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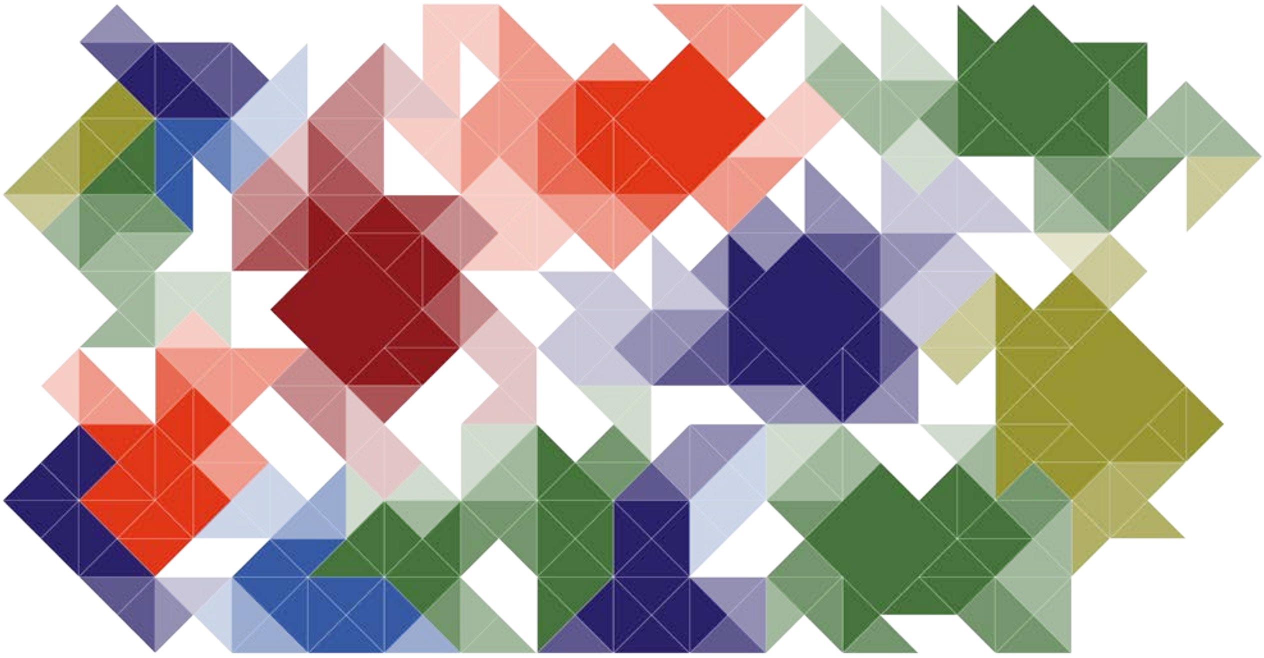
The Theory of Interdisciplinarity: An Introduction for Educators



Publications from Interdisciplinary Education at UCPH

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The Theory of Interdisciplinarity: An Introduction for Educators

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The aim of interdisciplinary practice is generally to solve interdisciplinary problems. An important aim for interdisciplinary teaching is therefore to prepare students for the practice of solving interdisciplinary problems. When considering course contents and methods for teaching and evaluation in interdisciplinary courses, it is therefore valuable to have some understanding of what characterizes an interdisciplinary problem, and what it means to solve one, as this is one of the main teaching objectives. In this paper I aim to provide this basic understanding. I start out by introducing the concept of an interdisciplinary problem as a problem where the solution is constrained by standards of quality and relevance from multiple disciplines. I further discuss the concept of a discipline as a community of researchers sharing a technical jargon and standards of relevance and quality. I then introduce the concept of an integrated solution to an interdisciplinary problem as a solution that is acceptable according to all relevant standards of relevance and quality. I argue that a partial aim of interdisciplinary teaching is to aid the students overcome the linguistic differences across disciplines and to prepare them for the methodological and philosophical issues that arise in interdisciplinary problem solving due to differing standards of quality and relevance. In this respect interdisciplinary courses share an aim with the philosophy of science courses that are mandatory at Danish universities, and I encourage teachers to cultivate this underexploited potential for cross-fertilization.

"Interdisciplinary Education at the University of Copenhagen" is a three year project (2014-2016) within the UCPH 2016-programme.

Details about the project can be found at the website http://www.ind.ku.dk/interdisciplinarity.

The project focuses on strengthening interdisciplinary teaching and education at UCPH. The project pinpoints the challenges and opportunities in interdisciplinary teaching as seen from the perspective of both educators, students and the organisation. To boost the interdisciplinary teaching and education, didactic tools, courses, and consultancy services will be developed throughout the project.

The material relevant for publication developed as part of the project – reports, course design, literature reviews, articles etc. - will be published in this series.

The series is edited by Jens Dolin and Christine Holm,
Department of Science Education, University of Copenhagen

Publications from Interdisciplinary Education at UCPH
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The Theory of Interdisciplinarity: An Introduction for Educators

Mads Goddiksen[1]

1 Introduction

Why do we engage in interdisciplinary teaching? An important motivation for many is the realization that some of the most interesting and pressing problems addressed by researchers today, including fighting climate change, understanding the workings of the mind and feeding the world's growing population, cannot be solved within just one discipline. Their solution requires some form of multi-, inter-, trans- or even postdisciplinary collaboration. To keep things simple[2], I call these problems that for some reason *require* collaboration across disciplines in order to be fully solved, *interdisciplinary problems*. Thus, interdisciplinary teaching aims at least partly to prepare students for working on, and perhaps even solving, interdisciplinary problems. The teaching of interdisciplinary problem solving opens special challenges compared to standard disciplinary teaching with respect to deciding what the students should be taught, how teaching should be carried out, and how the students' learning should be evaluated (Dolin forthcoming). Many of these challenges are due to the rigidity in the organization of major institutions like universities (Dolin forthcoming). Others are of a more methodological, even philosophical, nature and arise due to the special kind of problems addressed in interdisciplinary problem solving. It is these challenges that are the topic of this paper.

I start by spelling out the idea of an interdisciplinary problem as a problem where the solution is constrained by the standards of multiple disciplines (section 2). The idea is then elaborated through a more detailed discussion of what a "discipline" is (section 3). I then introduce the idea of an *integrated* solution to an interdisciplinary problem as a solution that is acceptable according to all relevant standards of quality and relevance (section 4). Finally, I consider some implications of the theory for teaching practice (section 5)[3].

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[2] For a discussion of the different kinds of crossdisciplinary research see (Lindvig & Ulriksen 2015; Klein 2010).
[3] The brief discussion below is largely a condensed version of the more elaborate discussion and literature review in (Goddiksen 2014).

2 Interdisciplinary and disciplinary problems

In order to get a more elaborate understanding of the characteristics of interdisciplinary problems and their solutions, I first consider problems and their solutions more generally (section 2.1), before contrasting disciplinary problems (section 2.2.) with interdisciplinary problems (section 2.3).

2.1 Problems and their solutions

When researchers work on a problem, they often, but not necessarily, formulate the problem as a research question that they seek to answer. But before a researcher attempts to solve a problem, she will first assess whether or not the problem is worth the effort – i.e. she will assess whether the problem is sufficiently interesting or relevant. Relevance is judged on a number of factors, that we can collectively call *standards of relevance*. These include the prospect of making any progress when working on the problem, which again depends on the methods mastered by the researcher and her collaborators. Relevance further depends on factors like the problem's relation to other problems that are deemed relevant, and whether the problem is in keeping with the background knowledge and assumptions held by the researcher. Methods mastered, background knowledge, and basic assumptions can all differ depending on which discipline the researcher has been trained within (see section 3). Thus researchers from different disciplines can have different standards of relevance.

Once a problem has passed the relevance test, it is time to begin solving the problem. But what does it mean to solve a relevant problem? It bars on the trivial to say that solving a problem means finding a good solution to the problem. But this answer is not entirely trivial; for what does it mean for a solution to be "good"? To some extent this depends on what kind of problem we are considering, but common suggestions would be that the solution should be internally consistent, in "agreement" with any available reliable data and accepted theory and other constraints that we might have imposed on the solution (e.g. budget constraints). Furthermore the solution should perhaps also have some further "virtues" like simplicity, generality, or even beauty[4]. Among the "further constraints" that we can impose on a solution to a problem, we should also count that the solution should be in agreement with the researchers' basic assumptions about the world, including assumptions about the kinds of interactions that can take place in the world, and the kinds of things that can take part in these interactions. In short, we have certain *standards of quality* that we use to assess whether or not a

[4] Some would argue that there is one further very relevant quality to look for in a solution to a research problem: truth. This may be so, but unfortunately we cannot judge truth directly, but must look for indicators of truth such as agreement with data and theory, simplicity etc. (see e.g. (Lipton 2004))

potential solution to a problem is "good", and we deem a problem solved if we find a potential solution that is acceptable according to these standards[5]. As with the standards of relevance, standards of quality can differ somewhat depending on which disciplines researchers are brought up in (as discussed further in section 3).

2.2 Disciplinary problems

Problems in general can be divided into a number of different kinds. The literature on interdisciplinarity frequently mentions interdisciplinary problems as a special kind of problem. To better understand what characterizes interdisciplinary problems, it is instructive to first consider what a *disciplinary* problem is.

Disciplinary problems are exemplified by the type of problems that the influential historian and philosopher of science Thomas Kuhn (1996/[1962]; 1977) called *puzzles*. Puzzles have the following characteristics:

1. They arise because researchers from a specific discipline have accepted certain theories.
2. They are deemed solvable through the kinds of methods used within the discipline.
3. Their potential solutions are judged only according to the standards of the researchers from that specific discipline.

Consider a historical example. In the early decades of the 20th century physicists adopted a new theory: Quantum Mechanics. With the new theory physicists were able to solve, or simply remove, a series of puzzles that had haunted classical mechanics. But quantum mechanics also created new puzzles. One of them was whether magnetic monopoles exist?

In school, we have all learned that when you break a magnet - with its north and south pole - into two, you do not get a north pole and a south pole (two monopoles). Rather, you get two magnets each with a north- and a south pole. To the best of our empirical knowledge this picture continues no matter how many times you break the magnet. In short: To the best of our empirical knowledge magnetic monopoles do not exist. However, when physicists looked deep into quantum mechanics they found that the theory actually allows for the existence of magnetic monopoles in the form of a new kind of elementary particle (which would be analogous to the electric monopoles – e.g. the electron and the positron). This theoretical result created a new puzzle for physicists: Was the reason why they had

[5] Of course, finding and acceptable solution need not imply that we stop working on the problem, as we might expect to find an even better one.

not detected a magnetic monopole that they do not exist, or was it that they had not yet been clever enough to catch one?

The monopole problem illustrates how puzzles arise within a certain discipline because a new theory becomes accepted. Furthermore, physicists had a pretty clear idea about what general empirical methods to apply to solve the problem.

In order to solve the monopole problem, physicists needed to find a solution that was acceptable according to their own standards of quality. To this end they needed help from non-physicists, particularly engineers, to build the sophisticated detectors needed to catch the monopole. This makes the problem appear interdisciplinary. However, the engineers that helped build the instruments had little influence on the standards for when a monopole had been detected. These were defined by physicists and physicists only and in this sense, the monopole problem was still a disciplinary problem[6].

2.3 Interdisciplinary problems

Now contrast the monopole problem with the problem of what to do about the obesity "epidemic" (WHO 1999) that we have witnessed in many parts of the world over the last few decades. This is a prime example of an interdisciplinary problem[7]. This problem has not arisen from a certain theory, and more interestingly: No one discipline can decide when a good solution to the general problem has been found.

The general problem may be broken down into a long list of sub-problems including: What is the role of genetics in developing obesity? How is society affecting our eating and exercise habits? Which diseases can be causally related to obesity? Should obesity be considered a disease in itself? Some of these sub-problems are intertwined in the sense that the solution to one affects the solution of others, and thus the individual sub-problems cannot be considered in isolation. This is a central characteristic of a *complex problem*.

[6] One could of course count all problems that require some form of input from other disciplines as interdisciplinary, but as argued in (Goddiksen 2014), this definition is not desirable partly because the class of disciplinary problems would then become very small, particularly in empirical research were mathematics and engineering very often provide vital input.

[7] In 2013, Copenhagen University launched a major interdisciplinary project on *Governing Obesity*. The project web-site contains, among many other things, a video discussing the interdisciplinary nature of the obesity problem (http://go.ku.dk/about/challenge_of_obesity/ [visited Dec. 2016]).

Solving the individual sub-problems may be outsourced to specific disciplines. For instance, we might initially leave it to sociologists to investigate the ways in which society affects our eating and exercising habits. However, the sociologists will not be the only ones who have a say in deciding when a good solution to their sub-problem has been found, because their solution is both affected by, and affects the solution to problems that do not immediately fall under their own field of expertise. Thus, when the solutions to the individual sub-problems are combined into a solution to the overall problem, at least some of the solutions to the sub-problems as well as the overall solution will have to be evaluated from the perspective of multiple disciplines. This distinguishes the problem of dealing with the obesity epidemic from the monopole problem in an important way, and I would argue that this is what makes it an interdisciplinary problem (for details see (Goddiksen 2014)).

To summarize, interdisciplinary problems have the following characteristics:

1. They are complex problems, in the sense that at least some sub-problems are intertwined.
2. The solution to the overall problem as well as some sub-problems cannot be evaluated solely according to the standards of one discipline.

Now, if all disciplines had identical standards of quality and relevance, there would be no difference between disciplinary and interdisciplinary problems (arguably some disciplinary problems are also complex in the sense defined above (Goddiksen 2014)), and the special challenges related to interdisciplinary teaching would be exclusively institutional. However, as a matter of fact, university teachers report that the special challenges related to interdisciplinary teaching are not exclusively institutional (e.g. (DeZure 2010; Repko 2008; Lélé & Norgaard 2005; NAS 2004; Bradbeer 1999)). University teachers report that students in interdisciplinary courses face challenges relating to differing disciplinary languages and differing disciplinary standards for relevance and quality, partly because it forces them to consider, and to some extent justify, their own standards. Environmental scientists Clark and Wallace formulate the challenge thus:

> Many students find it difficult to confront their own epistemology, cognitive status, disciplinary prejudices, and conventional notions about policy processes […]. It is, in fact, possibly the most difficult part of learning interdisciplinarity (Clark & Wallace 2010, p. 178)

How do we help the students overcome this challenge? A partial answer can be found in the review of the literature on interdisciplinary teaching in higher education by Spelt and colleagues (2009). Here it is argued that "[e]xplicit attention to […] disciplinary and scientific differences appears to be a typical condition for enabling the development of interdisciplinary thinking" (p. 367).

It seems, then, that one way in which we can help the students in an interdisciplinary course engage in interdisciplinary problem solving is by more explicitly discussing the notion of disciplines and the differences between the disciplines involved in the specific interdisciplinary course. To do so, we need at clearer understanding of what a discipline is.

3 Disciplines and research communities

In this section I characterize disciplines as communities of researchers that to a significant extent share a technical jargon and standards for relevance and quality. Before proceeding to elaborate this positive characterization, I will mention two related misconceptions of disciplines; namely a) that they are defined as the study of a specific set of phenomena or problems and b) that they are static.

3.1 Misconceptions about disciplines

Biology is often considered a discipline. What makes biology a discipline? Aristotle, by many considered the founder of biology, had an answer: Biology is a discipline because all biologists study the same kind of things: living things. A similar argument could be presented for all other fields named X-ology, Y-ography or Z-ometry. On this view disciplines are defined according to the phenomena they are studying. Although widespread, this view has significant shortcomings. Consider again biology. Yes, many biologists study living things, but so do medical doctors and sociologists (among others). Furthermore, many (molecular) biologists spend much of their career studying non-living parts of living organisms. So, the definition of biology as the study of living things is both too narrow and too permissive. Furthermore, it seems difficult to identify the specific kinds of phenomena studied by disciplines like physics or philosophy. Rather, it seems that we can study anything (including living things) from a physics or philosophy perspective. One could counter this criticism by saying that it is not the things "out there" that define the disciplines, but the *questions* being asked about them. On this view, biology is concerned with biological questions (or problems), sociology with sociological questions and so on. This view captures the fact that different disciplines may well study the same kind of thing, but ask different questions about it, which is one reason why interdisciplinary research can be so fruitful. Unfortunately, the attempt to define biology as the study of biological questions is not very useful, unless we can define what a biological question is. Defining biological questions as questions about living things will not work, for obvious reasons. Nor can we, on this view, define a biological question as the kind of question asked by biologists; that would get us caught in a vicious circle. The better alternative seems to be to keep the intuition, that there are problems that somehow "belong" to certain disciplines, partly because the methods currently used within this discipline are well suited to work on these problems, but reject the idea that these problems *define* the discipline.

As the methods and theories of disciplines change, the set of problems that "belong" to a certain disciplines also changes. Consider the problem of the age of the Earth (discussed in (Kragh 2004)). Initially, this problem was investigated by theologians using the records of the descendants of Adam in the Old Testament. Later, the problem came to be considered as belonging to the natural sciences. But which one? In the late 1800s, Lord Kelvin, the famous physicist, presented a new solution to the problem that was very different from the theological solution. The solution was contested, not by physicists, but by biologists and geologists who in order for evolutionary theory to be plausible needed the Earth to be significantly older than the 20 to 40 million years that Lord Kelvin had found. In the following years physicists and palaeontologists debated who should have authority on this matter. Eventually authority was claimed by physicists, when their methods of dating through radioactive decay became recognized as the most reliable.

Problems thus drift in and out of different disciplines. Some arise as disciplinary problems within one discipline and drift into another (Thorén & Persson 2013), others turn into interdisciplinary problems[8]. This historical perspective is useful to keep in mind when faced with the common objection to interdisciplinary problem solving that the problem being considered is not an X-ological problem. This objection could discourage some from entering into a potentially very fruitful interdisciplinary collaboration, but it could also prevent those who actually engage in interdisciplinary problem solving from getting publications and jobs because their peers find that they are not doing "proper" X-ology[9].

[8] One could argue that the monopole problem started out as a classic disciplinary problem but has since, turned into something resembling an interdisciplinary problem (for an illuminating discussion see (Kragh 1981)).
[9] For more on the common objections to interdisciplinarity see (Schäfke forthcoming)

3.2 Research communities

Let us now turn to the more positive characterization of disciplines. To this end it is again useful to look to the works of Thomas Kuhn. Kuhn described research disciplines as research *communities* (Kuhn 1996/[1962]). Research communities are groups of researchers that read and cite each other's publications, meet at conferences, are members of roughly the same professional societies and have gone through "similar educations and professional initiations" (1996, p. 177). Kuhn *claimed* that the members of these communities share important values and metaphysical assumptions and accept the same core theory; what he collectively called a *paradigm*. Kuhn further implied that different communities can have different paradigms and that the paradigm of one community can change over time (through what Kuhn called scientific revolutions). Through historical research Kuhn argued extensively for the claim that the paradigm of a research community can change over time, but he left it to others to investigate whether 1) all scientific communities in fact share a paradigm (as defined by Kuhn) and if so 2) to what extent the paradigms of coexisting communities are in fact different. A number of researchers within science studies, particularly sociologists of science, took up the challenge.

The picture that has emerged forty years later is a lot messier than the simple picture painted by Kuhn (for a review see e.g. (Morris & van der Veer Martens 2008))[10]. Kuhn pictured disciplines as separate silos: researchers are members of one well-defined community each, and are primarily collaborating with other members of that community to work on disciplinary problems. The picture painted by modern sociology of science and bibliometrics is one where some researchers are members of several communities at the same time and where there in some cases is plentiful collaboration across blurred disciplinary borders. The blurring of disciplinary borders also means that what is identified as a research community depends on how strictly one interprets the definition of a community. If one is very strict and requires that members of the same research community e.g. meet *regularly* at conferences, then one finds that research communities are rather small, perhaps less than a hundred people. This is of course very different from the huge, loosely connected community that we call psychology, where the members, at best, have some basic education in common.

Whether members of a scientific community in fact share a paradigm has also been subject to much debate. If we take Kuhn's original characterization of a paradigm as a set of laws (of nature), values

[10] For an elaborate analysis of the consequences this new messy picture has for our understanding of science in general see (Andersen 2016).

and metaphysical assumptions and core examples that embody these values and assumptions (what Kuhn called exemplars), it is quite clear that not all communities share a paradigm, simply because laws, in Kuhn's sense of the term, do not play a significant role outside physics and perhaps parts of chemistry. However, in their review Morris and van der Veer Martens concluded that it is possible to identify a number of what they call research specialties whose members

> "tend to work on a related set of problems, adopt a common paradigm, publish in the same set of journals, use a common technical jargon, attend the same technical conferences and cite the same set of core references in their papers" (Morris & van der Veer Martens 2008, p. 239),

if we by "paradigm" mean "validation standards", i.e. standards used to assess the quality of a solution to a problem, what I called standards of quality. Of course the extent to which the members "tend to" share a technical jargon and standards of relevance and quality depends on how strictly one has been reading the criteria for counting specific researchers as members of a given research specialty. Thus if we are very strict, we might only be able to identify a relatively small community of researchers who call themselves "experimental developmental psychologists", and find that they to a very high extent "tend to" share technical jargon and standards of relevance and quality. If we loosen the criteria for inclusion, we might find that the community is a lot bigger and call it "psychology", but find some variance in technical jargon and standards for relevance and quality. But chances are that the members of this community will have more in common with each other in terms of standards for relevance and quality, than they have with the members of the community identified as "sociology".

Although, sociologists may tend to share standards of relevance and quality with each other to a higher extend than they do with psychologists, there might still be so much diversity within the community of sociologists that we find it misleading to say they constitute *one* discipline. Some scholars have thus noted that the members of some of the "disciplines" (identified e.g. by having separate departments at universities) within the social and human sciences have almost nothing in common, and argue that these disciplines actually contain several distinct paradigms (see e.g. (Ritzer 1975)). While this does not falsify the central claim that research specialties are relatively homogeneous with regards to standards of quality and relevance, it should lead us to reflect on whether it is always useful to make general comparisons between the large communities that we normally call disciplines. Sometimes it is probably more useful to compare smaller communities, that some would call research fields or sub-disciplines[11]. Especially, the immense diversity, particularly within the social and human sciences, should discourage us from considering these “faculties” as vast communities with similar standards. The distinction between the faculties rather seems to be based on the problematic idea that disciplines are defined by the phenomena they study.

Summing up, a discipline can be characterized as a community of researchers who share a technical jargon, and criteria for relevance and quality (or at least share it to a significantly higher extent than other groups of similar size). The extensive literature on the challenges related to interdisciplinary problem solving bears witness to the fact that there can be significant, but not necessarily insurmountable, differences not only in technical jargon, but also in criteria for relevance and quality across communities[12]. The differences surface as disagreements about what sub-problems are the most relevant to consider, what methods should be used to investigate these problems (e.g. whether they should be quantitative or qualitative) and what counts as an acceptable result from these methods.

4 Solving interdisciplinary problems

4.1 Integration

We now have a characterization of what an interdisciplinary problem is, and know what the special challenges related to solving these problems are. I now consider a final concept commonly used in relation to interdisciplinary problem solving: *integration*. Interdisciplinary problem solving is commonly claimed to aim for integrated solutions to interdisciplinary problems. Exactly what integration means is often unclear, and the term is used in several different meanings in the literature. The two most common ways of talking about integration is integration as *integration of disciplines* and integration as *integration of cognitive resources*, where “cognitive resources” refers to the various theoretical resources available to researchers, e.g. theories, results, models, methods etc. Of the two, integration of cognitive resources seems to be the most basic.

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[11] Another benefit of this is that it makes it possible to talk about interdisciplinary research within the same general discipline, for instance across multiple sub-disciplines of biology (Bechtel 1986).

[12] Kuhn famously argued that paradigms are at least to some extent *incommensurable*, and that debates across paradigms therefore cannot be entirely based on rational arguments, as this would require reference to a common standard of rationality - a paradigm of paradigms (Kuhn 1996/[1962]). Kuhn said little about the consequences of this incommensurability for the possibility for interdisciplinary problem solving, but one interpretation of his general theory would be that the difficulty of interdisciplinary problem solving depends partly on the degree to which the paradigms involved are incommensurable.

In his textbook on interdisciplinary research Repko (2008) discusses a number of cases of successful interdisciplinary projects that have achieved some kind and degree of integration. One is the famous collaboration between James Watson, a trained biologist, and Francis Crick, a trained physicist, on the solution of the structure of DNA. Watson and Crick's discovery of the double helical structure of DNA is an important event in the history of the formation of modern molecular biology, but can also be appreciated simply as a prime example of successful interdisciplinary problem solving.

The problem of the structure of DNA arose as a sub-problem to the more general problem of explaining biological inheritance. However, some of the cognitive resources used by Watson and Crick and the experimental methods used by Rosalind Franklin to solve the problem were developed within physics and chemistry. Other problems arising within biology have been attempted solved using cognitive resources from other sciences. Not all of these attempts have been successful (yet). For instance there is currently some debate surrounding various attempts to explain the development of evolutionary innovations like the vertebrate jaw or avian flight that standard evolutionary theory has trouble explaining (Love 2008) by combining dynamical systems theory – a cognitive resource originating from physics and engineering – with evolutionary theory (Green et al. 2015). As Green and collaborators (2015) argue, these attempts have not yet been successful, partly because the kind of explanations that can be constructed using dynamical systems theory are not considered good and relevant explanations by evolutionary biologists. It is thus not trivial, that an acceptable solution to a problem originating within one discipline can be based on cognitive resources from other disciplines, even if it is another natural science, but Watson, Crick and Franklin managed to find such a solution, and this seems to be (at least a very important part of) what we mean when we say that an integrated solution to a problem has been found.

The work of Watson, Crick and Franklin further contributed to the formation of a new discipline: molecular biology. In this sense the work not only integrated cognitive resources from different disciplines, it also helped form a new discipline by integrating existing ones. Had the integration of cognitive resources not been successful, the integration of disciplines might not have taken place at that time. On the other hand there are plenty of examples of successful integration of cognitive resources that did not lead to the formation of a new discipline (some of which are found in (Repko 2008)). In this sense, integration of cognitive resources can be thought of as a prerequisite for integration of disciplines, and most individual interdisciplinary courses will primarily aim to teach integration of cognitive resources[13].

4.2 Achieving integration of cognitive resources

As with all problems, finding an integrated solution to an interdisciplinary problem can require significant creativity and skill. In addition, it can require learning parts of the technical jargon of another discipline. Practitioners report that this can be a significant challenge related to interdisciplinary teaching (Borrego & Newswander 2010), although, as we have seen, it is not unique interdisciplinary problem solving. But compared to disciplinary problems interdisciplinary problems pose the further challenge that the solution must somehow bridge the differences in standards of quality and relevance found among the disciplines involved. Knowing what these differences are seems to be a great help to the researcher trying to bridge them, although it will certainly not be sufficient.

Practicing researchers engaging in interdisciplinary research can learn about differences in standards of relevance and quality across the disciplines involved in their project by taking time to discuss them openly and explicitly (Öberg 2009). Recently *The Toolbox Project* (Eigenbrode et al. 2007; O'Rourke & Crowley 2013) even developed dedicated workshops based on research in science studies for researchers working on interdisciplinary projects. Here collaborating researchers get an opportunity to improve their collaboration by engaging in open discussions about quality, relevance and expectations. Similar initiatives could be transferred to interdisciplinary teaching, so that students get a chance to learn some basics of the theory of disciplines and encouragement to reflect on the differences in language and standards among the disciplines relevant to the specific course[14].

5 Should all interdisciplinary courses then have a philosophy of science element?

Introducing the theory of disciplines and spending time encouraging students to reflect on the differences in language and standards among relevant disciplines means taking away precious time from other topics that are of equal importance. Given that students are not generally very enthusiastic about discussing such abstract theories, teachers involved in interdisciplinary courses might be

[13] In some cases it is the other way around: integration of disciplines can be a prerequisite for integration of specific cognitive resources. This happens if the standards of quality differ so much across specific disciplines that integration of cognitive resources cannot take place before a change in standards has taken place (see (Goddiksen 2014) for further discussion).

[14] The game CoNavigator developed by Lindvig and colleagues (forthcoming) would be highly relevant in this context.

reluctant to introduce such an element. Fortunately for educators at Danish universities, many students have already spent time discussing these topics, although they might not remember it very well.

Almost all study programs at Danish universities include a course on the philosophy of the relevant discipline[15]. Among the aims of these courses is to give the students a wider perspective on the discipline they are being introduced into. There is significant thematic overlap among these philosophy of science courses, and very many include the topic of science as a social institution consisting of differing disciplines.

The challenge for the teacher in an interdisciplinary course therefore might not so much be to teach students about the theory of interdisciplinarity from scratch, but to investigate what the students already know about this, elaborate where necessary, and relate it to the concrete topic of the course. How best to do this is beyond the scope of this paper, but inspiration can be found among the results of the Interdisciplinary Education project (particularly (Dolin forthcoming; Lindvig forthcoming; Okholm forthcoming)).

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[15] In Danish these courses are known as "fagets videnskabsteori"

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