance to credibility rules established within the science system, which are not independent from broader societal contexts. Within this study, science is unfolded as a service
under pressure of practice, where it operates for the benefit of the public and on the marketplace of commercial interests (section 2.1). Corresponding research will thus also follow those epistemic patterns, which align with utility considerations. Unsurprisingly, the same holds true for decisions about the selection of research topics.

The processes between science and its societal background are here explained as co-evolutive mechanisms, where impacts of values on science and vice versa are intertwined (section 2.2.1). For science, it is conceivable that offering its service within the political arena might influence its intrinsic confirmation procedures. This influence and the above mentioned politicized relevance decisions on research agendas suggest that non-epistemic values affect the research process. The modern scientific system is based on society’s hope for social utility of its research output and applications developed on this output. What ‘social utility’ amounts to and what the ‘responsible’ means of achieving this utility are is subject to an extensive normative debate. Applied ethics is a suitable tool for the argumentative interpretation of normative terms such as ‘social utility’ and ‘responsible scientific research’. Since the aim of applied ethics is to master moral conflicts and as this mastering includes avoiding moral conflicts, ethical reasoning has an important role in the early phases of research, including research agenda setting (see section 2.2.2). Ethical reasoning must be augmented by input from other disciplines. Research agenda setting taking into account normative challenges is an important example of interdisciplinary co-operation in the sciences. Worldviews, i.e. fundamental orientational values such as naturalness, have an important impact on individual moral landscapes, and play a decisive role in individual assessments of scientific developments. A better understanding of the functioning of worldviews might make it easier to transfer controversies on modern science into argumentative tracks, and to prevent them from becoming ideological quarrels only.

The following section (2.3) explains the disciplinary differentiation and classification of the sciences and humanities so far and its underlying rationales, which stem partly but not completely from the above mentioned pressure of practice. On that basis, the authors unfold the meaning and interpretation of interdisciplinarity as well as frameworks of weak or strong interdisciplinary research. This section continues with the specification of trans-disciplinarity as competence for interaction between certain scientific and extra-scientific regimes. This competence seems not to be equally distributed among the disciplines so far; the section will then close with a note on the specific role of philosophy and its branches in trans-disciplinary research.

1.3.2 Knowing and Acting

Naturally, scientific knowledge cannot be simply transferred to the level of action. Therefore, it needs appropriate scientific expertise in order to fill the gap between the respective different “worlds”. The significance and broad acceptance of expertise depends highly on trustworthiness, which has epistemic but also social requirements to be realized (section 3.1). In this way, the usefulness of expert judgment relies heavily on epistemic but also social robustness. The latter encompasses the desiderata for expert legitimacy and social participation.
Epistemic robustness is achieved by crafting a policy advice such that its thrust remains unchanged even if the relevant natural conditions fluctuate or are unknown.

Problem-oriented and thus often interdisciplinary research has to comply with certain virtues and instrumental conditions, depending upon different goals and frameworks of interdisciplinarity as chosen (section 3.2). These conditions are specific to horizontal and vertical approaches of interdisciplinarity as well to those which aim either at mere analysis or even at the evaluation of problems at stake. Critical virtues of interdisciplinarity and trans-disciplinarity will be discussed as well as more general social aspects like trust and personal requirements in corresponding frameworks.

The section 3.3 describes how interdisciplinary research is operationally conducted. A short overview reflects the landscape of interdisciplinary research worldwide. The focus moves then to a more thorough description of the method of “rational technology assessment” as an example for institutionalized interdisciplinary deliberation. Besides general features of this approach, the procedural steps of rational technology assessment will be shown.

1.3.3 Trans-disciplinary Deliberation

Science-based policy advice is the ultimate objective of trans-disciplinary deliberation. Section 4.1 discusses the corresponding requirements for finding and formulating sound recommendations and suggestions for policy makers. It is debated whether scientific advice should be limited to aims-means considerations or if and how far the objectives of the clients themselves should be subjects of corresponding deliberations. Within this, the authors argue about the role of normative sciences\(^2\) and of organizational matters including measures for quality management of policy advice.

It is also disputed in how far public participation might be an opportunity or a problem for trans-disciplinary deliberation. Section 4.2 first offers some clarification on the notion of participation as well as a historical overview of participation from the view of the social sciences and in the fields of public administration, development, technology transfer and technology assessment. Specific deliberative challenges from public participation stemming from limited competence of the citizens and possible stakeholder fatigue but also any levelling tendencies to “tribalise” science and its representatives, are here discussed further.

The validity of trans-disciplinary deliberations also depends on additional, more specific justification challenges, which arise around the notion of uncertainty and w.r.t governance and communication problems of scientific expertise: Scientific uncertainty is a typical consequence of modern research although it is not part of the public view of science. Uncertainty stems for instance from variable model-based knowledge or from diverse methodological designs of similar research questions. Section 4.3.1 illustrates a corresponding classification scheme for uncertainty and explains the relation of uncertainty to precaution as one possible option to react if societal issues are affected. For this aim, the notion of the precautionary principle is clarified and analysed w.r.t. choices of different strategies and options for acting.

\(^2\) This continental European notion includes scholarly activities like jurisprudence or philosophical ethics.
Section 4.3.2 debates again the issue of scientific policy advice – this time w.r.t. its impact and its governance. Finally, the necessary communication between science and society is reflected (section 4.3.3). For this aim, the science system is critically analysed w.r.t. its relation to society at large, w.r.t. the virtues of the researchers, w.r.t. scientific policy advice and w.r.t. the media. This section argues on problems of selective information, on appropriate selection of reliable experts and on the risk of medial trivialization of science ethics.

The report ends with a concluding appraisal on best-practice for interdisciplinary research and its trans-disciplinary validity (section 5). Corresponding conclusions and recommendations address four main groups of recipients within research and politics: (1) scientists who are themselves involved in interdisciplinary research, (2) experts and their social and political clients in need for scientific advice, (3) decision makers in research politics, and (4) decision makers in higher education politics.
5 Conclusions

Interdisciplinary research is not a fashionable niche within the concert of disciplinary research but a cross-cutting effort with a clear purpose. The appropriateness of the interdisciplinary mode of research depends on the specific scientific questions at stake and the necessary perspectives, descriptions, theories and methods. It should be noted that in the history of science, scientific research was not disciplinary until the early 19th century. From this perspective, disciplinary studies might be seen as special(-ised) cases of research rather than interdisciplinary ones. This involves the reversal of the “burden of proof” from the adequacy of interdisciplinarity to that of disciplinarity.

Today, interdisciplinary research often has an application-oriented societal perspective. It is trans-disciplinary in that problems are selected by socio-political forces according to practical significance. Therefore, this type of advisory research not only has to be scientifically sound but also relevant with regard to the problem at stake as well as acceptable concerning any normative conclusions and their consequences drawn from interdisciplinary deliberations. The validity of and societal trust in trans-disciplinary research rests therefore only partially on the processes and criteria designed to secure quality which are well-established in the sciences and humanities. Actually, broad, sustainable and effective acceptance of and compliance with trans-disciplinary advice depends also (but not entirely) on the ability of the scientists to satisfy the respective addressees in good faith and to take their (implicit) objectives and the relevant contextual knowledge into account. This is an ambitious and complex task, which also leaves room for uncertainty and ambiguity. Although they should aim at overall impartiality and trans-subjectivity in their messages, some individual perspectives and accents are unavoidable – thus leading to different but intrinsically reasonable appraisals of the same matter. The resulting plurality of competing assessments might well explore or exhaust the range of possibilities but could confuse the addressees unless the assumptions underlying the particular assessments have been made transparent.

Based on this view, more specific conclusions can be drawn from this study: The results of methodological reflections from the prior chapters on the constitution of science (section 2), on knowledge and acting (section 3) and on trans-disciplinary deliberation (section 4) are condensed to central insights and recommendations for interdisciplinary research claiming trans-disciplinary validity. The following conclusions of the working group are directed towards interdisciplinary research itself (theses 1-5), towards its trans-disciplinary perspective if applicable (theses 6-10), as well as towards its addressees in research and education politics (theses 11-14).
5.1 Interdisciplinarity

(1) The social fundament of joint research is constituted by the mutual recognition of the cognitive competencies of the cooperating scientists.

In interdisciplinary frameworks, corresponding expectations are even more crucial than in disciplinary ones. The authority of researchers within interdisciplinary settings is bound to relatively narrow notions of their disciplinary competence, while some heterodoxy is still accepted in mono-disciplinary frameworks according to the established standards of the relevant discipline. Disciplinary competence and its recognition is therefore a prerequisite for successful interdisciplinary research.

(2) Scientific researchers could – to some extent – influence their respective native discipline.

Disciplines and their borders are not static and not predetermined by their objects alone. Their dynamics was and is influenced by cognitive interests of scientists and institutions as well as by changing demands of the broader society. That means: not only research findings, but also active researchers – although bound to their native disciplines – could (re-)shape the patterns of their professional discipline, at least in the long run (see chapter 2.3). Apart from substantial disciplinary paradoxes, anomalies and methodological crises, interdisciplinary challenges are the most important stimuli which lead to reconsiderations on the basis of a discipline’s methodology.

(3) Interdisciplinary efforts offer added values concerning the self-perception and the power of judgement of the participating researcher within multi-disciplinary settings.

Interdisciplinary discourses unravel the conditions and related limitations of single disciplinary perspectives. Experiencing disciplinary distance and engaging in critical reflection of one’s own position (e.g., by the need to argue and to convince the discourse partners) might raise overall creativity and innovative potentials of the discourse participants. At the same time, their individual capabilities to transcend their own constrained disciplinary perspective might be improved.

Nevertheless, critical self-reflection of one’s own disciplinary position should not be confused with giving-up a disciplinary perspective of the problem at stake (see sections 2.2.1 and 3.2).

(4) Interdisciplinary research requires social competence in addition to excellence on professional levels.

Taking up the cross-disciplinary perspective should not be confused with developing multiple disciplinary competencies in one person, which would be inefficient and squanders the
opportunity of a critical cross-checking among different disciplinary views. The relevant disciplines rather need representation in a group of researchers with profound scientific competencies in different disciplines. This inevitably requires communicative skills to elucidate the contributions of one’s discipline to members of other disciplines, to recognise approaches of other disciplines and to reach common conclusions (see section 2.3). Within transdisciplinary contexts, research has to fulfil specific roles and meet expectations that are articulated by the general public, even if they transcend the cognitive interests of the scientists (see section 3.2).

(5) **Interdisciplinary research requires the ability and the willingness to transcend the disciplinary perspectives of each participating expert.**

Disciplinary answers to trans-disciplinary problems always presuppose an adequate reconstruction of the problem within the terminology, ontology, the systematics, models and scales of the respective disciplines. Scientists and scholars who want to serve policy and society by adequate and useful advice, informed and enlightened, but not biased by their discipline, have to ensure that the result of their reconstruction is appropriate to the problem, not just appropriate to the standards of their discipline. This is a necessary precondition for success, where trans-disciplinary problems require interdisciplinary treatment. In order to arrive at a complementary transcending of disciplinary boundaries, instead of competing disciplinary recommendations, openness for other disciplinary views and a certain degree of understanding other disciplines’ aims and strategies is imperative.

5.2 Trans-disciplinarity

(6) **Effective interdisciplinary research with trans-disciplinary perspective presupposes sufficient organisational facilities.**

Expectations on interdisciplinary research cannot be fulfilled unless critical conditions and provisions are met. Among them, the personal representation from the relevant disciplines and the adequate project duration has to be secured. Both have to be balanced with regard to the trans-disciplinary question at stake and its urgency as well as with regard to the connected funding requirements (see sections 2.3 and 3.2).

(7) **Interdisciplinary projects with a clear trans-disciplinary perspective should recruit experts with normative competence, too.**

The need of integrating normative competence from jurisprudence, economics and moral philosophy arises from the problem-oriented nature of the societal questions at stake and the requirement to give socially acceptable answers. Normative competence is needed when debates on uncertainties appeal to the practical consequences of error. Interdisciplinary
discourse should therefore also comprise expertise from jurisprudence, moral philosophy and/or economics.

The alternative use of normative competence in the form of adjunct ethical boards, instead, often suffers from ad hoc or superficial interdisciplinary reflection. The tight integration of normative competence in interdisciplinary project groups is advocated here (see section 3.2).

(8) **Scientific controversies should not compromise the advisory competence of interdisciplinary expert groups.**

Scientific research aims more at the revision of knowledge than at its accumulation; research findings are tentative in general. This is why controversies among experts are a normal mode of exploring new ground scientifically and do not constitute a characteristic of science in the public arena. The plurality of different assessments of the same problem is often produced by diverging presuppositions with different associated research strategies. The underlying premises and assumptions should be made transparent to the addressees. In this way, the studies’ results constitute a framework of different but similarly reasonable options for making policy decisions (see section 3.2).

(9) **Interdisciplinarity in policy advice should aim at explicitly addressing and mapping the scientific uncertainties involved in the assessment.**

The process of mutual learning in interdisciplinary assessment tasks involves a special challenge with regard to scientific uncertainty. On the one hand, there might arise the temptation to disregard scientific uncertainty in order to make one’s own disciplinary background knowledge appear firmer than justified; on the other hand, precisely because interdisciplinarity involves mutual learning, there is a positive opportunity in the group process to address scientific uncertainties explicitly and to assess their importance for the general recommendations. For the recipient of the policy advice, knowledge of scientific uncertainty is often as important as knowledge about established and agreed upon scientific facts.

(10) **Scientific uncertainty on potentially harmful developments paves the way to a possible application of the precautionary principle, which is not to be confused with a principled avoidance of risky activities.**

Modern policy advice is usually confronted with the management of significant scientific uncertainty. The precautionary principle is designed as anticipatory guidance for risk management, and as such it is essentially value-laden and ultimately in the responsibility of the decision-maker. This principle is interpreted quite differently worldwide. The authors of this study favour a notion which demands weighing different modes of action in light of both opportunities and risks of both action and inaction. Action and inaction are on a par regarding the need of this assessment, even though they may differ in terms of ethical reflection and
normative assessments (see section 4.3.1). The application of the precautionary principle might be accompanied with a shift in the burden of proof from the potentially affected people to the actors.

5.3 Research politics and higher education politics

(11) **Interdisciplinary endeavours need specific support apart from disciplinary funding programmes.**

Interdisciplinary research is not simply additive but reflective. It requires adequate framework conditions and enough time, especially for clarification of key terms and their quite different notions across disciplines and sectors, for critical reflection of the disciplinary perspectives involved and for drawing sound joint conclusions. In particular, appropriate institutional designs and a framework for sustained research without narrow temporal constraints pave the way to sound conclusions (see section 3.3).

Frameworks with strong interdisciplinary capabilities should be stimulated. This calls also for appropriate funding schemes or even for institutional support for the demanding definition phase of problem-oriented interdisciplinary projects. Interdisciplinary funding schemes should also consider the support of impact assessments of completed projects, which would promote further focussed policy-relevant research.

(12) **Sound interdisciplinary research relies heavily on the learnt disciplinary competence of its participants.**

The consequence for academic training is that primarily profound disciplinary qualifications (e.g. on BA levels) are still necessary – also as sound basis for further post-graduate education, which might either specialise further or even cross disciplinary borders.

The latter would be better conducted at full-scale universities than at technical universities with a limited range of relevant faculties at hand (see section 3.3).

(13) **The interdisciplinary aspect of higher education should be fostered in certain faculties.**

Some professions like medicine or life sciences do have serious ethical implications and consequences of various kinds. Especially at interdisciplinary graduate schools these ethical dimensions should be made explicit both in the general educational programmes and in the layout of the individual research projects for doctoral students. Suitable training courses in applied philosophy (moral philosophy and philosophy of science) can be offered in the framework of the “studium generale” and realised by working out appropriate contextual regulations both in the programmes of the disciplines and in the graduate schools’ internal modules.
Although such a ‘reflective’ element in terms of ethical and methodological consideration has to be studied in general, it should not be put onto the agenda of the study programmes too early, since it can only be useful if some basic knowledge and research practice in the home discipline has already been gained (see thesis 12 above). Furthermore, specialised and contextualised courses in applied philosophy should be offered which fit the more specific research topics of the graduate school as such or the individual research projects of doctoral students in corresponding graduate programmes.

(14) Specialised extensions should make students more sensitive to cross-disciplinary challenges of single professions.

Study extensions towards moral philosophy or philosophy of science cannot teach full expertise in these domains. Instead, they will raise the awareness of students for options and preconditions of interdisciplinary work and its division of labour.
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Corresponding Author:

Dr. Stephan Lingner

EA European Academy GmbH
Wilhelmstr. 56, 53474 Bad Neuenahr-Ahrweiler
Germany
+49 (0)2641 973 306
stephan.lingner@ea-aw.de