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Lindvig, Katrine; Ulriksen, Lars

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Abstract
This review addresses a lacuna in the literature concerning interdisciplinary teaching by analyzing peer-reviewed articles that discuss empirical evidence of interdisciplinary teaching practices. The article reports on the wide array of purposes, approaches and designs of interdisciplinary teaching and learning found in the review, but an important, more general, point is that interdisciplinary teaching is, consistently, considered different from normal practices, hence positioning interdisciplinary teaching and learning as the other. This othering could be detrimental to establishing sustainable interdisciplinary educational provision. Our analysis suggests a need for stressing interdisciplinary practices as local, rather than as generalizable propositions.

Introduction
In this paper, we present a review of online, peer-reviewed articles on interdisciplinary teaching activities in higher education. The aim of the paper is to address a lacuna in the literature concerning concrete examples and empirical evidence of interdisciplinary teaching. As interdisciplinarity is a slippery term, which is reflected in the many alternative names and definitions constantly added to the field (Moran, 2010, p. 14), we employ, in the review, the widest possible definition of the term, namely “any form of dialogue or interaction between two or more disciplines” (Ibid). ‘Teaching activities’ are in this setting defined as formally structured activities planned by a teacher with the purpose of student learning in a variety of forms and scopes. We
include teaching activities taking place at any level of higher education. Hence, the articles included in the review all (in various ways and degrees) describe, address, discuss and evaluate interdisciplinary teaching activities based on empirical work. The paper consists of three main sections: The first section considers the choice and consequences of different review approaches. The second presents the main findings from the review and centers on the practices described in the reviewed articles, thereby zooming in on local configurations and definitions of interdisciplinary activities. The third section discusses one particular implication of the findings, namely the way the papers present interdisciplinarity. This final section, therefore, takes it point of departure in interdisciplinary teaching activities, but it also concerns the wider topic of interdisciplinarity.

**Literature on Interdisciplinary Teaching**

The lack of empirical evidence of interdisciplinary teaching and learning is a recurring theme (Haynes & Leonard, 2010; Lattuca, Fath, & Voigt, 2004, s. 24). Authors highlight the history of studying interdisciplinarity, where “interdisciplinary teaching and outreach activities were largely ignored” (Creamer & Lattuca, 2005, s. 6) and interdisciplinary education is seen as a “black hole” (Mansilla, 2005, s. 18). There have been calls for more systematic studies of interdisciplinary classrooms (Nowacek, 2005, s. 251) and “rigorous research about learning barriers, outcomes and concrete interventions to support interdisciplinary development” (Richter & Paretti, 2009, s. 29). As Rhoten, O’Connor, and Hackett concluded, “we are left with many aspirational assumptions and theoretical propositions about creativity and interdisciplinarity but few empirical explanations [...]” (2009, s. 85).

While a wealth of material centering on interdisciplinary teaching activities is available in the shape of books, dissertations, blogs and non-peer reviewed journals, these are not widely available outside of the communities in which they are produced. The Association for Interdisciplinary Studies (AIS), the Transdisciplinary Network (TD-net) and the Integration and Implementation Sciences network (I2insights) (to mention a few) have produced an array of material on interdisciplinary teaching activities; however, the majority of the material is either not peer-reviewed, or widely
available. In order to find it, you need to know it exists. With this review, we have thus wished to explore the literature available to the wider community of higher education teachers and researchers and thereby to understand how interdisciplinary teaching activities are portrayed to faculty outside of established interdisciplinary communities of practice.

The work on the review has been guided by the following question: If a faculty member from any given discipline, with no prior experience in interdisciplinary teaching, is planning an interdisciplinary course, what can he or she learn from previous, internationally available empirical examples? We have used this imagined teacher as a guideline, because it draws the attention to what is available in the publication channels that for an academic and researcher would be perceived as a warrant of quality and trustworthiness, namely, papers published in peer-reviewed journals. Our point is not that international peer-reviewed journals are the only legitimate platforms of publication. We are fully aware of the abundance of high-quality work available through other channels. Still, we consider it worthwhile to explore what a teacher would find, should he or she search for it in the peer-reviewed publications. This provides us with an insight into what is published in these parts of the official channels and through this, what could - by academics not familiar with the interdisciplinary communities - be found as legitimate knowledge based on empirical studies of interdisciplinary teaching activities.

We therefore conducted a literature review, specifically searching for empirically based descriptions of interdisciplinary teaching activities, i.e. articles that describe or build on empirical data, accounts and descriptions of interdisciplinary teaching activities at higher education level. In the following, we first discuss the methodology behind the review, before moving on to present the main review findings.

**Methodology**

**Search Process**

In conducting this review we have drawn on methods from the traditions of systematic review, qualitative meta-studies, scoping studies and the berry picking or
snowballing approach (See Tranfield, Denyer, & Smart, 2003 for an elaborated overview). In order to situate our review within the field of these varied methods, we have created a diagram (Figure 1) that illustrates the extremities of the review-genre with the two axes representing materials and methods, respectively.

Figure 1: The field of review methods. The numbers indicate four types of reviews: (1) the systematic review, (2) the qualitative meta-studies, (3) the scoping study (4) the berry picking or snowballing approach.

Our diagram is made with a very present awareness of the lack of “consistent definitions of these different review ‘animals’” (Arksey & O’Malley, 2005, s. 3), yet as an attempt to clarify some of the differences between them. The material axis spans between homogenic and reduced and heterogenic and plentiful and the method axis between systematized search and personal experience. Within this diagram we have identified four types of reviews (illustrated by the numbers 1-4).

The first type is the systematic review, where the aim is to select and compare the literature according to very strict parameters, in order to reach a conclusion as unambiguous and tight as possible (Davies, 2000). These reviews are
often used within the health sciences for mapping illnesses, treatments, side effects etc.

In this study, with the help of information specialists from the research library at the Faculty of Education, University of Aarhus, we conducted a systematic search in nine major search engines combining a range of different keywords, including some to target papers with an empirical basis. For further details, see below.

The second type in the diagram is the qualitative meta-studies. The name ‘meta-studies’ can cover many different types of reviews, yet they all have a systematic and stringent search in addition to a large and wide quantity of material as common denominator (Walsh & Downe, 2005). What makes these studies different from the systematic reviews is, firstly, that they gather a much wider variety of literature and material with the aim of creating detailed overviews of the field; secondly, the studies take a qualitative approach, though the modes of analysis vary from discipline to discipline (Finfgeld, 2003). In most cases, a meta-study is used for collecting literature from within the same field or discipline. The central search criteria might be a theme, an illness, a treatment, a political issue or an historic event (Jensen & Allen, 1996). In our case, the common denominator was interdisciplinary teaching practices. This resulted in articles spanning across all academic fields (i.e. arts & humanities, natural sciences, social sciences, health sciences, engineering & technology and law). In many of the articles, the focal point was something other than teaching, and the description of teaching and planning was not even a key feature of the article. Because the articles were written following different academic traditions, the outlines of the articles also varied considerably. What one article described in two pages might only be mentioned in a sentence in another. While the general practice in systematic reviews is to base the selection on titles, abstracts and keywords (Van Tulder m.fl., 2003), we therefore had to read the articles in their entirety. It also meant that we kept articles with a different focus, as long as they entailed an empirically based account of interdisciplinary teaching activities.

A third type of review is the scoping study where the aim is to “rapidly map the key concepts underpinning a research area and the main sources and types of
evidence available” (Arksey & O’Malley, 2005, s. 5). The outcome can be very heterogenic and closer to a personalized than a systematic approach, since the idea is to approach the study in whatever way works best; in other words, there is not one best practice within this method (Ibid). The fourth type of review methods differs in the type of material selected and included. Methods aiming for homogeneous material and based on a more personalized approach are sometimes referred to as the berry picking approach (Bates, 1998) or snowballing (Biernacki & Waldorf, 1981). Reviews that fall into groups three and four could take diverse forms, for example pilot studies that precede systematic reviews, accumulated lists of references or of literary canons. Though these methods differ substantially from the systematic review and the meta-analysis (and could be regarded as very normative), they are, nonetheless, used by most researchers in their everyday work of collecting literature for researching and teaching, and therefore parts of the review landscape (Arksey & O’Malley, 2005; Bates, 1998).

Based on a pilot search, we decided to work in two tempi, so in addition to the systematic search, and in order to get an overview of the field, we used the berry-picking approach. We chose highly cited references within the wider field of interdisciplinary education, written in English, (Augsburg & Henry, 2009; Creamer & Lattuca, 2005; Davis, 1995; Frodeman, Klein, & Mitcham, 2010; Klein, 2010; Lattuca, 2001). We tracked the references applied, read through these and tracked the references in this literature. This approach resulted in a total of 1,018 hits.

Simultaneously, with the help of information specialists from the research library at the Faculty of Education, University of Aarhus, we conducted a systematic search using nine search engines (ERIC, AUEI, BREI, Education Research Complete, Project MUSE, CBCA, SCOPUS, Web of Science). These engines were selected in order to reach journals with an emphasis on education and teaching practices across continents and across the large fields of research (i.e. health and natural sciences, social science, engineering & technology, arts and humanities). In the search, a range of different keywords, such as multidisciplin*, interdisciplin*, integrated learning, crossdisciplin* (see Appendix 2 for full list) were applied and combined with words
indicating the empirical aspect (e.g., *empirical, methods, data collection*). As a third parameter, we combined them with *higher education, university and tertiary education, student, teacher*. We combined the keywords in different search strings, adding and subtracting words in order to get different hits. In our first selection process, papers were included if they were published between 2000 and January 2014, in English and had an empirical perspective. This search gave us 2,175 hits.

Together, these searches yielded just over 3,000 references. By reading through the abstracts and methods section of these references and excluding the ones that did not fulfill the criteria (e.g. books and non-peer reviewed articles, book reviews and meta-studies), the number of references was reduced to 101 peer-reviewed articles, accessible online, written in English and based on empirical evidence of interdisciplinary teaching activities in higher education. This group of articles forms the basis of our analysis.

Our choice of review method is thus placed in the middle of four extremities (e.g. figure 1). Our focus on peer-reviewed journal articles, written in English, and accessible online potentially reduces the amount of material available. Yet, it is also heterogenic and plentiful because we have used several search engines, spanning all academic fields, which yield a very diverse group of articles. As to methods, our review is in the center because we have conducted a very stringent search on nine search engines as well as a second search inspired by the berry-picking approach. Finally, our analysis and the aim of the review lie between a thorough mapping of the field and a qualitative scoping analysis of the results of the search.

**Coding Procedures and Analysis**

We indexed the articles in a table (see Appendix 3) and coded them thematically in order to map overlapping trends (see Figures 2 and 3).
Figure 2. Sticky notes forming a map of themes. The themes are used for subsequent coding.

Figure 3. Sticky notes sorted in final themes

The coding synthesized findings across the articles and across the different readings (i.e. the table indexing and the sticky notes themes). The codes were not developed beforehand, but based on the generated themes. We developed a specific code for each
mentioned type within a theme (e.g. various teaching methods and assessment formats or different course types and levels) and we then coded the articles describing the specific variations within a theme (see Appendix 4 for full list). In our final analysis, these codes served two purposes: First, they helped us generate an overview of the articles – pointing us towards the most commonly used/described methods and teaching constellations. Secondly, they made it possible to detect commonalities between fields, levels, journals etc. Finally, the coding process led us to exclude 41 articles where the presentation of practices related to interdisciplinary teaching was insufficient to allow for coding. Hence, we ended with identifying a set of 62 core articles.

**Replicability and Validity of Search**

Our starting point and reason for conducting this study was that, whereas we needed empirically based knowledge of interdisciplinary teaching activities, the widely cited literature (articles, as well as books) had mostly dealt with descriptions of developing interdisciplinary programs, institutions or methods appropriate across a range of fields (see Klein, 2010; Lattuca, 2001; Repko, 2012). However, it turned out to be extremely difficult to find articles focusing on interdisciplinary teaching; for one because the indexing of the articles and keywords are so inconsistent. While this was already pointed out by Klein (1994) it still came as a surprise that so many articles were missed in the systematic search (and found by coincidence after the review process had ended). One reason could be that the word ‘discipline*’ did not occur in any variation in the article. Another reason could be related to the publication practices combined with our search criteria. We limited the search to widely available peer-reviewed journals in English. These journals publish papers that are considered of scholarly interest at a more general level than experiences situated in local practices. This means that the editorial policies as well as the self-selection of the authors would favor articles offering a generalized analysis and discussion of empirical experiences. Rather than presenting the nitty-gritty and practical details of interdisciplinary practices, the authors would extract the theoretical and de-contextualized points to be made about
interdisciplinarity, because that is what is expected by the journals and their readers. Then, the more practical experiences are either not shared or are more likely to be presented at national conferences, institutional seminars and teacher workshops or disseminated as cases in textbooks or in informal communication e.g. across the table in the coffee room or in documents for a local audience. This, nonetheless, deprives us of the opportunity to consider the diversity of practices and leaves us with abstract conceptualizations and taxonomies.

Out of the more than 3,000 references found, we only found 101 articles that did in fact focus on interdisciplinary teaching activities and out of these, only 62 articles involved concrete cases and empirical examples. Therefore, the following section is based exclusively on these articles.

Findings

We will first turn to the overall findings from the coding of the 62 articles with an emphasis on the varieties of methods, practices and approaches discussed in the articles. This leans towards the output styles of systematic reviews and meta-studies (area one and two in figure 1) (Noblit & Hare, 1988) and provides an answer to the question of what a university teacher would find.

We found that the various disciplinary fields are well represented, with arts & humanities and natural sciences most frequently represented in the articles (see table 1). Law was only present in one article, which was surprising. We do not have the total sum of courses and programs distributed on fields of study, and therefore we cannot say if some fields are over- or underrepresented.

<table>
<thead>
<tr>
<th>Field</th>
<th>Occurrences/62 articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arts &amp; Humanities</td>
<td>32</td>
</tr>
<tr>
<td>Natural Sciences</td>
<td>29</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>24</td>
</tr>
<tr>
<td>Health Sciences</td>
<td>18</td>
</tr>
<tr>
<td>Engineering &amp; Technology</td>
<td>23</td>
</tr>
<tr>
<td>Law</td>
<td>1</td>
</tr>
<tr>
<td>Level</td>
<td></td>
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<tr>
<td></td>
<td></td>
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<tr>
<td>----------------</td>
<td>-------</td>
</tr>
<tr>
<td>Undergraduate</td>
<td>36</td>
</tr>
<tr>
<td>Graduate</td>
<td>24</td>
</tr>
<tr>
<td>Staff Development Seminar</td>
<td>7</td>
</tr>
</tbody>
</table>

### Teaching methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group work</td>
<td>41</td>
</tr>
<tr>
<td>Case based teaching</td>
<td>28</td>
</tr>
<tr>
<td>Project based work</td>
<td>23</td>
</tr>
<tr>
<td>Lecture Based</td>
<td>22</td>
</tr>
<tr>
<td>Team Teaching</td>
<td>22</td>
</tr>
<tr>
<td>Problem based learning</td>
<td>13</td>
</tr>
<tr>
<td>Community based teaching</td>
<td>12</td>
</tr>
</tbody>
</table>

### Assessment methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essay Based Exam</td>
<td>20</td>
</tr>
<tr>
<td>Formative Feedback</td>
<td>14</td>
</tr>
<tr>
<td>Oral Exam</td>
<td>13</td>
</tr>
<tr>
<td>Portfolio exam</td>
<td>11</td>
</tr>
<tr>
<td>Web Log</td>
<td>11</td>
</tr>
<tr>
<td>Questionnaire</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 1 The codes used and the occurrences in the reviewed articles

The majority of articles covered teaching at undergraduate level, but graduate courses are also well represented. In terms of teaching and assessment methods, the coding showed that the articles mainly discussed assessment methods that are less commonly used in higher education (e.g., portfolio assessment) and teaching formats with an emphasis on methods where students work with cases or problems. Furthermore, it is noteworthy that team teaching occurred just as many times as lecturing. Even though a count of code occurrences offers some idea of overall patterns in the reviewed articles, a simple quantification may be misleading. Therefore, we will now turn to the more qualitative results of our review.

### The purpose and justification of interdisciplinary teaching and learning

**Developing particular competences**

Looking across the articles, it appeared that adopting an interdisciplinary approach to
teaching activities was rooted in different purposes and had various perspectives. A frequently used argument for interdisciplinarity was that monodisciplinary qualifications are insufficient to develop the required competences in university students. Some argued that contemporary social challenges, such as sustainable development or water resource management, require interdisciplinary approaches (e.g., Michelsen, 2013). Others emphasized that the scientific development has a pace and direction that the traditional monodisciplinary approaches cannot keep up with, e.g. virtual engineering (Häfner, Häfner, & Ovtcharova, 2013), biology (Dymond m.fl., 2009) or pharmacy (Montagna, Moreno, Verde, & Maifrino, 2011). In brief and across the different examples, the argument was that the students’ academic competences would be left wanting in some areas without an interdisciplinary approach.

Another argument concerning competences was that, by offering students the opportunity to work together with students from other disciplines, they would develop competences related to this kind of collaboration (Frank, Aldred, & Meyer, 2012). Furthermore, when the students worked together across disciplines during the courses, they would experience the approaches, methods and ways of thinking of students from other disciplines and through this could develop an awareness of the peculiarities of their own discipline (strengths as well as limitations) and of the potentials of other disciplines. An example of this was a course on data analysis in biology that recruited students from different biology-related disciplines (e.g., biology, bioinformatics and biochemistry) and from mathematics and statistics (Tra & Evans, 2010). Another was a course involving engineering students as well as students from, inter alia, sociology and business and economics focusing on life-cycle analysis (Richter & Paretti, 2009). The point of these interdisciplinary teaching activities was to allow students to develop particular competences that would be relevant, but which they would presumably not develop within a monodisciplinary context.

A course brought together students of medicine with art students and using drawing as a way of exploring the human body (Lyon, Letschka, Ainsworth, & Haq, 2013). The intention was that the students should develop particular competences through the interdisciplinary teaching activities, but that the medical students should
also develop knowledge about the human body, a common competence for medical students. However, by doing it in a different way (by drawing) the competence might also become qualitatively different. Furthermore, the purpose was also to develop the students’ competences related to creativity and innovation, something that would be in addition to the classic competences of medical students.

This was a second characteristic found across the articles: to adopt interdisciplinary teaching activities in order to develop competences in addition to the disciplinary ones. This could, e.g., be creativity, as in this case as well as in Rhoten et al. (2009) or communication skills (Simmenroth-Nayda, Alt-Epping, & Gágyor, 2011). A number of articles argued that interdisciplinary teaching activities foster critical thinking (Tsui, 2002), a reflective approach to knowledge and knowledge production (Cook-Sather & Shore, 2007) and challenge the students’ perceptions about what science is (Olsen, Bekken, McConnell, & Walter, 2011). Brew (2008) mentioned changes in scholars’ sense of affiliation with a particular disciplinary tribe or community and called for more fluid models of disciplinarity. This suggests that interdisciplinary teaching activities could have more profound consequences for the formation of academic identity and hence for the reproduction of academic cultures.

Some articles reported interdisciplinary teaching activities involving disciplines that were closely related and in other disciplinary environments would be considered belonging to the same discipline. This was, for example, a course integrating language and literature (Day, 2007) or including different theoretical approaches (post-colonial theory, feminist theory, etc.) in the teaching of literature (Kaur & Manan, 2013). Hence, these two papers also reflected the extent of specialization and division between different disciplines within ordinary study programs.

Similarly, the paper by Sarsengelding et al. (2013) dealt with the integration of mathematics and physics in the teaching of a physics course. This could be seen as an example of the teaching of service subjects (cf. later), but it could also be perceived as bringing together two elements that have been closely linked in the development of the discipline, but have been separated in the educational context (Uhden, Karam,
Motivation

Other justifications for interdisciplinary teaching activities stressed the motivational potential, for instance, as a way of getting geology students to learn mathematics (Wagner, 2000) or in the teaching of so-called ‘service subjects’, such as ‘law for business management’ or ‘information technology in (for) business’ (Yang, 2009). Interdisciplinary teaching activities could spark a sense of relevance and motivation in these contexts. Also, some articles focused on the potential of interdisciplinary teaching activities for including groups of students otherwise at risk of being marginalized or for kinds of knowledge usually excluded from academia (Brint, Turk-Bicakci, Proctor, & Murphy, 2009; Whimp, 2008).

Interestingly, there were also articles noting resistance from students when meeting interdisciplinary teaching activities. Examples included first-year students’ reluctance to learn in a different way from high school (Heiman, 2013), students’ previous learning experiences formed by monodisciplinary universities not equipping them to cope with the different design and expectations of an interdisciplinary course (Strain & Potter, 2012), and students not recognizing what they had indeed learned (White, Perlman, Fantone, & Kumagai, 2010).

Overall, the justifications for developing interdisciplinary teaching activities placed particular emphasis on interdisciplinary learning outcomes as different from the traditional courses. Students develop different competences, and they experience a different kind of motivation and sense of relevance. In brief, interdisciplinary teaching activities are different from and lead to other competences and learning outcomes.

Pedagogical and Didactical Forms

The reviewed articles reported the use of teaching methods with an emphasis on group work, case-based teaching, project-based work and problem-based learning. These are forms that give the students an explicitly active role, that emphasize collaboration and that organize the content in relation to cases, problems etc. Still, 22 of the articles
reported lecture-based teaching.

One group of articles presented interdisciplinary teaching activities that were mainly lecture based with some kind of interaction with the students. The teachers were perceived as carriers and representatives of their own discipline and in most of these articles, the interdisciplinary aspects emerged through the students being exposed to a variety of teachers with different backgrounds and approaches. In some cases, the teachers taught in teams (e.g., Frank m.fl., 2012) or courses were designed with teachers teaching separately, but effective cross referencing made the students experience the course as highly integrated and interdisciplinary (Nowacek, 2005). Elsewhere, professors did not directly engage in discussions with each other, but rather asked clarifying questions, “assuming the role of ‘super student’” (Orillion, 2009, s. 8).

In other cases, the students were the ones expected to enact and realize the interdisciplinarity. This would often be by having students from different disciplinary backgrounds working together at the same course or the students being exposed to teaching rooted in different disciplines (Laster & Russ, 2010).

However, it was more common to organize the interdisciplinary teaching activities in ways that differed from the conventional university lecture. A common denominator for these courses was that students should learn to work in an interdisciplinary context applying a variety of disciplinary components by actually doing so and by experiencing a subjective need for integrating different disciplines in order to succeed in dealing with the topic or problem at hand. Students should experience interdisciplinarity as relevant and inevitable. The activities were frequently organized around a specific case, problem or topic (Michelsen, 2013; Pharo m.fl., 2012; Remington-Doucette, Connell, Armstrong, & Musgrove, 2013; Rhoten m.fl., 2009), but it could also be a particular method (Lyon m.fl., 2013) or the history of the discipline (MacKinnon, Hine, & Barnard, 2013) that served as the structuring principle for the teaching.

Interdisciplinarity and the Comfort zone of Teachers and Students
A characteristic permeating the articles was that the design of the courses did not meet the students’ expectations. As mentioned previously, some articles noted that students
could react with resistance because they felt uneasy about the setting and the requirements. Other papers remarked that the different way of teaching, such as team-teaching, had an impact on the teachers’ roles. For example, team-teaching could result in teachers experiencing a loss of control and having to change their habitual way of teaching (Colwill & Boyd, 2008). Colwill and Boyd (ibid.) argued that exactly this sense of discomfort could be considered a core asset of team-teaching and interdisciplinarity, because it could be precisely that which could open the way to designing and practicing innovative teaching.

The sense of uneasiness occurring among some students and some teachers was related to changes in teaching practices and changes in the roles and expectations linked to being a student and a teacher in a particular context. However, besides this feeling of being outside ones comfort zone there could also be a more fundamental issue related to the development and maintenance of a particular identity as a student, a scholar and a teacher within a disciplinary context.

In some cases, this issue of identity could be experienced as a threat. In other cases, it was a point with the interdisciplinary component that students combined different disciplinary elements into their academic or professional practice or even developed their professional identity through participation in interdisciplinary teaching activities. An example of this was a group of lecturers in engineering who, in the process of attending a Master’s program in Engineering Education, also had to negotiate their academic identities. They came with the academic identity of an engineer “and approached student learning as an ‘engineering problem’: how to increase student ‘throughput’ without lowering engineering standards” (Winberg, 2008, s. 364), but during the program they negotiated and adjusted that identity.

Integrating other perspectives into an academic identity is, however, not without difficulties. Palaiologou (2010) showed that the common use of ‘the discipline’ as the basic building stone in academia and in higher education tends to marginalize knowledge domains and educational programs with a more integrative character. Brew (2008) argued that there was a tendency to over-emphasize the importance of disciplines in relation to academics’ sense of belonging. Instead, she suggested that we
should conceptualize disciplines as something more fluid and changeable than the frequently used metaphors of ‘tribes and territories’ (Becher, 1989) suggest. Less fixed metaphors would better capture the actual practices, developments and sense of affiliation found in academic practice. Brew’s study concerned academics’ sense of affiliation to disciplines as researchers, but that it varies across different institutions and higher-educational systems, to what extent programs and courses comply with traditional boundaries, is a relevant point.

**Summing up on Findings**

The analysis of the articles that fulfilled the selection criteria showed that the papers reported from interdisciplinary teaching activities covering a broad range of fields, with law as the one field standing out as only present in one article. A substantial amount of articles reported teaching formats focusing on students’ active involvement with the content in, e.g., projects or group work. Even though lecture-based teaching was also present, there appeared to be an emphasis on teaching formats other than the classical university lecture. Similarly, the assessment formats found were predominantly of the less traditional kind.

The reasons stated in the articles for embarking on interdisciplinary teaching activities were the belief that this would provide the students with the possibility of developing important and needed competences besides the disciplinary competences. Another reason was that interdisciplinary teaching activities would be more motivating for the students.

Concerning the difficulties in interdisciplinary teaching activities, the articles mentioned that teachers as well as students may experience the interdisciplinary setting as disturbing and even frightening, because it differs from the ways they are used to when engaging in disciplinary teaching activities, and because it can be seen as potentially threatening to the construction of a disciplinary identity. Some authors argue that this sense of uneasiness calls for a different way of perceiving and talking about disciplines, namely as something fluid and situated rather than as something solid, permanent and unambiguous.
Implications for Design of Interdisciplinary Activities

We found that the justifications and purposes for introducing interdisciplinarity broadly took two directions. One direction was related to the competences that students could develop in interdisciplinary courses. A second direction emphasized interdisciplinary designed courses as being more engaging and motivating for the students.

From the perspective of a staff member about to redesign a course, it is a main point that although these different justifications and purposes for interdisciplinary design of courses are not necessarily mutually exclusive it is still important to clarify in the design process what the main goal of the redesign should be. It is possible to design a course in a way that provides for more than one purpose at one time, but there are also differences in terms of which purposes are better catered for by different forms of interdisciplinary design.

This relates to another point of the review, namely that the design of interdisciplinary teaching activities takes different forms, thus making the concept of interdisciplinarity difficult to define. In a previous paper (Lindvig & Ulriksen, 2016) we suggested three metaphors for ways in which relations of connections and coherences between various elements in interdisciplinary teaching could be established. These metaphors are pearls on a string, the zipper and the snowflake. The three metaphors do not constitute a taxonomy of increasing levels of interdisciplinary integration, neither are they hierarchical in terms of presenting ‘more’ or ‘less’ interdisciplinarity. They are conceived as metaphors for the purpose of reflection in terms of identifying what kind of interdisciplinary integration that is explicitly or implicitly adopted in a particular course and for considering what kind of integration that would be the most sensible in a particular context.

In the following section we will apply these metaphors as a way to describe the interdisciplinary configurations present in the reviewed literature.
Three metaphors for interdisciplinarity: 1) pearls on a string, 2) the zipper 3) the snowflake.

The first metaphor refers to interdisciplinary teaching activities where the different disciplinary elements are presented one after the other (e.g. Laster & Russ, 2010; Orillion, 2009). In this design, the students meet individual disciplinary elements separately, but the intention is that there is a string running through the entire course or module tying the elements together. In the second metaphor, the zipper, the different disciplinary elements are presented separately, like in the pearls on a string metaphor, but with an explicit expectation that one actor, usually the students, will be the one tying the different elements together. The third metaphor is the snowflake (Figure 6). This design organizes the different disciplinary elements around a common center such as a particular social or scientific problem, a method, etc. Problem-based courses or teaching organized around a particular topic are examples of this.

The three designs each carry strengths and weaknesses. While the pearls-on-a-string design runs the obvious risk of the string not being clear or strong enough to link the different elements together, the snowflake design is vulnerable to students remaining in one part of the flake instead of integrating the different elements. Also, in all three models the students may be unaware of being engaged in interdisciplinary teaching activities and therefore not developing the awareness at a meta-level of the implications of integrating different elements. The importance of this meta-awareness, of course, depends on the purpose of the interdisciplinary teaching activities in the particular context.
If the justification of interdisciplinary educational components is to engage with real-world problems that involves several disciplines, it could be argued that due to the emphasis on the content it is of less importance whether the students develop a meta-perspective on the relations, differences and similarities between the disciplines. Nowacek (2007) argues that interdisciplinarity contains a meta-awareness of disciplines and the integration of knowledge and modes of thinking (with a reference to Mansilla, 2005). In the course, she analyzed, which was of a pearl-on-a-string type, she found that teachers more often linked content from different disciplines to each other than they did ways of knowing. In a snowflake-type course, a similar focus on content could mean that the students realized that different disciplines could contribute with different knowledge elements, but the students would not necessarily become aware of the different ways of knowing.

Nowacek suggests that the links concerning ways of knowing are less frequent because the teachers do not comment on those processes within their own disciplines either. They merely do them. Hence, it also means that it is not necessarily enough that students do interdisciplinarity if they do not know they do it: Nowacek (2005, s. 174) makes the point that we need to focus on “the ways in which individuals construct their understanding of both disciplinarity and interdisciplinarity”. Therefore, a snowflake-type interdisciplinary course is not a guarantee that students will develop interdisciplinary competences.

Therefore, there is no causal relation between the way interdisciplinary teaching activities are designed and the interdisciplinarity-related competences students develop. However, some designs offer a stronger invitation to the development of some competences than others do. The faculty member about to design her or his own interdisciplinary course that we took as the article’s starting point would therefore, first, have to reflect on what purpose and what competences the teaching should facilitate in particular. Based on that, the teacher should decide on which design to use, including the way the disciplines in question are linked together. The literature, hence, offers a framework for reflection and decision-making including
the opportunities and pitfalls of different designs, rather than a fixed set of models or
taxonomies to pick out and apply.

Discussion: the special and the ‘other’
Following the two first sections, where we analysed and discussed the review and the
findings, we will now change the focus slightly in this third section. Whereas the
presentation of the findings had the imagined teacher in focus, this section is directed
towards scholars, studying and publishing on interdisciplinarity.

The literature on interdisciplinarity is rich in variation concerning the
ways interdisciplinary teaching activities are conceived and practiced and how it
should be understood. Still, it is a common thread through most of the reviewed
articles that interdisciplinarity is presented as different from the usual way of
organizing teaching activities in higher education. Henry (2005) notes with a reference
to work by Rodgers et al. (2003) that interdisciplinarity is subject to “an ‘otherization’
process” employed by the disciplines to “disarm the threat of interdisciplines” (Henry,
2005, s. 25).

Interdisciplinarity as ‘the other’
Said’s (1979) study of orientalism made the point that authors and scholars from the
Occident (The United States and Europe) described the Orient (large parts of Asia and
the Middle East) as the ‘other’ compared to the Western world through stereotypes
that was imposed on the perception of the people and cultures of the orient. In the
work of the orientalists, the East was not a geographical area consisting of various
countries, peoples and cultures. As ‘the other’, the East was essentialized by suggesting
that the region and its people had underlying characteristics, homogenized by the
claims of it being one unit and finally feminized by suggesting it was an exotic,
barbaric and much less developed opposition to the west (Gallaher, Dahlman,
Gilmartin, Mountz, & Shirlow, 2009, s. 329). Through this, the West in the works of the
orientalists became the exact opposite of the orient and therefore an equally
homogeneous whole (Said, 1979). The othering, hence, maintained an image of the
world and the relation between East and West as essentially that of the true and of the other (Said, 1994).

Said’s critique was directed at the Western scholars othering the Orient. Transferred to our case, the othering of interdisciplinarity would be the doing of the monodisciplinary scholars, meaning that when described by monodisciplinary researchers, interdisciplinarity appears equally exotic, inferior and much less developed than its imagined counterpart. However, based on our review, we suggest that the othering is not just something disciplines do to interdisciplinarity. Following Gallaher et al. (2009), othering is also done by the involved researchers themselves when conducting studies in ways which homogenize and essentialize entire groups of people or, as in this case, activities (Gallaher m.fl., 2009, s. 332). When the protagonists of interdisciplinarity in the papers identified by this review emphasize that interdisciplinarity earns particular merits by being different from the run-of-the-mill disciplinary teaching and learning activities, they at the same time contribute to an othering of interdisciplinarity. As Henry claims, this may cause the interdisciplinary courses and programs to be more vulnerable in times of budget cuts and restructuring, not only because interdisciplinarity as ‘the other’ will be perceived as the superfluous elements, but also because monodisciplinarity, as the binary opposite to interdisciplinarity, will be perceived as a constant, static and grounded phenomenon. Additionally, there is the risk of stereotyping interdisciplinarity: rather than acknowledging and pointing out the differences and nuances in the way interdisciplinarity can be conceived and practiced, the literature adds to a particular understanding of interdisciplinarity as something extraordinary. Consequently, named interdisciplinary practices are more likely to be left on the periphery. This produces a self-confirming prophecy that interdisciplinarity will never be fully acknowledged even though it holds so much promise.

**The situated nature of interdisciplinarity**

The othering of interdisciplinarity also adds to some of the points we made earlier in this paper. This concerns that teachers find themselves at the border of their comfort
zone or beyond; that students in some cases are skeptical when being engaged in interdisciplinary teaching activities and the critique raised by Brew (2008): that disciplines are presented as more stable and consistent, than they actually are.

Firstly, the positioning of interdisciplinary teaching as ‘the other’ to the right teaching could spark uneasiness in the first place among teachers and students who might feel insecure facing this apparently very different way of teaching. Some of the elements, reported to make the teachers uneasy, were in fact related to the use of pedagogical formats, rather than to interdisciplinarity as such. These are formats where students have more influence on the selection of content, the pace, the sequencing of the different elements etc. (what Bernstein, 2000, calls “framing”), which could make the teachers sense a loss of control. Hence, this uneasiness is not necessarily related to interdisciplinarity. It has to do with adopting pedagogical formats that underpin the development of some of the competences, but the othering of interdisciplinarity associates this loss of control with interdisciplinarity.

Secondly, Brew’s point concerning the more fluid disciplines calls for an attention to interdisciplinarity as something that is fundamentally situated. What counts as interdisciplinary teaching activities is a local rather than a global issue. What is experienced as combining content and ways of knowing across disciplinary borders will be perceived differently depending on the local institutional setting. If this is disregarded and all the local practices are instead collected and transformed into generic definitions and understandings of interdisciplinarity, it creates a homogenized and essentialized image of interdisciplinarity that looks distorted compared to other ways of understanding teaching and learning. This is especially true when considering the differences in educational structures and in publishing structures across the continents. In our review, the number of articles reporting from American and Australian contexts constitutes the vast majority, hence leading a generalized image of interdisciplinarity in a direction very different from that of some European higher-education systems. Generalizing on local, situated practices relates to what Livingstone (2003, s. 142) problematizes as “the apparent universalism of science”. There is nothing wrong in learning from informed practices and transferring
knowledge from one site to another, as long as this is done in awareness of it being “less about the local instantiation of universally valid facts and more about the adaptation of local knowledge to create another” (Ibid).

The variations in how students’ study programs are organized can exemplify this. Some study programs consist of modules that students choose and combine. Other study programs are more fixed where students have to take a number of mandatory modules leading towards a particular degree in, e.g. Chemistry or Sociology. Some of the mandatory modules could be in service subjects such as mathematics or chemistry. In the former type of program, students’ difficulties with experiencing coherence through their study path as an issue will more frequently be identified as concerning interdisciplinarity. However, the latter, more structured study programs will often interpret the same lack of coherence as a problem within the named monodisciplinary study program. In other words: It makes a difference whether the issues of interdisciplinary education are addressed in relation to individual modules of disciplines or sub-disciplines, or in relation to study programs encompassing more than one discipline.

There are two points here: first of all, what is considered as cutting across different disciplines could also be considered as the challenge of linking two elements that are naturally related in the practicing of a discipline. Secondly, the othering of interdisciplinarity and the tendency to conceive and describe interdisciplinarity as a single entity conceal the variations.

**Conclusions: Reviewing Articles on Interdisciplinary Teaching Activities**

This paper is a result of the reading and analyzing of a collection of articles on interdisciplinatory teaching practices. In many ways, the collection appears inconsistent due to the various disciplined output styles and incomplete due to search limitations that leave out articles with the right content yet are not caught due to missing keywords, word indexing and interpretations. Above all, it seems incomplete because there is a lot of knowledge that, due to the publishing structures and incentives, are not shared in the output format we have focused on. Nevertheless, the absence of the
literature reporting practical examples in local papers and similar communication channels is a feature of our study, not a flaw. It points to the fact that teachers, who are not already involved in or related to communities working within interdisciplinarity, have a limited set of empirical examples available, should they search through the same channels and apply the same criteria as in research. Our claim is thus not that we found the empirical studies that are out there. Our point is that very few of the studies available in publication formats similar to what the faculty member will know from his or her research work, will in fact report on that kind of empirical experiences.

The review has not offered the empirical explanations called for by Rhoten et al. (2009). The reviewed articles provided numerous examples, experiences and reflections that all contribute to an increased and more nuanced understanding of interdisciplinary teaching and learning, but they do not add up to evidence-based conclusions about what works in interdisciplinary teaching and learning and what does not.

Our experiences from a larger research project on interdisciplinary activities in monodisciplinary structures confirm the existence of a vast and diverse amount of knowledge and experience on interdisciplinary teaching practices that is not disseminated through peer reviewed journals (Lindvig, Lyall, & Meagher, 2017). In this case, the main repercussion is the act of ‘othering interdisciplinarity’ that the limited outlet of peer-reviewed literature supports; ‘othering’ in the sense that through these few selected written accounts, interdisciplinarity is depicted as something completely different from monodisciplinarity.

Furthermore, we found that there is a discrepancy between the concrete examples, cases and accounts of interdisciplinary teaching activities that appear in non-peer reviewed literature, textbooks and blogs and the more generalized views and of interdisciplinary teaching activities that represent the field in the peer-reviewed literature. This creates a challenge for the faculty wishing to learn more about concrete practices of interdisciplinarity and it renders the many local interdisciplinary activities invisible to the wider public, thus not evaluated and valued (echoing findings from Lindvig m.fl., 2017). If the peer-reviewed literature is not grounded on local, situated
and research-based practices of interdisciplinary teaching and learning - but is instead homogenizing and over-emphasizing different and unusual aspects of interdisciplinary practices - the literature may depict interdisciplinarity as more challenging and risky to support. This also conceals what is particular about applying interdisciplinarity in a given context, because the othering generalizes the unusual by simply making it ‘the other’. Thus, adding the label ‘interdisciplinary’ to teaching activities may in effect be detrimental to developing, reflecting on and analyzing interdisciplinary teaching activities.

Hence, our findings point towards a need for more peer-reviewed papers that report and analyze specific, empirical examples of interdisciplinary teaching activities, but do this in a way that emphasizes the particular interdisciplinary practice instead of a general idea about interdisciplinarity.

Acknowledgements

This review was conducted as part of the project 'Interdisciplinary Education' at the University of Copenhagen. We gratefully acknowledge the assistance of the members of the project. In particular, we thank Assistant Professor, PhD Jesper Bruun for his valuable and constructive comments and contributions during the coding and the initial phases of the analysis.

Literature


Appendices

Appendix 1

Search Terms Used – Second Round

- Interdisciplin*
- Multidisciplin*
- *Disciplinarity
- *Disciplinary
- Cross*

disciplin* AND
- Higher education
- Universit*
- Academic education
- Tertiary

education AND
- Empirical
- Data
- Empirical
- Study
- Methodological approach
- Didac

tic* AND
- Students and learning
- Students and teachers
- Science education
- Interfaculty teaching
- Interdisciplinary learning;
- Curriculum Integration
- Interdisciplinary teaching approach
- Undergraduate Study
- Learning Processes
- Integrat* learning
Appendix 2

Search Strings – Second Round

Inclusion criteria:

Geographic area: EU, USA, Canada, Australia
Language: English
Publication type: No limits.
Date: 2000 – January 2014

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AUEI (Australian Education Index)

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# Appendix 3

Table for Initial Reading of Articles

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Table used for the initial reading of the articles to capture the main features of each article
Appendix 4

Codes Used for the Analysis of Articles

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Examples of codes for some of the reviewed articles. Not all categories were applicable for all articles.