Nordidactica – Journal of Humanities and Social Science Education
Transfer and Cohesion in Interdisciplinary Education
Søren Harnow Klausen
Nordidactica 2014:1
ISSN 2000-9879
The online version of this paper can be found at: www.kau.se/nordidactica

Nordidactica
- Journal of Humanities and Social Science Education

2014:1

NORDIDACTICA – JOURNAL OF HUMANITIES AND SOCIAL SCIENCE EDUCATION
ISSN 2000-9879
2014:1 1-20

Transfer and Cohesion in Interdisciplinary Education

Søren Harnow Klausen

University of Southern Denmark Odense, Department for the Study of Culture

Abstract: One of the great challenges of interdisciplinary education is to create sufficient cohesion between disciplines. It is suggested that cohesion depends on the transfer of knowledge (in a broad sense, which includes skill and competences) among the disciplines involved. Some of the most characteristic types of such transfer are identified and analyzed: Transfer of factual knowledge, theories, methods, models, skills, modes of collaboration and organization, meta-competences, disciplinary self-consciousness, problem selection, framework construction and motivation. Though some of these types of transfer may have a greater or smaller potential for creating cohesion, different kinds of cohesion may serve different interests, and there is no reason to assume that e.g. joint problem solving or theoretical integration should be more conducive to cohesion than e.g. contributions to motivation or disciplinary self-consciousness.

KEYWORDS: INTERDISCIPLINARY EDUCATION, TRANSFER, COHESION BETWEEN DISCIPLINES, FORMS OF KNOWLEDGE, LEARNING OBJECTIVES

About the author: Søren Harnow Klausen is Professor in Philosophy at the Department for the Study of Culture (Institut for Kulturvidenskaber), Syddansk Universitet Odense. His research area proceeds from philosophy (especially epistemology) and pedagogics with a special interest in interdisciplinary education.

Interdisciplinary collaboration brings together different people, backgrounds, disciplines, knowledge, methods, task or goals. Whatever else it is supposed to do, it connects elements that would otherwise have remained unconnected. And while some of the less ambitious forms of interdisciplinary collaboration – notably those which are often called "multidisciplinary" – do not affect the disciplines as such, in most cases disciplines are not merely placed and set to work alongside each other. Collaboration is a form of interaction, and when this goes beyond the mere coordination of tasks, it means that there is a real interplay between disciplines. Something – knowledge, methods, habits, standards, assumptions or definitions – is *transferred* from one discipline to another. It seems plausible that such transfer is crucial for the establishment of a real unity, or a significant degree of *cohesion*, between the disciplines involved. Since one of the most pervasive problems with interdisciplinarity, not least with interdisciplinary education, is how to achieve a real and significant unity among the disciplines and other elements involved – as opposed to a mere artificial agglomeration, e.g. "interdisciplinarity just for its own sake" – it seems worthwhile to look more closely at this phenomenon.

There has been relatively little focus on transfer in the literature on interdisciplinarity (including the literature on interdisciplinary education).[1] While this might seem surprising, and surely needs correction, it is in fact quite understandable. That knowledge and skills are transferred in interdisciplinary encounters may seem like a very abstract and almost trivial point, making it natural to move on to other and apparently less obvious aspects of interdisciplinary collaboration. More importantly, the predominant focus in the literature has been on the social conditions and social manifestations of interdisciplinarity. Building on the important insight that interdisciplinary collaboration is a social practice, and that its success or failure depends on a range of social factors, researchers have been less occupied with what could be called the content of the interdisciplinary transactions, or even with these transactions as such, as opposed to their background conditions.[2]

In the following, I shall make an attempt to go more deeply into the specific kinds of interplay, exchange, transfer, connection and cohesion that characterize specific forms of interdisciplinarity, and the establishment of which is the goal of various types of interdisciplinary collaboration. What circulates between the different disciplines and their practitioners? What is the fundamental "currency" of interdisciplinarity? What is the "glue" that binds different disciplines more or less strongly together?

---

[1] This is not to say that there has not been much focus on transfer (especially of skills) in educational research more generally. For example, the question of transfer of skills to contexts outside an "academic" field of study has received considerable attention (see e.g. Bridges 1993 and Chada 2006).

[2] Notable examples include Weingart & Stehr 2000; Lattuca 2001; Frodemann 2010. Wilson 2010 may at first seem to be an exception, with its apparently systematic focus on knowledge, but Wilson's systems theory approach still gives priority to structural aspects, and he seems especially keen to recommend, or argue for the irrelevance, of particular learning contents.

1. Domains and disciplines

Before moving on, let me address a likely initial objection: It might be argued that the very notion of transfer presupposes the existence of discrete domains (cf. Bridges 1993). And it is doubtful that there are such discrete domains; at least, it is doubtful that disciplines (or school subjects) are sufficiently discrete for the idea of transfer to carry any real weight. A domain is, like a discipline, an idealized construction. It might be said that disciplinary boundaries have "always already" been transgressed; that interaction and intermingling precedes and makes possible what later comes to be known as discrete domains. (I have myself argued for the view that interdisciplinarity is not, contrary to what is often assumed, based on monodisciplinarity; from both a historical and systematic point of view, transdisciplinarity is the mother of all disciplinary specialization (Klausen 2011).

I will in fact not only concede, but actively emphasize that knowledge, skills and methods are distributed widely across disciplines and school subjects. Especially when subjects are taken to represent the state of the art of a corresponding scientific discipline, say religious studies or biology, they are likely to encompass a variety of elements that are also associated with other disciplines or subjects (e.g. sociology, history, statistics, or chemistry). Moreover, inasmuch as the content and aims of a school subject comprise more than mere subject-specific knowledge – and this is very often the case, as specific learning activities often aims at furthering more general competences, like the ability to carry out empirical testing in general, critical examination of sources, presenting knowledge in a systematic and accessible manner etc. – it is also present in many of the neighboring subjects and so do not, apparently, have to exported to them.

Does this mean that the very idea of transfer is misguided or irrelevant? No. The term "transfer" also applies to cases where a discipline causes the practitioner (or learner) of another discipline to become aware of knowledge, skills or understandings that are already present in her own discipline (e.g. in her own practice, in a tacit, pre-reflective way, or in other parts of the discipline). What is transferred in such cases is a more explicit knowledge or consciousness of the elements of the "home" discipline.

Secondly, even though borders between disciplines are vague and unstable, and much is distributed across these borders long before the issue of collaboration is raised, it cannot be denied that any single moment, some knowledge, some skills and some understandings will be present to a larger extent, and more manifest, in some disciplines rather than others. Quantitative methods are applied widely across the whole range of disciplines, including the social sciences and humanities, and so it may be wrong to conceive of the qualitative/quantitative-distinction as marking out an essential difference between disciplines (Klausen 2005, 147f.). Still, it can hardly be denied that the discipline of mathematics puts more weight on, and contains more comprehensive and refined methods for, approaching problems in a quantitative manner, than most other disciplines. And it can hardly be denied that historians are occupied almost full-time with retrieving information from sources and reconstructing and interpreting the past, whereas this is at most a part time job for the social scientist

or biologist – and so on. This is more than enough for transfer to be both possible and significant. The disciplines may already always contain germs of what is usually associated with other disciplines; but more deliberate and systematic interaction, including the exchange of "amateurish" practices for more professional ones, can make the learning activities in question both deeper and more well-founded.

A different, though related objection is that there is more to interdisciplinary interaction than "transfer" or "borrowing". Often something new emerges which was not to be found in any of the disciplines involved before the interaction took place. This is of course correct. But such "co-creation", as it might be called, must still depend on distinctive contributions from one or both (or all) of the disciplines involved (though not necessarily contributions of something that is "typical" of, or "belong to", the disciplines in question), hence some kind of transfer has to take place. It would be quite wrong to view interdisciplinary interaction as a simple *transportation* of items from one disciplinary context to another. Nevertheless, it involves an exchange of items that are crucial to the formation of whatever joint, or "emergent", effects that the interaction might also have.

2. Forms and aims of interdisciplinary education

Interdisciplinary education serves many different purposes. It prepares students for further study and work in interdisciplinary contexts. But it also equips them with more general skills and competences which they will arguably need for living a good life in the future knowledge society. It thus serves both *learning for life* and *learning for further education.*

Moreover, while interdisciplinary education can be assumed to further students' abilities for cooperation, divergent thinking and the like, it may also be instrumental to educational goals that are not themselves related to interdisciplinarity. For example, interdisciplinary education may enhance students' motivation to learn something that is normally considered discipline-specific and part of the traditional curriculum, like grammar or mathematical statistics. It may do so by making more obvious the applicability and real-world relevance of such knowledge, or simply by providing a more varied and appealing setting for the learning to take place. Though the distinction is not clear-cut, we can thus distinguish interdisciplinarity as a *learning context* and interdisciplinarity as an *educational objective.* (Of course, interdisciplinarity as such is seldom an explicit educational objective, but there is a widespread assumption that working across disciplines can help foster "generic interdisciplinary skills" that can be of use in the supposedly complex future life- and learning-contexts, like differentiating, synthesizing, reconciling, translating etc.).

A further notable distinction is between *personal* and *interpersonal* interdisciplinarity. In educational contexts, interdisciplinarity may be established by teachers from different disciplines making different, discipline-specific contributions (i.e. by interpersonal collaboration), but it can also consist in a single teacher bringing in elements from other disciplines (what I refer to as personal interdisciplinarity).

Project-based learning is often based on interpersonal collaboration. However, the general trend towards interdisciplinarity has engendered a need for interdisciplinarity beyond the context of specific projects, and this might require the individual teacher to take it account elements from other disciplines and make them reflected in her own teaching. (In Danish Higher Secondary education, this has proven especially important in the specialized branches of study (*studieretninger*), which are expected to be given a particular "toning", i.e. a pervasive, common character, so that the overall orientation of the branch (say, physics and chemistry or social sciences) can be felt in the everyday learning activities. This clearly requires personal interdisciplinarity).

Perhaps most importantly, there are different forms and grades of interdisciplinarity, and the differences in degree and/or kind might correspond to certain forms and kinds of transfer. It is fairly common to distinguish between something like the following four levels (Klausen 2011; similar, though not quite identical taxonomies have been proposed by Jantsch (1972), Lattuca (2001, 79f.) and Klein (2010)).

a) *Instrumental interdisciplinarity*, i.e. cases where the problem addressed belongs clearly to one discipline, but where methods or results from other disciplines are used to solve clearly delineated sub-problems. Common examples are the use of statistics in the social sciences or the use of chemical synthesis in biology and pharmaceutics.

b) *Multidisciplinarity*, i.e. cases where two or more disciplines contribute jointly to the treatment of a topic, in a parallel manner, without interfering substantially with each other. Many allegedly trans- or crossdisciplinary projects – on e.g. topics like aging, the body, music or the like – exemplify this kind of (limited) interdisciplinarity, as the disciplines (or teachers) address different aspects of the topic and arrive at complementary results. The collaboration in question often consists mostly in coordinating the activities. However, since students can be expected to gain at least an implicit understanding of what distinguishes the different approaches involved, their learning outcome will often exceed the disciplinary confines. If this is made explicit by the teachers, multidisciplinarity might turn into a more advanced and genuine form of interdisciplinarity.

c) *Interdisciplinarity* proper (also called "*crossdisciplinarity*"), i.e. cases where more than one discipline is needed to address a problem adequately. Interdisciplinarity proper creates an *added epistemic value* (i.e. a surplus of knowledge, skills or understanding, compared to what could have been achieved by working in parallel). Still, it is characteristic of this form of interdisciplinarity that each contribution to the solution of the problem is made by a specific discipline and conforms to its usual standards.

Disciplines are combined, but not merged or integrated, though the result of their joint efforts is an integrated learning outcome.

d) *Transdisciplinary* research, i.e. cases where approaches or methods from two or more disciplines are merged together, resulting in a kind of teaching and learning that transcends the norms and standards of each discipline. Examples from the science include gender studies or cognitive science. Transdisciplinarity may appear extreme or subversive and thus way beyond what can be achieved – or allowed! – in ordinary school contexts. Yet in reality, transdisciplinarity is fairly widespread. It is an almost inevitable bi-product of almost all other forms of interdisciplinary work, which does not leave the practitioners or their disciplines unaffected (see also the remark about "emergence" or "co-creation" at the end of the last section). The need for joint grading of interdisciplinary papers has shown to lead to the emergence – after initial phases of trying to merely aggregate teachers' individual assessments – of new standards which cannot be traced back to any single discipline, as the "synthetic" or "holistic" qualities of a paper has to be taken into account alongside with the more discipline-specific.[3]

3. The currency of interdisciplinary transactions

Given the highly diverse aims and forms of interdisciplinary collaboration, it appears unlikely that we can find a single substantial factor, which is transferred in all cases of successful interaction. Be while it must indeed be assumed that widely different things are exchanged in interdisciplinary encounters (even in one and the same interdisciplinary encounter) – and part of my aim is precisely to identify different objects of exchange and draw further distinctions based on this recognition – it might still be possible to at least *conceive* of interdisciplinary transfer in a uniform way, provided that we can find a sufficiently general notion. This accords with the idea of a "currency" as a *medium of exchange*, which is more general than the concrete items that are actually exchanged (in the case of money all sorts of commodities, including ontologically diverse items like services, rights, entertainments or recipes).

I suggest that we take *knowledge* to be the fundamental currency of interdisciplinarity. If I am right in this (and I have some caveats myself, as will emerge), we can gauge (albeit hardly measure, since it is probably not quantifiable) the degree of interdisciplinary interaction by the degree to which knowledge is transferred – not just how much knowledge is transferred, but also how important or deep or significant knowledge is transferred. I shall make no attempt in this paper at

[3] This is explicitly required of the grading of interdisciplinary project work in Danish upper secondary education.

further clarifying these notions (quantity, depth and significance of knowledge), but simply assume that we do regularly distinguish between more or less significant knowledge, according to varying criteria, and that our judgments do tend to converge in many concrete cases.

My choice of knowledge as the fundamental notion is likely to prompt an objection: it might be said to represent an "intellectualist" prejudice and downplay the practical dimension of interdisciplinary interaction. But such an objection is misguided. It is in fact itself an example of intellectualism, since it assumes knowledge to be intellectual rather than practical. When taken in its most inclusive sense – and several influential strands of theorizing have sought to widen it for more than half a century (with Ryle and Polanyi as pioneers; see Klausen 2010) – the notion of knowledge comprises much more than intellectual acts or assets. Knowledge is not just "knowledge-that", propositional or declarative knowledge. It can also take the form of knowing how, procedural and tacit knowledge (there are subtle, yet significant differences between all those categories – e.g. not all knowing how is tacit, and vice versa – but this matters less for my present purposes). And it includes knowing how things look or taste (which is arguably not "knowing how" in the ordinary, practical sense of knowing how to *do* something).

It is not, of course, that everything is knowledge. Far from it: There are strict and relatively precise conditions for knowledge. While the traditional tripartite analysis of propositional knowledge as justified, true belief must be generalized in order to apply to other forms of knowledge as well, something like the following seem to be necessary (and perhaps also jointly sufficient) conditions for knowledge of any kind: It must involve some kind of (perhaps implicit or bodily) *representation*; the representation or manifestation of the knowledge must be *adequate* (true or correct in the case of knowing-that; adequate for the task in question, i.e. "living up to it", in the case of knowing-how), and it must be sufficiently *qualified* (e.g. reliable or warranted or justified; the intuitive idea is that for one to really *know*, one' representation or action must be based on a process or principle that ensures that it is not just accidentally successful).

Even though these criteria are quite demanding and specific (there is much that fails to meet them!), knowledge thus understood is a fairly wide notion, which *comprises skills and competences as well*. The term is widely applicable not because there are a large number of more or less uniform instances of knowledge, but because the notion it expresses is sufficiently abstract and general to cover quite diverse phenomena. Still, it is wrong to distinguish sharply between knowledge, skills and competences, as is often done in education and labour market policy contexts. In fact almost every ability can be described in terms of knowledge.

According to a prominent contemporary theory of knowledge, knowledge is itself a competence (Hetherington 2011). I am sympathetic to this view. But while it may imply that any instance of knowledge is, in principle, reducible to a certain (often highly complex) competence or ability, it does not give us reason to dispense with the notion of knowledge or prefer to speak about competences or abilities instead. Knowledge talk and competence talk are interchangeable; the same class of

phenomena can be described in both vocabularies, and knowledge attributions can be rephrased as competence attributions – and vice versa. Talk about knowledge is not (in fact, often far from) trivial. But since every instance of something being done in a sufficiently competent manner may be described as a manifestation of knowledge (e.g. knowing how to cheat, knowing how to impress other people, knowing how to cook Sauce Hollandaise etc.), the notion does apply much more widely than is usually acknowledged. Conversely, all instances of knowing something can be described as having a certain set of competences; this also holds for knowing *that p*, which arguably amounts to being able to appreciate, report on or reason about *p* or *p*-related aspects of the world (Hetherington 2011, 22).

Notice that not every instance of *successfully doing* something counts as an instance of knowing on this account. If it is due to pure luck or magic, or if the ability and/or its basis is completely intransparent to the agent, we will neither say that the agent has knowledge *nor* that she is doing what she does *competently*. Consider for example a case of miraculously getting down a dangerous ski slope or landing a lucky punch when completely overmatched.

It is no real challenge to my view that other philosophers have argued that knowing-how is really just a form of knowing that (e.g. Stanley 2012). This is just another example of the mutual interchangeability of the knowledge- and competence-vocabularies. If Peter knows how to knit, we might also say that he knows that Φ is a way to knit. This does not, however, make his knowledge any less "practical" or more "theoretical", since he does not need any explicit conception of knitting, nor can he have the knowledge in question if he is not able to knit (it has been alleged that know how can be present in the absence of an actual ability to carry out the action in question – say, if Peter is a historian or cultural scholar with a large, but impractical knowledge of ways of knitting. But this is a different, weaker (non-ability-entailing) sense of "knowing how").

But if knowledge and competence are more or less equivalent notions, why then opt for knowledge as the currency of interdisciplinary collaboration? It is, to a certain extent, an arbitrary choice. I might as well have couched my observations in terms of competences or abilities instead. But in the present context, the notion of knowledge seems to me the most apt, because it has certain connotations, or at least tends to highlight certain aspects, which are less strongly marked out by the alternative notions (even though they do cover them as well). By speaking of knowledge, one emphasizes the *qualification* and *representation* aspects: Knowing something requires one to have an appropriate *basis* for it and to be somehow aware of what one knows.

There may be examples of completely practical and almost instinctive interdisciplinary collaboration: People getting together completely unreflectively and interacting in a discipline-involving and/or discipline-affecting way, without any awareness or explication the disciplinary or interdisciplinary aspects of what they are doing. Yet this is surely extremely rare, perhaps merely a theoretical possibility. And in educational contexts, especially in formal school contexts, it is hardly relevant at all. Disciplines and school subjects are emphatically conceived of as *domains of knowledge.* Teachers and educational researchers may have an – understandable –

tendency to exaggerate the importance of the formal knowledge base and formal qualifications (for example by arguing that innovation requires substantial amounts of discipline-specific knowledge, which is actually doubtful). Still, it seems highly reasonable to insist that learning in school is, to a large extent, a matter or acquiring abilities that have an appropriate basis and are in some sense *qualifications.* This holds even for the large field of important abilities and traits that are not normally conceived as "cognitive".

The use of knowledge as an overarching notion should not mask the fact that widely different items are transferred in interdisciplinary interaction. Still less should it be taken to indicate that interdisciplinarity serves mainly "intellectual" or "academic" purposes. It simply provides a fitting and handy conceptual tool, which enables us to approach a blooming and otherwise intractable field in a principled, systematic manner.

I must concede, however, that even the very general and flexible notion of knowledge has to be stretched somewhat in order to make it cover all the positive effects that are brought about by interdisciplinary interaction. For example, interdisciplinarity may contribute to creating a certain social or cultural atmosphere and/or impact on students' wellbeing. Now it is indeed possible to describe this as a case where students get to know how to do (and feel) well. Nor is it completely pointless to do so, since the improvement in wellbeing must, if it deserves to be counted among the positive effects of interdisciplinary interaction, follow from the formation of some relatively stable disposition, and can thus be seen as the manifestation of a grounded ability. (Arguably, knowing how to do and be well is a very important kind of knowledge!). Still, it does admittedly sound strange, some might even say artificial or contrived. But apart from this, knowledge does seem to be the best candidate for an overarching notion.

Some may be sceptical of the very notion of a "currency" of interdisciplinary transactions. It may help to alleviate at least some of their worries to point out that the notion, as employed here, carry no economic connotations whatsoever. It probably does not even allow of quantitative measurement. Moreover, it does not imply that interdisciplinary activities are mere "transactions" in the sense of passing on some unit of value. It is intended to cover all positive changes in the competence level of (all of) those involved, including the fostering of competences none of the parties possessed beforehand.

4. Items of interdisciplinary exchange

Having settled for knowledge as the currency of interdisciplinary transactions, I now turn to the question of the different kinds of knowledge which might be exchanged or transferred. Though my main focus is education, in many cases research collaboration provide a good illustration. Due to the nascent state of many types of interdisciplinary education, we often have to turn to research collaboration for examples and inspiration. It might be objected that school subjects do not correspond

neatly to scientific disciplines. This is true, but does not render the analogy invalid. It should be borne in mind that I working with a liberal and flexible notion of a discipline (see section 1), which allows for a discipline to comprise of heterogeneous elements. And scientific disciplines are no less mongrel than are school subjects. School subjects like English or social studies comprise diverse elements like linguistics and literature or sociology and economics, but the same goes for scientific disciplines like biology or religious studies.

We can discern at least the following items of interdisciplinary exchange (I do not pretend the list to be exhaustive):

i. *Data and factual knowledge:* A discipline may borrow a set of data from another discipline. Cognitive psychology can draw on the results of brain-scanning. In a similar vein, a discipline may borrow some more or less "brute", factual knowledge. For example, historical knowledge of weather and climate conditions at certain times may feed into work on climate change, without any other aspect of the discipline (like the methods used for acquiring the knowledge, its degree of certainty, the further context etc.) being taken into account. Because of the theory-ladenness of observation and most knowledge of particular state of affairs, data-transfer often implies some transfer of theoretical elements as well, at least in the form of implicit assumptions.

ii. *Theories*: A discipline may borrow a theory (a statement of a general relationship between phenomena, i.e. a law, or a set of interrelated propositions that can be use to explain a phenomenon) from another discipline. For example, astronomers have made use of a variety of optical laws (that many of these laws were also discovered by astronomers, or even in the context of astronomical investigations, is a significant point that relates to the issue of discrete domains, cf. section 1). In a school context, the use of statistical laws in social sciences or history may be a typical example. It is, however, difficult to distinguish precisely between the use of a theory as such and the use of a (related) *method* or *model* (see below); the latter may be much more common in educational contexts, where statistical procedures or tests are used, but often without mention of their theoretical basis. The use of physical theories like thermodynamics to describe chemical processes are probably more common though also restricted to more advanced and specialized levels of education.
However, theories in the more loose and general sense are used in many different ways and contexts. Thus, sociological theories about general trends in society can be used to explain or analyse particular social phenomena. For example, theories about "late modernity" as characterized by fragmentation and reflexivity can be – and are actually – used to analyse literary works or historical events (for more about different notions and uses of theory and its role in learning contexts, see Klausen 2013b).

It is not part of my notion of a theory that it needs to be *explanatory* in any deep sense. Theories are regularly used for more or less superficial descriptions. But surely the use of a theory to explain phenomena described by another discipline is a prime example of cohesion-enhancing transfer (this includes the many cases of *partial* explanations). For example, theories of nuclear physics provide an important partial explanation of the atomic bomb destruction of Hiroshima and Nagasaki, even though it has to be supplemented with historical explanations as well. The creation of such joint explanations can be a forceful way of creating disciplinary cohesion.

iii. *Methods*: A discipline may borrow a method (i.e. a systematic procedure) from another discipline. Use of statistics or exponential functions in the social sciences or history may also be conceived as an import of a (mathematical) theory. Whether it should be described as the one or the other depends on the degree to which the theory is thematized as such, and the degree to which a particular use of the theory for a concrete purpose is also borrowed.

Sometimes, there is no precedence for applying or using the theory in question in the target domain, i.e. in the borrowing discipline. In that case, in can only be the theory that is borrowed, since the operationalizing must be done by those working in the target domain. Sometimes, however, there is a more or less established tradition making it possible to adopt the specific ways of applying the theory and less important to adopt the theory as such.

The use of linear regression to analyse data in the social sciences may be a clear instance of the use of a method. Less obvious, but no less important cases include the use of a "hermeneutic circle" for interpreting data in the natural sciences. This method has not been borrowed from the humanities, but developed independently within the natural sciences themselves. Still, an increased awareness of this methodological similarity can strengthen the ties between the natural sciences and the humanities, and so it can still be considered an item of transfer in the liberal sense for which I have advocated (see also vi) below).

iv. *Models:* A discipline may borrow a model from another discipline. This is a very widespread and important form of interdisciplinary cross-fertilization (Klausen 2013a; Klausen 2014). Often models are not used as such (as models in the narrow, technical sense), but function rather as symbolic catalysts for new conceptualizations of a field (i. e. like metaphors or pictures; examples of this may include the transfer of structuralism from linguistics to various kinds of cultural studies, or the generalization of psychological notions of repression and compensation to other domains.

Models are not easily distinguished from theories, especially when considered in their actual use. According to the received view, models are more concrete (or refer to more concrete events than theories and thus function as a bridge between theory and reality (Faye 2000, 151f.). Thus, a model of climate change may represent one of many theoretically possible sequences of events, making possible more precise predictions (and testing) than the more abstract theories behind the model. Evolutionary biology may be viewed as a theory (more or less equivalent to the "neo-Darwinian synthesis"). But it can also function as model, albeit in a somewhat different sense: It can function as a general paradigm, a pattern of thought that might be applied to different domains. For example, economy or creativity may be described in evolutionary terms. In these cases, the model is not more, but rather less concrete and specific than the theory: It abstracts from the biological content of evolutionary theory in order to get to its "core" or general principle, which might then be transferred to other domains that the biological. In this vein Nersessian has described the process of creating new scientific concepts, as exemplified by Maxwell's development of the theory of the electromagnetic field, as involving "abstraction via generic modeling", i.e. abstracting from a specific mechanism to the form of the general *kind* of mechanism under study (2008, 52ff.; cf. also Nersessian 2002). This can be a viable strategy, because constraints in an established theoretical framework (e.g. Newtonian mechanics) may not all correspond to the constraints in the target domain (e.g. electrodynamic systems).

This highlights another important characteristic of interdisciplinary interaction. Arthur Koestler (1964) famously described the creative process – in both science and the arts – as involving a connection of otherwise disconnected matrices. And he added that the recombination process seldom takes the form of a simple borrowing and application of theories (or methods or models, we might add). More often, both the source and the target domain are modified in the process to make possible an efficient combination. As Koestler remarked, when two conceptions are successfully combined, both acquire "a new look in the process" (1964, 233). This is clearly exemplified by Maxwells' use of mechanics to understand electricity and magnetism, a laborious process in which mutual adjustments were made along the way (Nersessian 2008).

Hence it is not only the case that the domains interacting in interdisciplinary collaboration are vague, transient and overlapping. The items that are transferred seldom have any very stable identity themselves. Thus "transfer" is often "re-creation" (and the transfer is often perceived as involving some kind of misunderstanding on part of the practitioners of the borrowing discipline). This holds for the exchange of all sorts of items, i.e. different forms and formats of knowledge. But it is probably more typical of models. There is an expectation that at theory will have to retain most of

its defining or central characteristics, whereas a model is understood as more flexible in its use and subject to fewer specific constraints. (As I pointed out above, evolutionary theory may be said to function as a model rather than a theory in certain kinds of interdisciplinary interaction, precisely because only parts of its theoretical content is retained).

v. *Skills.* A discipline may borrow a skill or set of skills from another discipline. Because of the interchangeability of skill and knowledge terminology noted above, it is difficult to distinguish the exchange or importing of skills from transactions involving other items. Importing a method involves transfer of the skill of using it (though the need for adapting it may mean that the skills needed cannot be borrowed completely from the source domain, but have to be developed by the borrowing discipline). But it is possible to make a rough distinction by using the term "method" to denote a systematic, step-by-step-procedure, which can more or less adequately expressed in a verbal instruction or recipe (ideally, by something like an algorithm). A skill in the narrow sense is, by contrast, a habitually grounded ability that represents a more tacit form of knowledge (that is, an *ability-entailing* but not *completely verbally expressible* knowing ho*w*). It follows from this that skills are less easily transferred than methods, since they cannot be taught by mere instruction (i.e. through linguistic communication), but require learning by doing. Yet interdisciplinary collaboration may sometimes provide a context for such learning, for example if students learn skills of presentation in an arts and humanities context, which they can later apply to topics in the natural sciences.

vi. *Modes of collaboration or organisation:* A discipline may borrow a certain mode of collaboration or organisation from another discipline. Again, this could be conceived as the acquisition of a certain skill: Learning to be able to collaborate in a certain way. Yet it seems natural to reserve the expression "skills" to abilities of individual agents (and perhaps also to abilities with a more or less local focus, abilities "embedded" in a close and contiguous environment). So-called "social skills" may constitute a borderline case, but are still conceived as characteristics of an individual. In contrast, disciplinary interaction may lead the practitioners of one discipline to adopt a certain *collective* mode of organization, or to the formation of a new form of organization not previously found in any of the disciplines involved. (For example, roundtable discussions may be imported from English to Maths, and joint discussions of course goal and content in the context of limited project work may engender long-term collaboration between teachers).

vii. *Meta-competences:* Interdisciplinary education is commonly thought to be conducive to the acquisition of various meta-competences. While some of these might border on skills in the narrow sense (cf. iv)), e.g. being able to structure a paper or a presentation, being able to collect and interpret empirical data etc., some are so general that they are better seen as a distinctive item of exchange. For example, interdisciplinary encounters may foster a general ability to reflect on tasks, goals and methods, or an ability to engage with people with different backgrounds, perhaps a very general "intellectual flexibility" or open-mindedness.

viii. *Disciplinary self-consciousness:* Interdisciplinary encounters often prompt those involved to reflect more deeply or clearly on the nature of their own discipline. This includes both what is distinctive and what is perhaps less distinctive, i.e. aspects of one's discipline which turn out to be more common than initially expected. For example, teachers from the humanities and the natural sciences may come to view their own discipline differently by learning that e.g. chemists interpret their data according to the same general principles which guide standard literary interpretation (Jensen 2003; for more on the similarities between the "hermeneutic circle" and the use of "hypothetical-deductive" reasoning in the natural sciences, see Klausen 2005, 153f.).

Disciplinary self-consciousness covers both the strength and weaknesses of a discipline (or of specific theories, methods or approaches usually associated with the discipline). Thus use of quantitative methods in the humanities and social sciences may lead to a better appreciation of their explanatory potential, but also an understanding of their limitations or difficulties with respect to their real-world application. Exponential functions may show their worth when used to analyse historical events like the spread of the Black Death during the Middle Ages. But application to actual events, as reported by historical sources, may also bring out the limitations of formal models of epidemics, since they will never capture all relevant factors; diseases, like populations, do not grow perfectly exponential.

Sometimes the self-consciousness induced by interdisciplinary interaction takes the form of a general *memento*, a reminder of some general condition or constraint. It can be a heightened awareness of the complexity of a subject matter, or an understanding of the relevance of aesthetic or ethical concerns besides scientific or technological ones (or vice versa). As mentioned earlier, interdisciplinary interaction can also lead to disciplinary "self-finding", calling attention to knowledge or skills inherent to the discipline but not hitherto recognized.

The disciplinary self-consciousness prompted by interdisciplinary encounters can also take a less idealistic or appropriate form. Interdisciplinarity can trigger anxiety and defence mechanisms, making

teachers insist on the special importance or authority of their discipline. This is of course not a form of knowledge exchange or creation, knowledge being per definition positive and appropriate, but it deserves mention nonetheless.

ix. *Problem selection and attention-directing:* A discipline may help to identify and formulate a scientific problem which is then mainly addressed by another discipline. It may help to direct the attention of the other discipline's practitioners to a certain aspect of reality, to certain theoretical and methodological challenges or new combinations of themes and approaches. This is a very important, but often overlooked form of interaction. Studies of consumer or user behaviour, needs and demands may articulate the demand for certain technological solutions (or even raise deep scientific problems, if current technology is inadequate and incremental innovation will not do). Cryptology has obviously benefitted from mathematics, but it has also inspired mathematical work in e.g. number theory, and can be said to have partly determined the paths and goals of certain branches of mathematical research. Gender studies and colonial and post-colonial history have prompted literary scholars to read works of fiction from new perspectives. The rise of genetics has lead to work on problems in ethics that would otherwise hardly have been contemplated at all.

The importance of this kind of interaction becomes particularly obvious when one realizes that a discipline has no special authority when it comes to determining its priorities and general objectives (see also Kitcher 2003). Scientists or teachers might be able to formulate list of problems currently considered the most important ones in their discipline (though consensus will often be hard to come about!). But such a list will be overly conservative, tending to focus on extensions of existing research and pointing to fields in which the potential for real breakthroughs is probably limited. (This is not to say that "internal", discipline-specific considerations are not *partially* relevant and maybe indispensable for setting the priorities and choosing the right subjects; it is just that they are seldom sufficient. External influences are often needed to achieve the right balance between different dimensions of importance and relevance). Exactly the same goes for school subjects: The math teacher may be superior at teaching math, but not necessarily equally good at singling out the most important or useful mathematical knowledge. Teachers of other subjects hardly know any better, but interdisciplinary interaction may lead to decisions that reflect a variety of relevant perspectives and effect a reasonable compromise between novelty and feasibility.

x. *Complementation through joint framework construction and understanding-formation.* As noted earlier, interdisciplinary interaction is

not always – and not merely – about literarily "borrowing" from other disciplines. Sometimes, e.g. in multidisciplinary settings, disciplines come together and create a common learning context without directly influencing one another. Project work on the body may cause the students to form a complex conception of the body as being both a natural and a cultural entity. The disciplines might be said to *complement* each other, adding specific perspectives on a topic and thus jointly contributing to constructing a more comprehensive framework. In practice, it is highly likely that there will also be some prompting of disciplinary self-consciousness, which is why pure multidisciplinarity is very rare, if at all possible.

Educational contexts may differ somewhat from scientific contexts in this respect. Since education does not, in itself, aim at solving particular problems, but only does so instrumentally (in order to achieve certain learning goals), there does not have to be such a problem at all. It might be enough to achieve a comprehensive *understanding* of a field or topic. This is not to deny that a common problem and a common solution may often help to further integration and have other benefits. It is just that there is no guarantee that these effects will be achieved, and that the construction of a common framework around different activities might create just as much cohesion (albeit of a different sort) than a joint use of methods and assumptions. If instrumental interdisciplinarity (which otherwise has a strong potential for creating cohesion) is *not* accompanied by a joint framework construction or other "reflective" activities – if distinct contributions are simply given in a linear fashion, it might actually achieve *less* in terms of *perceived* cohesion.

xi. *Motivation:* Interdisciplinary interaction is often sought in order to, and may actually help to, enhance students' motivation for learning. This can raise new doubts about the appropriateness of both the transfer and the knowledge terminology. Motivation, so it might be thought, is not borrowed from another discipline, and it hardly constitutes a form of knowledge. But motivation is arguably brought about *by* acquiring a certain knowledge – e.g. knowing how to use statistics, knowing that it can be used for this or that, knowing that climate change or global welfare is a complex and interesting problem etc. Moreover, the relevant kind of motivation will often have to be knowledge-related, e.g. a motivation to seek more knowledge (stimulating students' *curiosity* is often seen an important goal). Besides, in some cases, motivation *can* be said to be transferred or exchanged, as less popular or less obviously relevant disciplines may literally borrow engagement or fascination from other, more popular ones by working together.

There is evidence from creativity research that "internal" motivation – i.e. students being driven by an interest in, or enjoyment of, the task at hand

itself – has a more positive effect than mere "external" motivation caused by rewards, threats, competition and the like (Amabile 1996; cf. also Csikszentmihalyis theory of "flow", total absorption in an activity, which is a supposedly optimal state with respect to both students' well-being and their learning achievements). Inasmuch as interdisciplinary education can give students a stronger sense of the intrinsic significance of learning contents, it can thus be expected to foster a more fruitful kind of motivation and facilitate both their learning in general and the development of their creative potential. (Of course there is also a danger that interdisciplinary education instrumentalizes certain learning contents or makes students' encounters with them too brief to give them a sense of their intrinsic significance).

5. Connection and cohesion

The different items of interdisciplinary exchange and interaction are interesting not least because they are, presumably, crucial to the cohesion between disciplines – and cohesion is a much-desired goal or aspect of interdisciplinary activities. I have already suggested that we might gauge the degree of cohesion and integration between disciplines by seeing what – and how much – is transferred between them. How plausible is that proposal, now that we have taken a closer look at the different items of exchange?

It is clear that any such estimation will remain rather vague and subjective. A multitude of factors are involved, some of which cannot always be distinguished clearly from one another, and the specific interests of those doing the estimations will almost inevitably influence their selection and weighting. But interest-relativity is no serious problem – indeed, it is not only what we should expect, but what we should want, since interdisciplinary interaction have different aims and goals and should be assessed accordingly (though the assessment should also take into account the possible side-effects, positive as well as negative). And compared to the present state of things, where interdisciplinary interaction is treated almost as a magical "black box", which supposedly produces all sorts of good effects in unknown proportions through unknown means, an analysis in terms of transfer of (relatively) specific forms of knowledge (including abilities) can hardly fail to provide a more accurate measure.

It seems fairly obvious that the mere import of data or factual knowledge contributes relatively little to creating cohesion. In such cases, there is simply too little of the exporting discipline that goes into the transaction. But the less "brute" – the more theory- and interpretation-laden – the knowledge in question is, the more it is likely to contribute to the cohesion between the disciplines. An explicit focus on this aspect may tighten the relationship further, though explication is not always the best way to strengthen cohesion. Fostering a tacit reliance on, and appreciation of, a disciplinary contribution can be just as efficient.

Some might think that collaboration on the level of problem solving or theoretical integration is fundamental, and that other kinds of influencing are more superficial and should count for much less. But this is doubtful, at least in educational contexts. How interdisciplinary interaction should benefit education is a complex and controversial question. For present purposes we might simply assume that educators are interested in a wide variety of goals, both of "internalist" and more or less "externalist" sorts, for example fostering discipline-specific knowledge as well as meta-competences. Besides, they are obviously interested in the *perceived* cohesion: students should not just achieve the learning goals that are actually supported by interdisciplinarity but also *experience* the process as meaningful and the context as sufficiently "natural" and well-defined. There is an understandable quest for fostering a sense of cross-disciplinary "identity" in interdisciplinary encounters. But there is no need to assume that such an identity or experience of cohesion can only be achieved by meeting "internalist" objectives, i.e. through joint contribution to problem solving. A sufficiently integrated *framework* – be it a mode of organization or meta-reflective context, i.e. an overarching discussion of possibilities and limitations of different approaches – can provide an equally strong sense of cohesion. This can be seen from the fact that many established disciplines contain very diverse elements that are seldom or never used to treat the same type of problems (consider English, for example, which comprises topics as different as theoretical linguistics and postcolonial literature – as noted earlier, this goes for both school and academic contexts). Their institutionalized coexistence and a certain traditional demarcation of the very general object or domain (e.g. "living organisms" or "English language and culture") appear to be sufficient.

That the currency of interdisciplinary exchange is *knowledge* means, however, that the degree of cohesion will depend on the degree to which students (and teachers) form new knowledge (of some sort) through the interdisciplinary activities. Hence in a way, knowledge outcome is a fairly straightforward indicator of cohesion – though of course not all the knowledge produced is relevant, since some or of much of it may be traced back to the individual disciplines rather than to the interaction. Moreover, due to the broadness of the notion of knowledge, it is still necessary to take into account a wide variety of processes and effects.

It should be noted that I have been concerned almost exclusively with *possible* effects of interdisciplinary interaction. Though I have given examples of how these may be achieved in practice, I have remained agnostic about the degree to which certain kinds of interdisciplinary interaction actually lead to the desired outcomes, and their likelihood of doing so. Analysing the processes in terms of knowledge transfer helps us understand how they *could* achieve the various affects, and this gives us some a priori reason for thinking that they do. As a matter of fact, I am relatively optimistic about the effects of interdisciplinary education. Especially when one takes into account the wide variety of possible benefits, and the different forms and aspects of interaction that may take place, often in one and the same concrete setting, the chances of achieving a positive outcome appear good, even though the costs and risks are also significant. The balance may appear even more favourable if it is granted that isolated,

discipline-specific work has significant shortcomings in terms of diminishing returns, exaggerated conservatism, limitations on creativity etc. The latter point is controversial, however, and in any case the reasoning remains rather speculative. Transfer, cohesion and the attainment of educational objectives should be subject to extensive empirical study. As always, operationalizing the theoretical notions and finding reliable indicators will pose a huge challenge. Still, understanding the elements and aspects of transfer and cohesion is a necessary first step.[4]

References

Amabile, T. M. (1996). *Creativity in Context.* Boulder, CO: Westview

Bridges, D. (1993). "Transferable Skills: A Philosophical Perspective". *Studies in Higher Education*,18, 1, 43-52

Chada, D. (2006). "A Curriculum Model for Transferable Skills Development". *Engineering Education*, 1,1, 19-24

Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience*. New York: Harper and Row

Faye, J. (2000). *Athenes Kammer.* Kopenhagen: Høst

Frodeman, R. et al (ed.). 2010. *The Oxford Handbook of Interdisciplinarity*. Oxford: Oxford University Press

Hetherington, S. (2011). *How to Know. A Practicalist Conception of Knowledge.* Oxford: Wiley-Blackwell

Jantsch, E. (1972). "Towards Interdisciplinarity and Transdisciplinarity in Education and Innovation", in Apostel, L., Berger, S., Briggs, A., & Machaud, G. (red.). *Interdisciplinarity, Problems of Teaching and Research in Universities*. Paris: OECD, CERI, 97-121.

Jensen, K. J. (2003). "Kemiens fortolkninger". *Aktuel Naturvidenskab* 37-40

Kitcher, P. (2003). *Science, Truth and Democracy.* Oxford: Oxford University Press

Klausen, S. H. (2005). *Hvad er videnskabsteori?* København: Akademisk

Klausen, S. H. (2010). "Erkendelsens former" [The Forms of Knowledge]. *Slagmark* 58, 51-171

Klausen, S. H. (ed.). (2011). *På tværs af fag* [Across the Disciplines]. Copenhagen: Akademisk

[4] Work on this paper was supported by the EU Interreg 4a program

Klausen, S. H. (2013a). "Sources and Conditions of Scientific Creativity", in Chan, J. & K. Thomas. (eds.). *Handbook of Research on Creativity.* Cheltenham: Elgar, 33-47
Klausen, S. H. (2013b). "Teoretisk erkendelse og læring", *Studier i Pædagogisk Filosofi* 2, 2, 1-18

Klausen, S. H. (2014). "Interdisciplinarity and Creativity", in Shiu, E. (ed.): *Creativity Research. An Interdisciplinary and Multidisciplinary Research Handbook.* London: Routledge, 31-50

Klein, Julie Thompson. (2010). "A Taxonomy of Interdisciplinarity", in Frodeman, R. (red.) (2010). *The Oxford Handbook of Interdisciplinarity*. Oxford: Oxford University Press, 15-30

Koestler, A. (1964). *The Act of Creation.* London: Penguin

Lattuca, Lisa R. (2001). *Creating Interdisciplinarity.* Nashville: Vanderbilt University Press.

Nersessian, N. (2002). 'The Cognitive Basis of Model-Based Reasoning in Science', in Carruthers, P. et al. (eds.): *The Cognitive Basis of Science.* Cambridge: Cambridge University Press, 133-153

Nersessian, N. (2008). *Creating Scientific Concepts.* Cambridge, MA: MIT Press

Stanley, J. (2012). *Know How.* Oxford: Oxford University Press

Weingart, P. & Stehr, N. 2000. *Practising Interdisciplinarity.* Toronto: Univ. of Toronto Press

Wilson, A. J. 2010. *Knowledge Power. Interdisciplinary Education for a Complex World.* London: Routledge