Tilburg University

Time for interdisciplinarity: An essay on the added value of collaboration for science, university, and society

A Time for Interdisciplinarity

An essay on the added value of collaboration for science, university, and society

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1. Introduction and Phrasing of the Question

"The university of the future will be interdisciplinary," the headline in *The Guardian* said on January 24, 2018. It concerned an opinion article by Zahir Irani, Dean of Management and Law at the Bradford University School of Management in the United Kingdom. Irani argues that traditional departmental structures impede research and education in their evolution in a changing world. These structures lead to rivalry and a struggle for resources and funding, rather than encouraging collaboration. According to him, it is time for something new. Irani (2018) sees an urgency in terms of content:

> Departments make it harder for academics to push boundaries as they struggle to find new intellectual homes for ideas that don't fit neatly into disciplinary boxes. Students lose out too: poorly managed course development across disciplines can lead to a joint degree that is two mealy halves joined together rather than a seamless matrix of ideas and challenges.

It is precisely the design of interdisciplinary courses, in which one discipline learns from another and disciplines are integrated, that would lead to context-specific programs that better serve organizations in the outside world and better prepare students for the labor market. It could also reduce the artificial and wretched separation within the university between education and research. Moreover, according to Irani, academic members of staff at universities also have an interest of their own because research councils, such as the *NWO* (Nederlandse Organisatie voor Wetenschappelijk Onderzoek – The Netherlands Organisation for Scientific Research), the *FWO* (Fonds Wetenschappelijk Onderzoek – the Research Foundation – Flanders) in our region, and other research funds are increasingly willing to invest in broader, innovative, and socially relevant research. Think of the Dutch National Research

Agenda and the new Horizon Europe program, which will be discussed later in this essay, in which interdisciplinarity and co-creation are central.

"I'M ON THE VERGE OF A MAJOR BREAKTHROUGH, BUT I'M ALSO AT THAT POINT WHERE CHEMISTRY LEAVES OFF AND PHYSICS BEGINS, SO I'LL HAVE TO DROP THE WHOLE THING."

Source: Sidney Harris via CartoonStock

The ultimate argument here, which is further discussed in this essay, is that interdisciplinary collaboration is a prerequisite for science to contribute to major problems – *wicked problems* – and thus generate impact of knowledge (Tromp, 2018). Menken & Keestra (2016, p. 34) put it briefly and to the point: complexity is "the main driving force behind interdisciplinarity." However, as Brewer (1999) puts it succinctly, "The world has problems, but universities have departments" (quoted by Hoffmann - Riem et al., 2008, p. 4).

Interdisciplinarity is also pursued in practice elsewhere

The discussion about interdisciplinarity does not only play a role within the university or higher education but also, largely, in the practice of other sectors: wherever knowledge is applied. Think of healthcare. In hospitals, for example, a large number of specialists work who have a lot of knowledge of a part of the human body. It remains

difficult to organize it in such a way that a patient with his or her problem is diagnosed and treated in an integrated and interdisciplinary way (and not only partially or sequentially) while he or she is indivisible and there are all kinds of connections between different functions and somatic and psychosomatic abnormalities.

In the mid-1990s and at the beginning of the 21st century, the debate on the transcendence of disciplinary research was fundamentally fueled by authors such as Michael Gibbons, Camille Limoges, Helga Nowotny, Simon Schartzman, Peter Scott, and Martin Trow, who saw or advocated a shift from so-called Mode 1 science to Mode 2 knowledge production (Gibbons et al., 1994; Nowotny, Scott & Gibbons, 2001; Barry & Born, 2013b, p. 1). Mode 1 is solely about striving for scientific knowledge, in the form of fundamental research while Mode 2 is about the collaboration or integration of scientific disciplines that, in their application, are focused on real life problems (see diagram 1 below). This knowledge is, therefore, not only disseminated academically (journals, conferences, scientific societies), but also in society.

Diagram 1

Mode 1	Mode 2
Academic context	Context of application
Disciplinary	Transdisciplinary
Homogeneity	Heterogeneity
Autonomy	Reflexivity/social accountability
Traditional quality control (peer review)	Novel quality control

Obtained from Hessels and Van Lente (2008).

The Royal Netherlands Academy of Arts and Sciences (*KNAW*) has been actively engaged in the theme of interdisciplinarity since 2006. In "Bruggen Bouwen" (Building Bridges*)* De Boer et al., 2006), the experiences and visions of scientists are identified and various recommendations are made. As a sort of sequel, the *KNAW's* The Young Academy presented its advisory report "Pushing Back the Boundaries: Opportunities and Obstacles to Interdisciplinary Research" *(*Grensverleggend. Kansen en belemmeringen voor interdisciplinair onderzoek). The Young Academy sees every reason to break down barriers in scientific research: interdisciplinary research contributes to scientific innovation and results in the broadening and deepening of individual disciplines. It creates knowledge that transcends disciplines and seems indispensable for solving complex social issues. In the same year, the Flemish counterpart of the Young Academy - the Young Academy of the Royal Flemish Academy of Belgium for Science and Arts *(KVAB*) - published the "Standpunt Interdisciplinair onderzoek in Vlaanderen" (Viewpoint Interdisciplinary research in Flanders). In this Viewpoint, a number of challenges are exposed that (young) interdisciplinary researchers in particular face, and suggestions are formulated on how university boards and councils and academic

stakeholders can better support interdisciplinary research (*KVAB* Young Academy, 2015).

In 2016, the League of European Research Universities (*LERU*) published the report "Interdisciplinarity and the 21st century research-intensive university" in which interdisciplinary collaboration is considered the "powerful driver of knowledge creation, scientific progress and innovation." This report also contains a multitude of observations and recommendations regarding the organization and facilitation of interdisciplinarity.

Recently, the *KNAW's* The Young Academy (2018) published a similar exploration and inventory with regard to interdisciplinarity in academic education. These opinions and the advantages, disadvantages, and obstacles identified in relation to interdisciplinarity are discussed in more detail below.

However, the above insights and positions with regard to exploring and promoting interdisciplinarity are not undisputed. This is made clear in various publications, including the book by Jerry A. Jacobs with the self-explanatory title *In Defense of Disciplines* (Jacobs, 2013, see also Graff, 2015). Jacobs resists the image of "disciplinary silos" that need to be demolished, and he observes that the exchange of ideas and research results among disciplines generally runs smoothly. He doubts whether a reorganization of the university structure will lead to added value and argues that the promotion of integrated courses at the university is as difficult as organizing interdisciplinary research. He also states that disciplinary specialization is a reaction, perhaps not perfect, to the dire need to distinguish intellectual domains. With more than 28,000 peer-reviewed journals and hundreds of scientific societies, no new organizational arrangement for academia could avoid a certain degree of specialization.

Another frequently heard counterargument is that the movement towards interdisciplinarity would come at a cost for the scientific strength and sharpness of disciplines. The doom image is that scientists will become jacks of all trades, neglecting their own discipline, developed with great pain and effort, which will ultimately lead to "undisciplined" science practice or even undisciplined chaos (Darbellay, 2014), which is at odds with scientific standards. It is obviously important to take these criticisms and reservations seriously (Szostak, 2017).

In this essay[1] we want to continue on this issue, which is essential for science, university, and society. We do this by raising the following questions in this order:

1. What exactly is interdisciplinarity and how does it distinguish itself from other forms of collaboration that transcend disciplines?

2. How, in short, has the practice of science proceeded with regard to the organization in disciplines; is interdisciplinary scientific practice increasing; and where do we stand now?
3. Is there a case for further strengthening and stimulating interdisciplinarity in research and education at the university? Why or why not?
4. If so, how can interdisciplinarity best be organized in academia, specifically in Tilburg? We also refer to the developments that are taking place within our partner university the KU Leuven.[2]

2. What Is Interdisciplinarity?

2.1   The I-Word

For a further debate on the desirability of promoting interdisciplinarity in research and education, it is important to have a working definition of the concept. Formulating such a definition is less obvious than it may seem. The Young Academy refers in its aforementioned advisory report from 2015 to the i-word and to a foggy situation (see also Klein, 1990, p. 12). A nice anecdote from The Young Academy's side (2015, p. 10) is that its potential new members are also asked during the selection procedure how interdisciplinary the candidate's research is:

> Candidates do their utmost best to ensure that they have a strong aversion to disciplinary boxes and compartments and spread the interdisciplinary idea in both research and education. Nobody is raising his or her eyebrows to ask the selection committee "what exactly do you mean by interdisciplinarity?" Yet that would not be a crazy question to ask in return. The term nowadays functions as a kind of magic word in the academic landscape, without it being clear exactly what it means and to which concrete research practices it refers.

Barry and Born (2013a, p. i) also state in the foreword to their edited collection *Interdisciplinarity: Reconfigurations of the social and natural sciences* that the idea that research should become more interdisciplinary is a commonplace, but that the term is still not very illuminating:

> The idea that research should become more interdisciplinary has become a commonplace. According to influential commentators, the unprecedented complexity of problems such as climate change or the social implications of biomedicine demand interdisciplinary efforts integrating both the social and

natural sciences. . . . yet the term tends to obscure as much as illuminate the diverse practices gathered under its rubric.

With regard to a first definition of interdisciplinarity, The Young Academy refers to the definition of the *OECD*, the Organisation for Economic Cooperation and Development (Apostle, 1972), which can be found in much literature, such as in the report by de Boer et al. (2006.p. 12). This definition reads as follows:

> Interdisciplinarity is a noun describing the interaction of two or more different disciplines. This interaction may range from simple communication of ideas to the mutual integration of organizing concepts, methodology, procedures, epistemology, terminology, data and terms organized into a common effort on a common problem with continuous intercommunication among the participants from the different disciplines.

As Lattuca (2003) rightly points out, this definition implies that interdisciplinarity has a continuum, ranging from informal exchange to the complete integration of concepts, methodology, etcetera. This is a more general view: interdisciplinarity as a continuum of intercommunication between disciplines. For example, the *KVAB*'s Young Academy (2015, p. 13) describes interdisciplinarity as "intense collaboration across the boundaries of existing disciplines, both within and outside the academic world" (with reference to Repko, Szostak & Buchberger, 2014, p. 368). It notes in this respect that, depending on the intensity of the collaboration and the result achieved, a number of gradations can be distinguished (such as multi-, inter-, and transdisciplinarity; see more about this below).

The integrative aspect of interdisciplinarity is essential, as is its innovative character (Davies, Devlin & Tight 2010, p. 12). The *OECD* (2010) gives the example of nanoscience as an interdisciplinary domain, integrating physics and chemistry. Conversely, it contrasts research into the environment, for which a multidisciplinary approach predominates because the various disciplines operate strongly independently of each other. Another example is criminology, which can be regarded as an interdisciplinary behavioral science to which sociologists, psychologists, anthropologists, and lawyers contribute (Jefferey, 2006, Bosma & Buisman, 2018). Disciplinarity can be "forgotten" interdisciplinarity (Schaffer, 2013, p. 58). Also consider astronomy.

Barry and Born (2013b pp. 3-4) rightly point out the need not to portray interdisciplinarity as a historical novelty, in the sense that, in the past, generating knowledge was exclusively done via separate disciplines. Science has always developed in various institutions and not only in laboratories and closed domains. Moreover, the development of disciplines has regularly led to an interdisciplinary phase and to the emergence of practices and methods that would now be seen as interdisciplinary.

2.2 Other Forms of Transcendence of Disciplinarity

What matters is to compare the concept of interdisciplinarity with and distinguishing it from other forms of cross-disciplinarity. In particular, the difference with multidisciplinarity needs to be clarified because, as The Young Academy and many other commentators have observed, interdisciplinarity, on closer inspection, is often about multidisciplinarity. It starts, of course, with the term "discipline," which we will discuss in the next section. For now, a discipline can easily be described in the Stichweh formulation (2001) as the primary unit of internal differentiation of science for both research and education. Monodisciplinarity then seems obvious as the carrying out of research within the confines of one such "primary unit" or discipline. However, another dimension can be added here with the term intradisciplinarity. If we take the discipline of law, for example, the interaction between labor law and tax law in research into the self-employed worker is a form of intradisciplinarity.

Multidisciplinarity (sometimes called *pluridisciplinarity*) is generally described as a joint or separately organized form of researching of an issue looked at from the point of view of several disciplines, whereby the disciplines continue to work with their own standard disciplinary frameworks (Barry & Born, 2013a, p. 8; Klein, 1990 p. 56).

Cross-disciplinarity is also referred to in a specific sense as viewing a particular discipline from the perspective of another discipline, whereby aspects of one discipline can be explained by another discipline. Think of the politics of literature or the physics of music (Davies & Devlin, 2010, p. 11).

Transdisciplinary research is described as a new field of research that is developing in the knowledge society and links science and policy to address problems such as environmental degradation, new technology, health, and social change. Through a transdisciplinary approach, researchers from different disciplines work together as well as with external stakeholders to tackle problems in the "real world" (Hadornet et al., 2008; Cronin, 2008).

Finally, the term *postdisciplinarity* has also been coined, whereby the starting point is that disciplinary structures are completely abandoned in favor of intellectual freedom. In the words of Buckler (2004, p. 2):

> The term "postdisciplinarity" evokes an intellectual universe in which we inhabit the ruins of outmoded disciplinary structures, mediating between our nostalgia for this lost unity and our excitement at the intellectual freedom its demise can offer us. Is the era of postdisciplinarity upon us now?

Post-disciplinarity could thus be understood as the definitive reunion or reintegration of individual disciplines.

A musical *art-science* project about interdisciplinarity in Tilburg

A specific form of interdisciplinarity consists of initiatives developed under the heading of art-science (Born & Barry, 2013a, pp. 247–272). The relationship and collaboration between science on the one hand and art and literature on the other is growing. It works both ways. Science and scientific ideas have always inspired the arts. But science is increasingly offering new media and methods for artistic exploration, such as the use of artificial intelligence and robotics in composing music or making paintings.

Science, in turn, can develop better means of communication through collaboration with art and reach a larger or new audience. It is even possible that better science could be achieved by working with art and artists, because artists ask different questions than scientific peers do (Kieniewicz, 2012, 2013).

In the light of writing this essay and addressing the theme of interdisciplinarity, we have set up an art-science project initiated by Tilburg University. A group of musicians consisting of Jan Wirken, percussion and coordination; Philipp Rüttgers (Germany), piano and composition; Mete Erker, tenor saxophone; Hein Offermans, double bass; and Romain Bly (France), horn, has accepted the assignment to make a composition and to perform during the Dies celebration on November 15, 2018 on the theme of interdisciplinarity from a musical-artistic interpretation. During the musical process and the process of writing this essay, there was regular contact between one of the authors of this essay and the group of musicians, in which a spoken word text, definitions, analyses, and dilemmas of interdisciplinarity were exchanged and discussed. Scientists were also present at the rehearsals and recordings.

The *spoken word* text, written by Ton Wilthagen, which is included in the composition, reads as follows:

A Time for Interdisciplinarity

We've arrived at the intersection
Ready for joint action
To go beyond boundaries
With musical passkeys
Discovering the methodology
Now we can hear and see
The full potential of the interplay
Of disciplines across a wide array
Here's the allusion
To the added value of fusion
New players, new jam sessions

Or chord progressions
Contextualizing harmony and innovation
A future ahead of co-creation.

The Young Academy (2015) is not satisfied with the above-mentioned *OECD* definition of interdisciplinarity – because the disciplines are the beginning and the end – and, in its advisory report, it tries to define the concept of interdisciplinarity, based on a Socratic discussion with scientists from various disciplines.

The conclusions of this brainstorming session are (The Young Academy, 2015 p. 12):

1. On closer inspection, often interdisciplinarity is multidisciplinarity;
2. Interdisciplinarity changes the scientific identity of the researcher;
3. Interdisciplinarity can come about in different ways;
4. Interdisciplinarity has positive and negative effects.

Ultimately, The Young Academy (2015, p. 14 defines interdisciplinarity as "a transformation of scientific identity created by symbiosis of disciplinary questions, methodologies, and outcome measures." The focus on scientific identity, alongside integrality, is an interesting starting point, which we will return to in this essay. In relation to education, The Young Academy (2018, p. 6) uses the following definition of interdisciplinarity, which is reasonably in line with the oft-cited *OECD* definition:

Education given by teams or individuals in which information, data, techniques, methods, perspectives, concepts, and theories from two or more disciplines or fields of education are applied and integrated, with the aim of addressing practical or theoretical problems of which the solution is outside the scope of one discipline.

3. The Development of Scientific Disciplines and Interdisciplinarity

3.1 The Organization of Science in Disciplines

The term "discipline" is etymologically related to the Latin *disciplina*, which means education, science, rules and fundamental principles, as well as giving instructions to a disciple (etymologiebank.nl). "Disciplines discipline disciples" (Barry & Born, 2013b, p. 1). Chettiparamb (2007) notes that the Oxford English Dictionary situates the word in the Middle Ages but that the origin of disciplines as a way of structuring academic practice varies geographically and depends on the type of discipline. Of course, as Chettiparamb continues, there is a relationship with the emergence of universities, as, in our part of the world, in Bologna and Paris. In the American context it concerns the later period 1870–1900.

Nevertheless, it can also be said that disciplinarity has developed much earlier in a non-scientific context, for example, in the specific working method of the Roman bureaucracy. In early medieval cathedral schools, the aim was that specialization would take place in a community of general studies. Also philosophers like Plato, Aristotle, Rabelais, Kant, Hegel, and others can be considered interdisciplinary, in the sense that they considered the unity and integration of knowledge of paramount importance (Klein, 1990, p. 19). They often had also been trained in several sciences.

In the literature, we find two important factors that contribute to the emergence of disciplines: the natural tendency of mankind to distinguish, classify, and conceptualize

the environment and the need for science to take full advantage of the accumulation of knowledge and to advance science – and thus society. Specialization and demarcation are also conditions for professionalization and educating new generations of scientists.
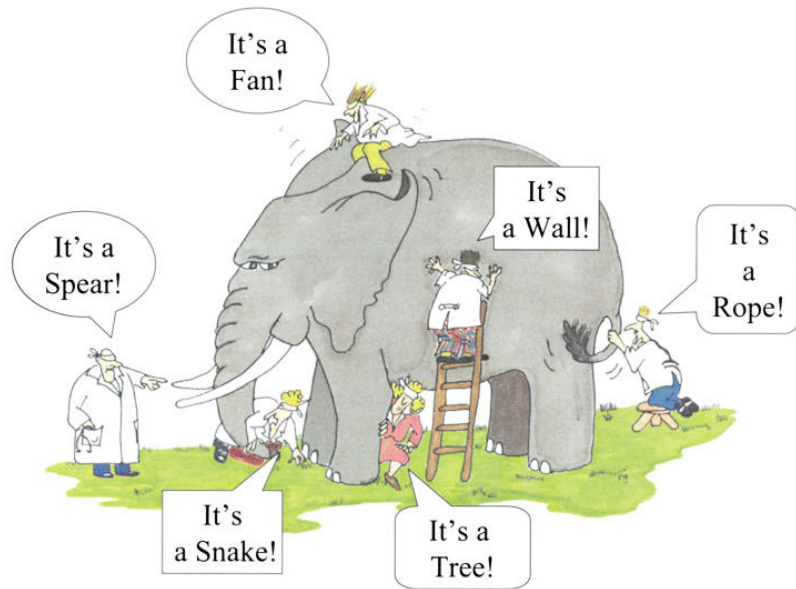
At the same time, the development and branching of disciplines can be considered as the regulation of an internal market (Chettiparamb, 2007, p. 2, in a reference to Turner, 2000). Not all approaches make it into an established discipline and – we would like to add – not all disciplines that establish themselves will prove and remain successful. From that point of view, disciplines can also be seen as forms of and attempts at protectionism.

As Luhmann also states (1990), the growth of scientific disciplines can also be seen as a process of functional differentiation *(funktionale Differenzierung)* in society, in which new, autonomous communication systems are created. In the words of Lievers (2006): "Since the 17th century, truth can differentiate itself in science as a different code of communication than in faith." These scientific communication systems then branch off into a tree structure. As Stichweh (1992) notes, each individual discipline is embedded in an internal environment of other disciplines. The constant mutual observation and interaction of these disciplines is the most important factor in the dynamics of modern science.

Kuhn describes in his authoritative book *The Structure of Scientific Revolutions* (Kuhn, 2012) the rise, late 18th century, early 19th century, of "communities" of specialists, of scientific communities. In a sociological sense, disciplines become communities and entities of scientists and students, with a focus not only on their own theory, objects, and methods but also on "disciplining" habits, customs, rules, and structure formation. This involves awarding degrees of qualifications, publishing a certain type of publications in certain journals, organizing meetings and, thereby, setting up systems for status, remuneration, and careers on which power and position can be based.

Apostle (1972, pp. 146–147), quoted by Chettiparamb (2007, p. 5), even goes so far as to posit the statement that:

> a discipline does not exist. A science does not exist. There are persons and groups practising the same science or the same discipline. In other words a discipline can only be defined by indicating: 1. P: a group of persons, 2. A: a set of actions, performed by these persons, 3. I: a set of interactions or communications, among these persons and to other persons, 4. E: a method of regenerating the set of persons by means of certain communications of an educational nature 5. L: a set of historic learning methods.

3.2 Detaching from Faith as Well as Philosophy

Distinguishing-dissociating-from faith is a major, constituent step for science and the establishment of universities as sanctuaries and bastions for *universal* (i.e., non-ecclesiastical or religious) knowledge. But within that science itself, a big step is also taken when the natural sciences, or more broadly, the empirical sciences detach themselves from philosophy, the "mother of all sciences," which in its (non-empirical) way "knows" and orders the world, nature, society, and man.

It is mainly in the social sciences where, in the course of the 20th century, a movement towards interdisciplinarity arises. In the natural sciences on the other hand, a further branching off is taking place. The developments in the social sciences are a reaction to the disciplinary structure that is becoming increasingly dominant in the original liberal arts colleges. These colleges arose in the Western world from the 17th century onwards, and their broad mission can be found in the so-called Yale Report from 1828. These colleges were increasingly replaced by research universities. In fact, the liberal arts concept goes back further, namely to Greco-Roman antiquity and to the Socrates method. At that time, free people were educated in rhetoric, logic, language, and (later in the Middle Ages) in arithmetic, astronomy, etcetera in order to participate in civil society. Unfree people, i.e., slaves and serfs, were given vocational and technical training (Liberal Arts School Review, 2017).

The debate on interdisciplinarity receives a new and strong impulse in the 1920s. Then, there are also skirmishes between sciences such as sociology and biology about the delimitation of everyone's territory and research object.

Around the end of the First and Second World Wars respectively, the following momenta for interdisciplinarity arise. In the first period, it is a spill-over of instruments and quantitative methods and techniques from the natural sciences to other sciences; in the second period the emphasis is on integrated approaches and unity of science, and in the United States, this includes the study of specific geographical areas (area studies) (Klein 1990, p. 24, with a reference to Landau, Proshanky & Ittelson). In the forties cross-fertilization takes place as a result of trends in the natural sciences due to the use of the machine-organism analogy. Mission-driven programs, externally funded, may have had the greatest influence on the stimulation of interdisciplinarity, of which the American Manhattan project for the development of an atomic bomb is the most famous one (Klein, 1990, p. 33).

The 1960s provide a favorable climate for the growth of interdisciplinary initiatives and created a kind of watershed. A large number of national and international organizations, including the *OECD*, show themselves to be ardent ambassadors of a discipline-transcending approach and advocate "interdisciplinarity exogenous to the university," aimed at "real" problems and enriching endogenous interdisciplinary orientations that mainly focus on strengthening the unity of science (Klein, 1990, p. 37). In this period, up to and including the seventies, literature and the discussion about interdisciplinarity also increase significantly. In the 1980s, however, optimism turns into *empirical realism*, based on an appeal to academic responsibility, which heralds a return to individual disciplines (Papadopoulos, quoted by Klein, 1990, p. 39).

An important and relevant concept in Kuhn's work, mentioned earlier, is "normal science," based on paradigms and communities. Kuhn observes that science is not aimed at creating real innovation, it is rather a form of puzzling: "The most striking feature of the normal research problems we have just encountered is how little they aim to produce major novelties, conceptual or phenomenal."[3] In other words (Hacking 2012), "Normal science does not aim at novelty but at clearing up the status quo. It tends to discover what it expects to discover." Renewal does not come about when something goes well, but when something turns out or goes differently than expected, if, in Kuhn's words, there is an anomaly.

In any research journal, three types of problems are usually addressed: 1) determining significant facts because the theory describes certain phenomena inadequately and then certain facts can be better determined by measurements; 2) cleaning up the theory

because fixed observations do not correspond with the theory, and the question is what is wrong then; 3) articulation (as Kuhn calls it): making explicit by mathematical analysis what is still implicit in the theory. Kuhn is of the opinion that the primary task of science is theoretical in nature and his characterization of normal science does not have a negative meaning. Kuhn did not yet foresee the emergence of experimental and instrumental approaches in science that occur in the 1980s. For this reason, normal science can indeed contain a degree of innovation, and not merely have a theoretical character (Hacking, new foreword to Kuhn, 2012).

In the nineties and in the new millennium, the climate is favorable again for interdisciplinarity. There are many places where the dialogue amongst disciplines is conducted although they are not always clearly visible and known. Meanwhile, there are also quite a few scientific journals with an interdisciplinary orientation, such as *Interdisciplinary Science Review* and the *Journal of Interdisciplinary History* (Klein, 1990, p. 49). Certainly in specific sectors or around specific themes, various journals present themselves as an interdisciplinary or at least as a multidisciplinary journal: think for example of *Climatic Change* (Springer), *Policy & Internet* (Wiley), or *Telecommunications Policy* (Elsevier). Moreover, interdisciplinary work and its results are also published in disciplinary journals although this is not always easy or obvious.

Globally, including in Europe, and in particular in the Netherlands and Flanders, interest in and debate about interdisciplinarity have increased in the past two decades (*LERU*, 2016). Nevertheless, research councils in the Low Countries (*NWO* in the Netherlands and *FWO* in Flanders), as well as universities, still predominantly organize themselves in the traditional tree structure of disciplines/subdisciplines and scientific fields (the *FWO*-Flanders, for example, works with 30 subject-specific panels and—only—one interdisciplinary panel). Flemish universities stimulate interdisciplinary research mainly through special programs within their research funding (*KVAB* Young Academy, 2015, p. 16). For a long time, the KU Leuven had a special research program *IDO*, which had interdisciplinarity as its main objective; now it works with a financial and evaluative bonus for projects with an interdisciplinary component (although its research council has recently launched a call for a new type of research proposals, called Interdisciplinary Networks - 'IDN').

Both in the Netherlands and in Belgium (with the exception of the Flemish strategic research centers; see below), interdisciplinarity is mainly organized in relatively small-scale research institutes within a School or between Schools, often referred to as centers (such as TILEC, Tilburg Law and Economics Center, and the Leuven Centre for Global Governance Studies). Some of these institutions come and go, and sometimes get into trouble when the initial funding is lost and other income, such as education, is lacking; others last longer.

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[3] Thus summarized and quoted by Ian Hacking in his introductory essay to Kuhn's *The Structure of Scientific Revolutions* in the 2012 edition.

3.3 Interdisciplinarity in Education

In education, a distinction can be made between four levels of interdisciplinarity (Klein, 1990, p. 57, referring to Armstrong) that are found in practice:

1. Students take a selection of courses from different departments;
2. There is an institutionally provided opportunity for students to meet and share insights from various disciplinary courses;
3. Offering courses aimed at an interdisciplinary subject, in which various schools or faculty members participate;
4. There is a conscious attempt to integrate material from various fields of knowledge into a new, single, intellectually coherent entity, with an understanding of epistemology and methodologies of other disciplines and building a common vocabulary.

There has been enthusiasm for interdisciplinarity in education since the 1920s, and it is clear that this approach is continuing in education although the benefits are not equally firmly supported by theory and research yet (Adler & Fihan, 1997). Today, as in the past, liberal arts colleges are the most striking interdisciplinary programs, for which there is a great deal of interest. In 2016, broad Bachelor's programs such as Liberal Arts & Sciences showed the largest growth in percentage terms (increase of 38%). It is estimated that, annually, 2000 students enroll for the small-scale Liberal Arts programs. The rise of modern liberal arts colleges is seen as the turning point at which interdisciplinarity develops or redevelops in response to the dominance of disciplinarity. Both Tilburg University and the KU Leuven have set up such colleges, which usually also have their own accommodation. At a European level, there is the European Liberal Arts Network (ELAN).

In the Netherlands, The Young Academy (2018) begins its report on interdisciplinarity with the observation that there are quite a few popular cross-disciplinary programs at both Bachelor's and Master's level, such as Health and Society, Environmental Sciences, Future Planet Studies, Language and Cultural Studies (Bachelor's) and Environment & Society Studies, Urban Studies, Earth, Life & Climate, Literature, Culture & Society, and Regenerative Medicine & Technology. As far as Tilburg is concerned, reference can be made to Global Management of Social Issues, Cognitive Science and Artificial Intelligence, Public Governance, and to the interdisciplinary data science programs offered by the Jheronimus Academy of Data Science, the partnership between Tilburg University and the Eindhoven University of Technology in Den Bosch. A Leuven example is the recent Master's in Digital Humanities. The Young Academy (2018) relates the rise of such programs to the introduction of the bachelor-master system, in which students opted more frequently for broadening whereas, in the past, they increasingly specialized in a certain direction.

In the United States, courses such as Computational Law, Programming for Lawyers, or Coding for Lawyers are becoming increasingly popular. Harvard Law School (2017) motivates their offering such a course as follows:

> Modern legal practice requires deep understanding of technology. Advocates must understand what it means at a technical level to "speak" online, to "sign" a digital contract, to "search" a computer, or to "delete" evidence. And law firms must understand what tasks can be most efficiently done by custom software and what are best left to human beings.

4. The Case for Strengthening Interdisciplinarity at the University

4.1 Reason and Need for Interdisciplinarity

The following reasons for an interdisciplinary approach are frequently mentioned in the literature (Klein, 1990, p. 11; Valcke, Graef & Clifford, 2018, p. 712):

- Answering complex questions, which have a multitude of aspects *(multi-faceted)*.

- Addressing broad issues.

- Exploring disciplinary and professional relationships.

- Solving problems that lie outside the scope of any discipline.

- Achieving "unity of knowledge" on a large or smaller scale.

The League of European Research Universities, *LERU* (2016, p. 7), sees a mission for universities to work in an interdisciplinary manner in both education and research. This in the light of globalization and the global challenges it poses (including migration, contagious diseases, financial crises, and sustainable development) due to the vulnerability of the complex global system characterized by a high degree of interdependence:

_____ The expertise of academic institutions is needed to develop interdisciplinary approaches that the dominant strain of disciplinary science has been ill-equipped to provide. It is equally important for academic institutions to train students … in these integrative approaches to enhance the capacities of governments, the private sector, media, NGOs, civil society, and others to use and implement them at all levels of society.

We would like to add that, in international comparative research, it is difficult to research only the narrow object of study because this object is located in a context in which multiple factors will vary (politics, law, culture, customs, religion, prosperity, economy, law, history, path dependence, etc.). An example is the study of part-time work in the world. Comparison and explanation are not possible from a monodisciplinary perspective. Whereas in the Netherlands there is a strong, culturally determined preference for part-time work, especially among women, this form of work elsewhere, certainly in less prosperous countries, is regarded as a form of precarious work that stands in the way of people's economic independence, of women in particular.

Newell (2001) has tried to formulate a theory of interdisciplinary studies, in which the degree of complexity of systems is the determining variable. The essence of this theory is that interdisciplinarity is necessary if the complexity of the system is considerable; otherwise it is not:

_____ The phenomena modeled by most complex systems are multi-faceted. Seen from one angle, they appear different than they do from another angle, because the viewers see facets (represented as sub-systems) where different components and relationships dominate. The frequent pairing of complexity and interdisciplinarity is no coincidence. Complex systems and phenomena are a necessary condition for interdisciplinary studies. So if a behavior is not produced by a system or the system is not complex, interdisciplinary study is not required.

In their comparative study of interdisciplinary areas, such as research on climate change and the field of IT, Barry and Born (2013a) and Born and Barry (2013) respectively conclude that there are three forms of logic that permeate interdisciplinarity: the logic of accountability, regarding scientific research to society; the logic of innovation, the need for scientific research to foster industrial or technological innovation or economic growth; and the ontological logic, the focus of interdisciplinary practices on transforming the practice of research and training, inside and outside the academic world, leading to the identification of new problems and research objects and research relationships. This third form of logic is strongly linked to the other forms.

The moment universities focus on generating impact with their knowledge on major social issues (Wilthagen, Den Hertog & Denollet, 2017), we see that research and

working methods require interdisciplinary collaboration. This is crucial within the so-called fourth generation universities. Funders and commissioners of this type of research are also increasingly focusing on this when setting conditions for research proposals, whereby the emphasis on interdisciplinary and multidisciplinary approaches and the focus on impact are often indicated in one go.

We will give two examples of this development. The initiative of the Dutch National Research Agenda (2015) was taken by the Knowledge Coalition with the aim of better equipping scientific research in the Netherlands to find answers to the major challenges of our time and to bring about the necessary transitions in such areas as energy use, health care, social and democratic progress, safety and security, and world food security. These issues are typified as complex and characterized by "conflicting values, mounting political pressure, and major economic interests."

The following is noted:

_____ Such complexity requires the involvement of multiple parties and approaches, as well as innovative new connections and partnerships. The National Research Agenda aims to spur us into forging uncommon alliances and exploring unanticipated relationships. The Research Agenda focuses specifically on interdisciplinary and multisector challenges. It should generate more synergy in research as a whole and augment the consistency, efficiency and impact of Dutch research.

However, the following comment is also important for our argument:

_____ The Research Agenda does not, however, cover the entire field of science, and is not meant to be a comprehensive agenda for research across the board … every matter included in the National Research Agenda should be important, but not every important matter must be included in the National Research Agenda. Small scale, specialist research is no less significant and merits our support and sympathy.

In the recently launched program Digital Society of the Dutch universities united in the *VSNU* (Association of Universities in the Netherlands) the importance of interdisciplinarity is key (VSNU, 2016, p. 11):

_____ Every discipline in the field of science will have to develop, expand and maintain digital knowledge, skills, methods and infrastructure. This particularly applies to data science: a new, multidisciplinary field which, besides technology and IT, also involves disciplines such as social sciences, mathematics and physics.

In the last three decades, Flanders has established five scientific strategic research centres (*SOCs*), namely imec, the Flanders Institute for Biotechnology (*VIB*), the Flemish Institute for Technological Research (*VITO*), Flanders Make, and iMinds (the first and last one merged in 2016). Within this framework, interdisciplinary research is carried out—across university boundaries—on certain key issues, such as climate change, food security, sustainable energy supply, broadband technology, or industry 4.0. However, unlike the recent European framework programs for research and innovation, the integration of social sciences and humanities within the *SOCs* remains very limited. This is regrettable.

Another important example is the European Union, which, since the 8th Framework Programme for Research and Innovation (Horizon 2020), has been strongly committed to interdisciplinarity (*LERU*, 2016, p. 9). The social sciences and humanities have been integrated - and are expected to play an important role - in all the pillars of the program (Societal Challenges, Future and Emerging Technologies (FET), Industrial Leadership, etcetera). The European Union is currently preparing for the next major European Framework Programme for Research and Innovation, Horizon Europe, which will be mission-driven (European Commission, 2018). In the foreword to a policy paper on this subject, the influential advisor Prof. Mazzucato (2018, p. 2) writes:

> I look at what we can learn from the missions of the past—like the Apollo Program—and how to apply those lessons to the more complex challenges of today. A key lesson is that missions must be bold, activating innovation across sectors, across actors and across disciplines.

These principles are confirmed in the policy paper (p. 15):

> Missions should be framed in such a way as to spark activity across, and among, multiple scientific disciplines (including social sciences and humanities), across different industrial sectors (e.g. transport, nutrition, health, services), and different types of actors (public, private, third sector, civil society organisations).

In the case of the implementation of results from scientific research (e.g., the implementation of new technologies), an interdisciplinary approach is even regarded as a requirement (The Young Academy, 2015; *LERU*, 2016).

The debate about and movement towards interdisciplinarity and the question whether a given knowledge practice is too disciplinary or interdisciplinary, or not disciplinary enough has become an issue for governments, policymakers, and institutions that offer funds for scientific research, according to Barry and Born (2013a, p. i). They speak of a "key political preoccupation." A similar observation is made in the Netherlands by The

Young Academy, which states that the discussion on interdisciplinarity is partly driven by a political-administrative agenda:

> Discussions about interdisciplinarity are regularly politically charged (not in the narrow sense that they deal with The Hague's policy, but in the broad sense that they serve policy objectives and the exercise of power). In the name of interdisciplinary research or education, entire departments are being cut back and well-run education modules are being replaced by cheap, "interdisciplinary" lectures for hundreds of students at the same time. The sceptics, therefore, have a point. Every time the i-word falls, a wise person asks himself: What interests are at stake here and who or what will soon lose out as a result of interdisciplinarity?

At the same time, The Young Academy rushes to add that this is not the whole story and that scientists who work with colleagues from other disciplines often have real "aha experiences." They report on insights, which, they say, they would never have gained with their own immediate colleagues, and they point out the creativity and innovation that result from this cross-border cooperation.

Also Barry and Born (2013b, pp. 3–4) argue that the temptation should be suppressed to see the current emphasis on interdisciplinarity as too political and instrumental. This focus is not only driven by governments' tendencies towards the (knowledge) economy, innovation, universities' accountability, a stronger connection with society, or by commercial interests.

The discourse on interdisciplinarity stems from needs on the part of the government, from a reflexive orientation within the academic world, and from the substantive object of research. The application of interdisciplinary research is not an operation that is aimed at and will, on balance, lead to an infringement of the autonomy of research in general. Through interdisciplinary knowledge development and methods, new research areas and initiatives can also arise with new forms of autonomy and protection against reductionism.

4.2 The Experiences and Visions of the Scientists Themselves

With regard to research

In order to determine the added value and obstacles of interdisciplinarity in academic research, it is obviously important to take a closer look at the experiences and vision of scientists themselves. In the Netherlands, four organizations, including the *KNAW and the NWO*, have set up a research project to map the experiences of Dutch researchers with interdisciplinary projects and programs. To this end, 15 researchers were interviewed in the period 2005–2006. The above-mentioned report was published in 2006 under the title *Bruggen Bouwen* (building bridges) (De Boer et al., 2006). The introduction to the report notes that the title should not be seen as an indication that interdisciplinary research is being or will be carried out across the board. It should be noted, however, that there is a risk that research resources will not be used efficiently if no attention is paid to the experiences of scientists. Moreover, under certain conditions, interdisciplinary research could generate added value in the form of new insights, combinations, integral visions, and specific knowledge.

The interviewees appear to agree on the potential added value of interdisciplinary research (De Boer et al. 2006, p. 59):

> that truly effective interdisciplinary research can have social, scientific, and personal added value and depends largely on the good will of the participants. Everything starts with the right attitude. Even if there are fundamental differences between natural and social scientists and even within the various disciplines: where there is a will, there is a way.

Respondents agree less on the extent to which interdisciplinarity should be institutionally shaped. Some scientists point out the importance of a charismatic and experienced leader, who can create the right climate in his or her research group, and that additional resources and facilities are not of great importance. Other researchers, on the other hand, draw attention to the need for extra time, extra money, extra manpower, and separate positions and institutes.

Still others do not see so much difference with monodisciplinary research, in the sense that interdisciplinary research is sufficiently valued, awarded, published, and so on. It should be noted that certain top publications and Nobel Prize winners can be considered interdisciplinary and that this is seen as encouraging.

Following in the footsteps of the above-mentioned study, The Young Academy (2015), by means of a survey and a series of interviews, identified the obstacles that members of The Young Academy experience in setting up and conducting interdisciplinary research. Many of these obstacles are also found in other publications on interdisciplinarity. We have summarized these (types of) obstacles below:

- Remuneration of interdisciplinary projects is not always very promising; the selection is made too early—it is better to select on relevance before selecting on quality—and the assessors often represent a certain discipline and, from that viewpoint, none of them can properly assess the entire project, which does not easily lead to a high score. This has, by now, become a point for attention for the *NWO, KNAW, FWO,* etcetera. However, if the interdisciplinary character of research proposals is explicitly assessed, this is not easy either (Huutoniemi et al., 2010).

- There is too little flexibility in funding and duration: interdisciplinary projects often take longer than four years. The Young Academy (2015, p. 22) gives the example of Dutch experimental physicist Tjerk Oosterkamp, who was forced to stop promising research: "We had to stop our work on aorta research because there was no more money for it. We had good publications. But because it was such a difficult research, no one repeated it and so it was not quoted much." (see also KVAB Young Academy, 2015, p. 7).

- It is not always easy to get interdisciplinary research published because there are fewer interdisciplinary journals and because the reviewers of disciplinary journals have difficulty assessing this type of research (LERU, 2016, p. 28; KVAB Young Academy, 2015, p. 8). Also, as mentioned above, interdisciplinary research would be quoted less. Moreover, interdisciplinary work would systematically end up in journals with lower rankings and book publishers would also have a preference for monodisciplinary texts. This in turn has consequences for the assessment of the quality of this research and the researchers themselves when assessing research applications. At the same time, in *Nature* ("Interdisciplinary research by the numbers," 2015, cited by The Young Academy, 2015, p. 11), Van Noorden notes that since the mid-1980s research papers have increasingly quoted work outside their own disciplines. Moreover, it appears that interdisciplinary research may receive fewer citations in the first three years, but that the citation score is significantly higher after thirteen years.

- It can be difficult to show the results, the impact, of this type of research, as well as of attempts to involve the public. The availability and use of appropriate impact indicators is of great importance for this purpose.

- More incentives are needed for interdisciplinary research from the funding institutions—for this too there is a movement by now, as indicated elsewhere in this essay.

- Systems for assessment, remuneration, and promotion (i.e., HR policy) as well as for quality assurance within the academic world are still strongly based on the division into scientific disciplines. Interdisciplinary work is promising but also a risky career path, especially for young researchers. If you are a university professor, it is a lot easier. Institutions do proclaim the desire and necessity to work interdisciplinarily, certainly in self-studies with a view to site visits, but in practice this work still has less prestige.

- In recent years, many disciplines have been further mathematised or permeated by complex models, techniques, and data science. For the disciplines including the alpha disciplines, for which this does not apply or to a lesser extent, it has

  become less easy to connect and work together. On the other hand, these disciplines are often open to this development.

- Views on the nature of theory and methodology differ significantly from one discipline to the other; the gap between those views is particularly striking between the empirical disciplines, on the one hand, and the normative, argumentative sciences, on the other hand. Where, simply put, empirical sciences such as economics and sociology try, based on the theory, to make a connection – cause and effect – between individual phenomena (or variables), jurisprudence relies on principles of law, legislation, legal history, and case law, to derive legal consequences from facts defined as legal facts. Also between the so-called exact sciences and humanities, there is a big gap in terms of jargon and methodologies, as became e.g. apparent in research in which computer scientists and lawyers try to further clarify the contours of concepts such as "privacy by design" (Le Métayer, Bossuet, Coudert et al., 2017).

As an example of the need for cross-disciplinary approaches to major problems, the climate crisis is often mentioned. Barry and Born (2013b, pp. 25–26) discuss three arguments for not only relying on the natural sciences to deal with this problem, but also for bringing socio-cultural sciences into the picture: 1) Natural science models are implicitly also formed from political assumptions and cultural values, usually without making them explicit. 2) It is important to recognize the knowledge and experience of non-experts such as interested parties (e.g., local residents) and practitioners and to not only consider these as perceptions but as expressions of citizen science. 3) Environmental and climate problems have a hybrid character, and splitting them into distinct natural and social aspects is impossible.

In the exploration of The Young Academy (2015, p. 50), Dutch scientist Willem Schinkel gives a fine concrete illustration in this context:

> A climate scientist who wants local peoples to adapt to a changing climate cannot assume that all peoples of the world use our scientific concept of "climate." He should first study what "climate" means to different groups of people. According to anthropologists, some peoples see the climate as a living being or recurring cycle; sometimes they have a very religious view of it. If you want to use the knowledge that climate science provides to change people's behavior, you first need to delve into such matters.

With regard to education

The Young Academy (2015, p. 19) concludes in its report "that interdisciplinary education can have added value. The question is, however, at what stage this form of education will be most effective." Most members feel that basic knowledge of a certain discipline is a requirement. They prefer that students first study a certain discipline before broadening their horizons. As long as no disciplinary basis has been laid yet, it is wise to introduce interdisciplinary education in doses. A broad, interdisciplinary education may be important for a better preparation for the multifaceted labor market and increasing demand for multidisciplinary or interdisciplinary research. As multidisciplinary or interdisciplinary research institutes are more intensively involved in providing education, interdisciplinary research and education can reinforce each other in a positive sense. In addition, there are disciplines that transcend discipline by definition, such as biomedical technology and gender studies. Bottlenecks and obstacles experienced in introducing interdisciplinarity in education are the threat of the elimination of disciplinary education, practical obstacles such as separate budgets and organizational structures, difficulty in examining and assessment, and a poor match with professional profiles.

5. How Can Interdisciplinarity Best Be Organized in Academia?

5.1   Dichotomy or Paradox?

By means of differentiation, specialization, and professionalization, scientific disciplines have made an enormous contribution to scientific progress, from which society has benefited. And that is still happening, unabatedly. The value of disciplines lies in the fact that they are able to account for their conditions of existence and the way in which they gather their knowledge (Strathern, 2004, p. 5, quoted by Barry and Born, 2013b, p. 7). As Stein (2007, p. 93) puts it, "disciplines are methodological lenses employed by communities of investigators relative to particular phenomenon." Nothing more, but nothing less.

It would be a wrong way of thinking to see disciplinarity as homogeneous and closed and interdisciplinarity as heterogeneous and open. Also interdisciplinarity can be or become limiting and might involve closure (Barry & Born, 2013b, p. 7).

At the same time, it can be said that progress within individual disciplines will sometimes remain more limited than progress in collaboration between disciplines. The risk that monodisciplinary approaches fall short is not negligible. In discussions, it is sometimes pointed out that monodisciplines wrongly claim to have the analysis and solution for major problems, such as the major economic crises or climate change, and that, therefore, these problems are, in part, maintained. As already mentioned, interdisciplinarity contains a great promise of added value through collaboration. This promise means that it is possible to broaden and enrich knowledge and, especially in complex social issues, to move beyond individual disciplines.

Osborne (2013), under the motto "Inter that discipline", states that the outlined dichotomy between disciplinarity and interdisciplinarity is completely misleading. Interdisciplinarity is, in fact, not opposed to disciplinarity because it presupposes a certain awareness of disciplinarity for its realization. "... as if there were an array of rather miserable, bunkered, puritanical disciplinarians ranged against bright, progressive, brave-new-world interdisciplinarians" (p. 82). Osborne expresses what we consider to be a crucial observation: "If you lack a discipline to 'inter', you can't be interdisciplinary." A scientist who does not master, cherish, and honor his own discipline and loses contact with the discipline and his own colleagues has little to offer colleagues from other disciplines in a movement towards interdisciplinarity. We would like to speak here of an interdisciplinarity paradox. Klein (1990, p. 106), in fact, sees a disciplinarity paradox, in which it would not be possible to be both disciplinary and interdisciplinary.

Osborne (2013, p. 95) goes one step further by stating that it is precisely the disciplines that do not have a strong foundation that will be the main victims in a world that is more intensively oriented towards interdisciplinarity:

_____ the main casualties ... will not so much be disciplines themselves as those areas of inquiry that don't really amount too much as disciplines at all – for instance, those disciplines that are weakly formed in the sense of being diffuse in their concerns, unsure of their object and (in other words) not disciplinary enough.

For example, Osborne fears for sociology because it would neither (or no longer) have a distinctive research methodology (the survey has been adopted in all kinds of domains, such as marketing) nor its own research object.

The League of European Research Universities (*LERU*, 2016) also sees no contradiction between discipline and interdisciplinarity, but rather complementarity:

_____ disciplines should remain a central element of the academic system, as they have an unrivalled power to structure and understand the world. However, as the constant tensioning of ideas is central to the creation of knowledge, collaboration between disciplines is a way of questioning the potential, limits, and margin of progression of the disciplines. Because knowledge produced by the disciplines needs to be tensioned against each other, interdisciplinarity is not against the disciplines but a driver of progress in the creation of knowledge.

5.2 The Organization of Interdisciplinarity through Team Science

Science is performed and published by teams. An analysis of millions of papers and patents over a number of decades shows that in many fields of science, not only in the technical sciences but also in the social sciences and humanities, teams outnumber individual authors (*LERU* 2017, p. 11, reference to Wuchty, Jones & Uzzi, 2007). Interesting is the rise and existence of the science of team science, in which scientific study is conducted into the functioning of scientific teams (see Stokols et al., 2008; Hall et al., 2008). For interdisciplinary research, it is even more the case that this is done or should be done in teams (Fiore, 2008).

_____ interdisciplinary research is team research, that is, research conducted by a team – it is team science because it is infeasible to conduct interdisciplinary research independently. Although throughout history there have been a small number of truly erudite scholars whose breadth and depth of understanding was so vast that they could be considered independent interdisciplinary researchers (e.g., the classic example is Leonardo da Vinci), today, given the complexity and quantity of knowledge within individual disciplines, no one person is capable of maintaining the deep understanding necessary to conduct truly interdisciplinary research (Fiore 2018, p. 272).

In interdisciplinary teams, consideration should be given to the greater complexity that working in such teams can bring compared to homogeneous teams. The first named teams are more open and often created by an external organization or person who will not always operate predictably. It is not always certain that the team members speak the same language, and there is also a greater risk of status conflicts around prestigious individuals or disciplines. It is recommended in the literature that, in order to be successful, these teams should not be made too large, so as not to fall back on the smallest common denominator and that they should include scientific staff with a permanent position *(*tenure). Time and seed money, preparatory work on conceptual models, traditions, and literature are essential as well as sufficient space and shared facilities, liaisons with the organizations in the outside world involved, and an internal management structure in matrix form, highly placed within the university, plus systems and routines for accountability, information gathering, monitoring, and dissemination. Team and project leaders must be able to stimulate interaction and communication and create team building (*LERU*, 2016, p. 14).

There must be means to give departments a form of "disciplinary compensation" for unexpected costs and expenses. The reality is, however, that there are no widely accepted criteria for evaluating the success of this type of collaboration projects and that the applicable disciplinary standards are often inadequate, especially with regard to the

impact of the results outside the academic context but also for peer review (Klein, 1990, pp. 126–135).

The literature even shows that there is an "interdisciplinary individual", a personality who could be recruited, in large numbers if desired, by universities when further investing in interdisciplinary research and education. This person is reliable, flexible, patient, resilient, sensitive to others, risk-minded, has a thick skin, and a preference for diversity and new social roles. Another commentator mentions a high ego strength, a tolerance for ambiguity, entrepreneurial, assertive, a broad education, and a sense of dissatisfaction with monodisciplinary limitations. Divergent thinkers are more interested in interdisciplinary research than convergent thinkers are, and "analog thinkers" are better able to do integrative work than "digital thinkers," who think too narrowly to deal with cross-sectional issues (Klein, 1990, pp. 182–183).

According to Klein (1990, pp. 188–189), there is no blueprint for the integrative process of interdisciplinary research, but the following steps are important:

1 a. defining the problem (question, topic, issue);
 b. determining all knowledge needs, including the appropriate disciplinary representatives and advisors, as well as relevant models, traditions, and litera-ture;
2 a. specifying particular studies to be undertaken;
 b. engaging in "role negotiation" in teamwork;
 c. gathering all knowledge and new information;
 d. resolving disciplinary conflicts by working towards a common vocabulary (and focusing on reciprocal learning in the teamwork);
 e. building and maintaining communication through integrative techniques;
3 a. collocating all contributions and evaluating adequacy, relevancy, and adaptability;
 b. integrating the individual pieces to determine a pattern of mutual relatedness and relevancy;
 c. confirming or disconfirming the proposed solution (answer); and
 d. deciding about future management or disposition of the task/project/patient/ curriculum.

5.3 Further Recommendations for Interdisciplinarity in Research

For information and inspiration, we provide a brief summary below, certainly not exhaustive, of further recommendations made in the literature to stimulate interdisciplinarity in research (mainly based on the reports of the *KNAW*, The Young Academy, *KVAB* Young Academy, and *LERU*, which are very useful in this context):

With regard to the university researchers involved

- "Theorize" and study interdisciplinarity, including the extensive literature on it and your own practical experiences.

- Develop interdisciplinary competences during your career.

- Organize colloquia and seminars with colleagues from other disciplines in order to discuss classical and/or high-profile research together.

- Invite fellow researchers from other research groups to your own congresses, symposia, or workshops.

With regard to the relevant university administrators

- Establish interdisciplinarity as the core business of the institution, profile the institution as a place where interdisciplinary research (and education) is valued and, as leadership, allocate time and resources to the most promising scientific areas, which may vary from one institution to another.

- Make an inventory of what you already have regarding interdisciplinary research.

- Set up incentive awards for promising and original interdisciplinary research.

- As a university, facilitate and stimulate career paths for interdisciplinary researchers in recruitment and broader HR policy. In the cycles of result and development interviews, systematically discuss the development of scientists both within and outside their own specialism.

- In the training of PhD candidates, encourage more risk-taking, and initiate interdisciplinary PhD projects amongst Schools and Departments. This should also be a possibility for tenure tracks.

- Look for researchers who have the potential to lead interdisciplinary teams, and supervise and support these researchers.

- Create visiting scholarships or visiting professorships for scientists who want to acquaint themselves with knowledge outside their own field of expertise, the same for travel grants.

- Stimulate interdisciplinary and transdisciplinary research together with knowledge institutions and/or companies from outside. Look at the innovation potential and the added value that can be achieved with it in both economic and social terms. For the institutional design of this, the exact sciences already have facilities such as Science Parks and campuses, but also the potential of research in the fields of arts and humanities and social and behavioral sciences is considerable and can be realized through social venturing.

- Ensure adequate evaluation mechanisms and criteria for interdisciplinary research, and take into account that this research needs more time including start-up time.

5.4 Further Recommendations for Interdisciplinarity in Education

For interdisciplinarity in education, the following recommendations can be derived from the literature (particularly from the sources mentioned in the previous section):

With regard to the lecturers involved

- Deepening and strengthening interdisciplinarity can only be achieved on the basis of collaboration and genuine curiosity; it is best to start with a small team for the sake of cohesion.

- More often take a closer look at the education of colleagues from other disciplines.

- In interdisciplinary courses, determine whether the students have sufficient capacities to function properly in the course, and whether they have the right expectations.

- In practical terms, start with an appealing and relevant theme, in which various disciplines have a share. Every discipline involved must be able to come into its

own and interdisciplinarity must not immediately be focused on too heavily and too much.

- Ensure that there is a coordinator who is responsible for the interdisciplinary course.

- As involved lecturers, jointly determine the exit qualifications for an interdisciplinary course-these should not be defined per discipline. Organize a summer or winter school to make it easier and faster to start and do try-outs outside the regular program.

- Together with the students, monitor the coherence in study programs and learning paths and keep an eye on career and labor market perspectives (of course within and outside science).

- Bring students into contact with models and examples of interdisciplinarity from research conducted on campus.

- Take note of the good introductory books that are now available to introduce students (and researchers and lecturers) to interdisciplinary working and studying (Menken & Keestra, 2016; Repko, Szostak & Buchberger, 2017).

With regard to university administrators

- Include the importance of interdisciplinary education and propagate it in the vision or mission of the university, and then make it concrete, for example, in the form of interdisciplinary minors.

- Set up a committee for interdisciplinary education that develops a strategy.

- Facilitate lecturers to lecture across Schools and make agreements about the deployment of lecturers from the various Schools and Departments.

- Ensure that it is easy and attractive for Master's students and PhD candidates to develop and carry out interdisciplinary research.

- Provide means to lecturers who are committed to interdisciplinary education, and support, also financially, existing or new networks, platforms, or centers.

- Maintain a good balance between the availability and contribution of interdisciplinary initiatives and existing disciplines.

6. Brief Outlook: How Do We Work in Tilburg?

Interest in interdisciplinary collaboration has fluctuated over the last century. Occasionally there was a lot of attention, sometimes less. In recent years, this interest has definitely increased, also in the Netherlands and Belgium. This is certainly also due to the fact that science and societal challenges are rightly becoming more closely interlinked. There is an interest in, also by Tilburg University, working on generating social impact in co-creation with social parties. For example, the Impact program has set up a PhD program in collaboration with the Schools, in which collaboration amongst Schools is paramount.

Of interest is the 'Policy Plan for Interdisciplinarity: look beyond your own corridor' (2018), launched by the KU Leuven earlier this year, which creates space for larger-scale interdisciplinary research institutes (such as the Leuven Cancer Institute and Leuven Brain Institute), for an Institute for Advanced Study, and for interschool lecturers and PhD candidates. One of the objectives of the new Policy Plan is to generate a greater impact in the longer term.

As science and scientists are expected to contribute to solutions for complex, multifaceted wicked problems through knowledge and research, the discussion about joining forces arises. After all, no discipline can offer a theoretical viewpoint covering the issues sufficiently and an optimal methodology. Collaboration between disciplines is crucial here. Consolidated repositories are needed with validated insights into well-defined wicked problems. This requires new working methods and associated grant instruments to stimulate interdisciplinary projects. And that should contribute to the creation of new ecosystems in which ex ante and ex post transfer of knowledge are arranged.

The same applies to education. If the aim is to educate students in such a way that they can make a meaningful contribution to social issues after graduation, then the university must ensure that the right baggage is provided. Education and research should be more integrated so that students can learn about interdisciplinarity at an early stage and participate in these types of projects. The title of the Tilburg Strategy 2018–2021 "Connecting to Advance Society" is deliberately chosen. The Strategy also refers to the honors program as follows: "In our honors program, students work on 'wicked problems' in interdisciplinary teams, developing their professional skills and engaging with society." We can extend this to all courses. And interdisciplinarity links up seamlessly with the new Tilburg Education Profile, which aims to develop students' knowledge, skills, and character (de Regt & van Lenning, 2017).

In the field of education, KU Leuven has, for a number of years, been offering PiP educational projects (Product Innovation Project) coordinated by the Leuven Community for Innovation driven Entrepreneurship (Lcie). PiP is a full-fledged course unit where an interdisciplinary team of students, during a full academic year, under the supervision of their lecturers, come up with joint solutions for a project that is provided by a project sponsor (a company, a local authority, an association) (Lcie, 2018). At Tilburg University, Prof. Vermeulen recently introduced a "Coding for lawyers" course in the International Business Law Master's program. The course is designed to teach students how to think in a digital age and aims at giving them the capacities to navigate a world in which computer code is embedded in every aspect of economic and social life. According to Prof. Vermeulen, such course on "multi-disciplinary coding" can help us in solving many contemporary economic, environmental and social issues.

For the above reasons, we believe it is time for interdisciplinarity, as the title of this essay indicates. In our opinion, however, this does not mean that disciplines will become a thing of the past. What we have called an interdisciplinarity paradox in this essay applies. Without strong disciplines, interdisciplinarity cannot develop and prove successful.

There are rather strong images of interdisciplinarity: science is captured by the "outside," by political administrators or powerful companies or, at another extreme, it is the sanctifying solution to all problems that transcends the silo mentality of outdated disciplines. These kinds of images are not correct and do not make sense. The literature regularly mentions that disciplines are not the same as departments ("departments are not disciplines"). This means that the departmental structure does not necessarily have to be demolished to promote interdisciplinarity. However, and that is the philosophy of the School of Management of the English Bradford University, with which this essay started, more can and should be directed towards "open, flexible boundaries" and "shifts from structure to cooperation," so that "higher education will spring into new life."

Time for interdisciplinarity does have a second essential dimension and meaning, namely, that the design, organization, and outcome of interdisciplinary research and education need time. Our scientists must be given more time and take more time to work on this. Writing this essay has made it clear that this can be done pre-eminently by means of team science, in collaboration across the boundaries of departments, institutes, and Schools and on the basis of our scientific competences, with an associated system of appreciation and reward. The same applies to lecturers. More can be done to facilitate and experiment with regard to offering minors, but also new interdisciplinary courses that offer the best of several disciplines in a balanced way and are, therefore, attractive and relevant to (more) students. This requires inspiring and connecting leadership in the workplace.

Interdisciplinarity is thus a learning process, but, for that learning, time and resources are needed. It also helps, of course, as the literature makes clear, if we as a university declare that interdisciplinarity is an important means for us (not an end in itself), and decide on which themes, and we design HR policy in such a way that interdisciplinary activities are stimulated and valued, also in terms of career prospects.

The Young Academy (2015, p. 14) states that interdisciplinary work involves a transformation to a 'new scientific identity'. That sounds exciting and attractive, but we do not know yet what this new identity entails. We will have to experience this as we go along.

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Prof. Emile Aarts has been Rector Magnificus of Tilburg University since June 1, 2015, and within this position he is responsible for education policy and research and impact funding. He studied mathematics and physics at Radboud University and obtained his PhD at the University of Groningen in 1983. From 1983 to 2012, he worked at Philips Research in various research and management positions. In 2012, he left Philips to pursue his academic career as Dean of the Department of Mathematics and Computer Science of the Eindhoven University of Technology until his appointment at Tilburg University.

He was involved in the launch of the innovation concept Ambient Intelligence (1997) and the founder of the Philips ExperienceLab (1998), the Intelligent Lighting Institute (2008), and the Data Science Center Eindhoven (2013). In 2014, he co-founded the Jehronimus Academy of Data Science (JADS) in which Tilburg University and the Eindhoven University of Technology, together with the city of Den Bosch and the province of North Brabant, are promoting the creation of a center of expertise in the field of Data Science with international allure. In all these initiatives, interdisciplinarity played an important role, and he was guided by the insight that the combination of technical and people-oriented disciplines is necessary to achieve socially relevant innovations.

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Colophon

A TILBURG UNIVERSITY ESSAY ON INTERDISCIPLINARITY

TILBURG ◆ UNIVERSITY