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Annie Aarup Jensen
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Interdisciplinarity and Problem-Based Learning in Higher Education

Research and Perspectives from Aalborg University

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Contents

Part I
Conceptualising Interdisciplinarity in Problem-Based Learning

Chapter 1
Introduction

Diana Stentoft, Annie Aarup Jensen, and Ole Ravn

There can be no doubt that rapid changes in societal and technological conditions are radically altering the agenda of higher education. Students and teachers in universities around the world face complex knowledge domains new knowledge domains and access to information in abundance; with these factors comes the need to consider how educational settings can and should accommodate these changes, along with others yet to come. These new developments have led many universities to initiate explorations of new pedagogies and modes of learning that meet the need to address the complexities of knowledge while also building a bridge to the world beyond the institution, enabling more rapid transfer of knowledge from the spheres of education and research to those of production and structures in businesses, public institutions and civil society. In recent decades, two notions have played significant parts in the transformation of universities worldwide. One strategy has been for universities to incorporate a notion of interdisciplinarity into the portfolio of educations and the way curricula are organised and delivered. This conception of higher education in terms of interdisciplinary learning is reflected in the array of undergraduate and postgraduate education programmes seeking to combine disciplines or even develop new ones. These programmes are often established based on input from stakeholders seeking new scientific and academic perspectives on major problems, and as such, interdisciplinary learning can be viewed as one way for universities to respond to the demands of such stakeholders. A second strategy adopted by universities for addressing new epistemologies and building bridges is derived from the acknowledgement that entirely new pedagogical approaches are required to face

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the challenges of today's world. One such pedagogy, which has gained ever-increasing momentum over the past four decades, is that of problem-based learning. Problem-based learning initially emerged as a response to the identified need in educational practices of building bridges between science and academia and the complexities of real-world problems. Hence, problem-based learning is often seen as a strategy for the organisation of curriculum in that it enables student-centred learning processes with an emphasis on the exemplary problem as reflecting the complex realities faced by graduates when they complete their education. Over the years, problem-based learning has come to be known as a pedagogy accommodating interdisciplinary learning, and the aim of this book is to address this perceived connection between notions of problem-based learning and interdisciplinary learning by posing the following research question:

> How can we develop problem-based learning in support of interdisciplinarity and interdisciplinary learning processes in higher education?

Even though PBL is often referred to as an approach supporting interdisciplinary learning, there has thus far been little research exploring this assumption in more detail. We therefore wish to challenge this often implicit assumption that a problem-based approach to learning is by default scaffolding interdisciplinary learning processes. With this book, we wish to explore under which conditions PBL may actually enable interdisciplinary learning as well as to expose potential challenges in this area.

This edited volume consists of chapters written by researchers involved with an array of problem-based educational programmes at Aalborg University, Denmark. Aalborg University was established as a dedicated PBL university in 1974 and thus has more than 40 years of experience with PBL across all higher education domains. The contributors to the book come from all faculties of the university, bringing research and practice together to bring about a comprehensive understanding of both the theoretical underpinnings and practical implications of considering problem-based learning as an opportunity for students to navigate interdisciplinary and complex problems in their studies. Consequently, some chapters address the theorising of PBL related to interdisciplinarity, and others consider the organising, implementing and practicing of PBL and interdisciplinarity. Different perspectives, including those of students, supervisors and institutional settings, are represented. By highlighting the plurality of lenses through which interrelations of PBL and interdisciplinarity may be viewed and articulated, we wish to contribute to a more nuanced understanding of the possibilities and limitations of current pedagogies underpinning higher education and of the need to avoid limiting discussions of higher education merely to instruments and regulations. Rather, we wish to draw attention to the interwoven complexities, contexts and participants in higher education, which combined constitute the premises on which pedagogies should be built. Put more simply, the book aims to demonstrate how the success or failure of adopt-

ing a problem-based approach to enhance interdisciplinary learning and education all hinges on the way we consider subject matter and context as well as students and supervisors. Here a clarifying note on the terminology of the volume is in order, in this institutional setting the term ‘supervisor’ covers what in other PBL contexts may be termed ‘instructor’ or ‘facilitator’.

1.1 Organisation of the Book

The book is organised into two parts. Chapters in Part I are all related to theoretical and philosophical aspects of PBL and interdisciplinary learning. Chapter 2 conceptualises the notions of problem-based learning and interdisciplinary learning and highlights some key overlaps and ways of conceiving of their interrelatedness. Chapter 3 discusses the role of problem-based medical education in relation to interdisciplinary professionalism in medical education. Chapter 4 takes the reader into the realm of Techno-Anthropology as it discusses the role of problems and projects in transgressing disciplines, and Chap. 5 presents an analysis of three challenges facing new students when entering interdisciplinary and problem-based higher education. In Chap. 6, the need for supervisors to scaffold open and uncertain scientific spaces is discussed, and is identified as being particularly evident in interdisciplinary PBL projects.

Part II focuses on practicing interdisciplinarity in problem-based higher education. Chapter 8 explores how the construction of problems in interdisciplinary PBL projects can be seen from the perspectives of multicultural groups; this is followed by an examination of group processes in interdisciplinary PBL projects in Chap. 9. In Chap. 10, the authors take a closer look at how students are positioned and position themselves in the complex transdisciplinary PBL project, and in Chap. 11 the focus turns to student practices in interdisciplinary PBL.

The research presented in both parts was conducted at Aalborg University, Denmark; however, the issues covered illuminate more general issues in PBL and interdisciplinarity relevant to any higher education institution considering or already implementing the approach. In order to bring the research presented into a broader context, we invited Professor Lisa Lattuca of Michigan State University and Dr Terry Barrett of University College Dublin to contribute a reflective chapter concluding each part. In Chap. 7, Lisa Lattuca reflects on Part I as she discusses how students and supervisors in PBL can be seen as participants in an interdisciplinary learning community. Concluding Part II, Terry Barret discusses the new contributions to understanding the characteristics of PBL emerging from the chapters and reflects on the implications for PBL practice strategies.

1.2 Writing a Book on Problem-Based Learning Was a Problem-Based Project

The empirical work and the theoretical considerations and reflections developed throughout the book were produced by a dedicated group of education researchers qualified for the job by their many years of research experience and daily practice with PBL in interdisciplinary education settings. This is a community of researchers with a shared interest in exploring new insights into the impact and implications of the complexity of the pedagogical philosophy and practice of PBL. The process of making the book has itself followed many of the steps of a process of problem-based learning. First of all, we considered the theme of the book as an ill-defined problem, which needed to be examined and further explored. These explorations were defined and determined by the contributing authors when discussing preliminary outlines of the various chapters. During the initial phases we all learned more about what interdisciplinary PBL could encompass, as well as how various educational programmes and different research perspectives could yield new and diverse insights into problem-based learning, which are often taken for granted at Aalborg University given its long history of PBL.

From our discussions, it became apparent that the notion of interdisciplinarity is nearly impossible to pinpoint when considered as a premise for pedagogy in higher education, and for this reason, the idea of bringing together researchers with diverse interests in education in general, and PBL and interdisciplinarity in particular, seemed relevant. Thus, the group of researchers from Aalborg University contributing to this book are spread across research groups, departments and faculties.

Furthermore, as we wished to explore the concepts of interdisciplinarity and their meanings in relation to learning and PBL, the group of researchers were at liberty to work with the conceptual framework relevant for their research. This resulted in the various chapters drawing on different sources of inspiration for thinking and working with interdisciplinary learning. However, we acknowledge the complexity and the contested nature of the terms and concepts used and we therefore wish to refer interested readers to e.g. the chapter by Thompson Klein (2010) 'A taxonomy of interdisciplinarity' as well as Latucca et al. (2004) 'Does interdisciplinarity promote learning? Theoretical support and researchable questions'.

For the creation of the book and the writing process, we were keen to create the framework for an interactive and iterative process for all involved to make sure that all were part of and were supported through the process, and that all knew and understood the idea, scope and content of the book as a whole. Consequently, all contributors met regularly to discuss each chapter and to receive constructive feedback from peers.

On a final note, it is important for us to reiterate our hopes for this book. Through the diversity of the chapters that follow, we wish to open a debate on interdisciplinary learning in higher education. Our proposition is that problem-based learning is a well-suited pedagogy that has the potential to create conducive and inclusive learning spaces where students and supervisors can meet and explore

interdisciplinary problems and interdisciplinary settings. However, as is evident from the chapters, these learning spaces are not open by default. For the advantages of problem-based learning to be fully realised in interdisciplinary education, there are a multitude of factors and processes that must be considered and scaffolded, from ensuring adequate competencies of both students and supervisors to setting the scene for multicultural groups, while dealing with uncertain and sometimes wicked problems in the process.

References

Latucca, L. R., et al. (2004, Fall). Does Interdisciplinarity promote learning? Theoretical support and researchable questions. *Review of Higher Education, 28*(1), 23–48.

Thompson Klein, J. (2010). A taxonomy of interdisciplinarity. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity* (pp. 15–30). Oxford: Oxford University Press.

Chapter 2
Problem-Based Projects, Learning and Interdisciplinarity in Higher Education

Annie Aarup Jensen, Ole Ravn, and Diana Stentoft

2.1 Introduction

The increasing speed with which knowledge and information are emerging, coupled with the growing complexity of the problems which science is expected to address, mean that the role of higher education today is entirely different from what it was only a few decades ago. In the past knowledge, skills and competencies developed through a university degree ensured a solid foundation for life. However, today students in university degree programmes cannot even be sure that the knowledge and skills gained during the first year of study will be comprehensive on graduation day. Or put differently "*So we are trying to prepare our students for the unknown by using what is known*" (Bowden and Marton 1998: 26). Parallel to, and perhaps as a consequence of, this development, the landscape of tertiary education is becoming increasingly diverse. New student groups are finding their way into university, significantly altering the composition of the student population. This is not least due to the international restructuring of educational systems where, for example, student populations in master's programmes may be both multicultural and composed of students with diverse degree backgrounds. These changes are strongly encouraged through international qualification frameworks as for example the European Qualification Framework emphasising mobility, lifelong learning and transferability of qualifications (The Council of European Union 2017).

The fact that higher education institutions must now educate students in ways that still ensure a sound knowledge base while also offering possibilities to develop

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strong competencies to continue learning beyond graduation and formal education is making the choice of pedagogical approach increasingly important and simultaneously difficult (Miller 2010). These changing conditions of higher education have been referred to as the postmodern condition (Lyotard 1984) constituting a new arena for doing research and offering higher education (Gibbons et al. 1994). Under postmodern conditions for knowledge production, interdisciplinary learning in higher education is centrally positioned as a conceptual framing that can build bridges and fill voids between traditionally irreconcilable disciplines. This has contributed to a new vocabulary of contemporary higher education that is not limited to an exclusive academia behind the university gates.

This chapter will address the complexities of interdisciplinary higher education and will frame some of the unresolved issues that continue to challenge interdisciplinary teaching and learning, as well as the underpinning pedagogies. More specifically, the chapter will, through the case of a specific university, highlight some of the ways in which interdisciplinary learning may be perceived and conceptualised in higher education. In particular, the chapter will discuss the premises of problem-based learning as a pedagogical approach that may offer the potential for opening interdisciplinary learning spaces. Thus the aim of the chapter is to highlight key issues that need to be researched and better understood if the principles of problem-based learning and the intentions of interdisciplinary learning are to be a compatible match.

As a point of departure it is important to emphasise that here we will not offer a precise definition of the concepts of interdisciplinarity or interdisciplinary learning. Rather, we acknowledge that these concepts may have different meanings and uses that vary with the context. As a consequence, with this chapter we wish to contribute to the development of a nuanced and comprehensive vocabulary of interdisciplinary learning that will broaden what we can and cannot think and do in higher education settings and which will allow us to discuss how issues of interdisciplinarity have very real and direct implications on pedagogical and didactical considerations and on students' learning.

2.2 Complexities of Interdisciplinary Learning in Higher Education

The notion of interdisciplinary learning is difficult to grasp, and is given a variety of meanings in literature and research depending on context (DeZure 2010). Somehow research into the field is still relatively limited and, it has been suggested, points in multiple directions (Mansilla 2010). As will be evident through the chapters of this book interdisciplinary learning can be conceptualised in one of two ways; *through the characteristics of the people involved,* or *as the way knowledge is produced and handled* in the learning process. Thus the phrase 'interdisciplinary learning' may signal the complex and diverse characteristics of persons involved in shared

processes of learning. In higher education this condition may arise when students from mixed educational backgrounds, holding varied views on shared problems come together to collaborate and extend their perspectives. This conception of interdisciplinary learning emerges as a consequence of the specific and diverse characteristics of the persons involved. On the other hand, interdisciplinary learning can be conceptualised as the way in which learners construct and produce knowledge. In this conception, interdisciplinary learning is not framed by the characteristics of the persons involved, but rather by the way these persons develop and design their shared learning process to construct new knowledge. In this conception it is the actual interactions within and across disciplines that delimit the boundaries of what can be understood as interdisciplinary learning. Both conceptions are addressed in this book, and both have a place in discussions of higher education, yet each conception make its own contributions to the understanding of interdisciplinary learning in higher education settings.

In higher education settings, the approach to and conception of interdisciplinary learning largely depends on the organisation of the curriculum and actual learning activities. Students may work in a monodisciplinary, multidisciplinary, or interdisciplinary educational environment, and as such it may be the curricular adherence to disciplinary boundaries that implicitly determines the actual scope and nature of interdisciplinary learning. For example, students in a monodisciplinary setting keep well within the boundaries of disciplines when learning. The problems addressed, the methods applied to reach an answer and the theories used are in this setup clearly within the traditions and scientific practices of a particular scientific community and overall paradigm. In contrast, in multidisciplinary learning settings students address issues or phenomena from a multitude of disciplinary perspectives, but do nothing to navigate and explore the intersections of these disciplines. Often such educational settings emerge in interprofessional programmes and courses where students from varied backgrounds come together to illuminate a shared problem from multiple perspectives. An example could be students from psychology, teacher education, social work and nursing bringing together their various perspectives on how to work with children who have experienced domestic violence. Working and creating knowledge from an interdisciplinary perspective, in contrast, calls for the development of processes whereby the intertwining of several disciplines can lead to knowledge and comprehension beyond what any one discipline could offer. In these processes, students may transgress boundaries and contribute to the development of products and professions not yet conceivable or defined. Klein (2012) offers a detailed and elaborate taxonomy of interdisciplinarity characterised by words such as integration, interaction and collaboration.

Whether interdisciplinary learning in higher education programmes is defined according to the backgrounds and competencies of the persons involved or the way processes of knowledge construction are developed and designed, there is no doubt that moving from monodisciplinary to interdisciplinary education adds layers of complexity and requirements to the roles of both student and teacher. However, venturing into interdisciplinary education is also political in the sense that it carries with it a perspective on students and professions that acknowledges the need for

graduates to deal with uncertainty and to have the competencies to construct knowledge not within but across disciplines. As such, offering interdisciplinary higher education emphasises emerging professions rather than contributing to hyper-specialisation.

Regardless of the approach to interdisciplinary learning, higher education institutions offering interdisciplinary programmes are faced with a considerable pedagogical challenge. This challenge is particularly evident when transforming interdisciplinary intentions and learning objectives of curricula into the actual practice of education (Nowacek 2009; Stentoft 2017). To meet this challenge, problem-based, case-based and project-organised learning are often brought forth as pedagogical approaches that can open up spaces for interdisciplinary learning (e.g. Majeski and Stover 2005; Sternberg 2008). Here we will refer to these by the commonly used term 'problem-based learning', or simply PBL.

2.3 Problem-Based Learning in Higher Education

Problem-based learning (PBL) is based on a philosophy of learning that takes complex, ill-defined real-life problems as a point of departure for learning (Dewey 2005). As a pedagogical approach, PBL was first developed and implemented in the 1960s at the medical school of McMaster University, Canada (Servant 2016; Barrows 1996; Savery 2006). The principles of PBL have since gained worldwide recognition in numerous domains, which has led to PBL today being adopted for a variety of models and strategies for learning in higher education settings that are locally adjusted to accommodate educational beliefs, policies and demographic and economic realities.

Since its first implementation, PBL in higher education has developed in response to changing educational and societal conditions and as an attempt to strengthen the interplay between the sciences and the world to which these sciences are meant to positively contribute. Servant (2016) has in her work uncovered the diverse historical contexts of four universities which continue to play significant roles in PBL today, namely McMaster University, Maastricht University, Roskilde University and Aalborg University. These four universities all took a progressive stance towards higher education in the late 1960s and 1970s and continue to offer education based on the principles of PBL today.

The reasons for adopting a problem-based approach in higher education are many, and the approaches and practices arising from the overall principles of PBL are highly diverse (Savin-Baden and Major 2004; Stentoft 2016, 2017). Even within a single institution there may be significant differences in the way problem-based learning is practiced, depending on the field of study and the prospects for students beyond their university education. However, all practices of problem-based learning take their point of departure in real-world problems rather than firmly defined disciplines and well-structured textbooks.

To be more specific about the theoretical underpinnings and practices of PBL, it appears sensible to take a closer look at one higher education institution, which from its establishment has embraced and continued to develop the principles of PBL across the entire institution. This will allow for a discussion of the process of bringing principles into educational practice and of the value of PBL when intended for interdisciplinary learning. It is, however, important to also bear in mind that each institution will have its own contextual setting and characteristics, meaning that no single implementation of PBL can be considered ideal for all.

2.4 Case: Project- and Problem-Based Learning at Aalborg University, Denmark

In Denmark, Roskilde and Aalborg universities were established with an institutionalised PBL approach in 1972 and 1974, respectively. These universities emerged with a specific philosophy of learning and education based on problem orientation and participant-directed project work in groups. This approach was referred to as problem-based learning, and the universities were from the outset considered to be somewhat in opposition to older and larger universities in the country. The Danish education professor Knud Illeris offered considerable insights into the theoretical foundations of problem-oriented project work in a Danish context, initially in his book *Problem orientation and participant direction: An introduction to alternative didactics* (Illeris 1974) and later in numerous books and articles.

The approach to problem-based learning adopted at Aalborg University is based on the following six principles (Askehave et al. 2015):

- The problem as point of departure in the learning process.
- Projects are organised in groups.
- The project is supported by courses.
- Collaboration is essential within the project groups and with supervisors and external partners.
- Problems and projects must be exemplary.
- Students take responsibility for their own learning.

Taking a *problem* as the point of departure for the learning process means that students investigate and study the knowledge, methods and theories relevant to a specific problem rather than focusing on a narrow discipline-bound theme or task. Consequently, interdisciplinary learning is often a prerequisite for fully comprehending the problem. The problem is not predefined by the study programme or by the teachers, so the students themselves are required to find and define the problem they wish to investigate further. In defining the problem, students must argue for its relevance and the context in which it is relevant, thus tying the problem to realities outside academia. Simultaneously, developing a problem-based project is a highly academic and analytical exercise. Students consequently have ‘ownership’ of the

problem and make their own decisions on how to organise their investigations. In other words, the work is *participant-directed*. The students' processes of handling and constructing knowledge relating to the initially ill-defined problem and their deliberations on the relevance of theories and methods for investigating the problem gradually lead to a more profound understanding of the complexity of the problem. When reaching a point where the problem can be stated as a clearly defined research question, students move on to plan their further research into the problem. The curiosity and the challenges experienced in this process, as well as the wish to better comprehend the problem (or to answer the research question), are some of the motivating factors. Often, addressing a problem also involves collaboration with *external partners* (e.g. organisations, companies or public institutions), which further contributes to the engagement of students.

Studying in a problem-based setting at Aalborg University is primarily organised around *projects,* most often one large project per semester, and accounts for approximately 50% of study programmes. The remaining 50% consists of *course work*, lectures, workshops, assignments, etc. Although these study activities may support and inspire students in their project work, they are assessed separately. Students work on one project per semester, which continues through the entire semester. An important aspect of problem-based project work is that it is *group based*. This provides a basis for peer learning, the development of *collaborative* skills and scientific and academic vocabulary proficiency, which the students practice in discussions and the negotiation of meaning as well as in written communication, since the research processes involved in studying the problem and its potential solutions are documented in a project report. The group is thus an important factor in the students' learning as they become responsible for organising and leading both their own and their fellow students' learning processes.

To support the learning processes of the project, the groups are assigned a *supervisor* with whom they discuss how the project is progressing. The supervisor provides formative feedback and comments on their drafts for the chapters of the project report. The role of the supervisor is important as a discussant for the group – asking critical and constructive questions to make the students reflect on their work, their understanding of the problem and their choice of theory and method for further exploring their research question. The supervisor's focus is also on unleashing perspectives to ensure a comprehensive and critical examination of the problem from all angles. Furthermore, the supervisor has the responsibility to ensure that the project falls within the formal, thematic framework of the semester in question and enables the students to fulfil the requirements of the study. The PBL approach applied at Aalborg University is based on the principle of *exemplarity*, which means working from problems that are representative of more general issues, and are realistic and relevant to a future working life and profession. This will enable students to transfer scientific and interpersonal knowledge, skills and competencies developed in one project into future unknown situations involving similar issues.

The members of the project group are jointly responsible for the final project report, which forms the basis for their oral group assessment.

A problem-based project tends to go through the following phases:

- The thematic framework for the semester is presented. In some cases, supervisors present a number of more specific areas or issues to inspire the students to engage in the project work process.
- Project groups are formed. Ideally based on students' shared interests, but they may also be formed administratively based on predefined criteria.
- The groups define a scope for their project within the overall thematic area of the semester in question and they start their first reflections on relevant problems in cooperation with the appointed supervisor. An example of a semester thematic area in sport science could be physical activity in children, and a project group could choose to delimit the project to be about preschool children's activity in kindergarten.
- The project groups start framing the problem they wish to address. This is a dynamic process that continues throughout the project period; as the group becomes more knowledgeable they continuously refine the problem statement/research question. During the initial weeks of the project period, much effort is put into researching the literature and identifying relevant gaps in existing knowledge in order to present a strong and concise argumentation leading to and emphasising the relevance of the actual research question.
- When the research question is established, the groups engage in reflection on methodology and research methods and make decisions on how to design the research process to best address this question.
- Some study programmes include specific peer learning and reflective activities in the form of midterm seminars/status seminars/opponent seminars, the analysis of metacognitive processes and writing of process reports. In seminar activities each group may be assigned an opponent group and an opponent supervisor, who are expected to provide constructive feedback on the project and the progress. Reflective activities are fruitful for the students as they receive valuable feedback, while through their feedback to other groups they simultaneously have an opportunity to reflect on their own work as well as the academic decisions and progress in their own projects.
- Finalising and submission of the project report, which may in some study programmes also contain artefacts such as physical models, pieces of software, prototypes etc.
- Oral examination in groups. The examination takes its point of departure in the project report. Generally, the oral exam is organised into several stages. First there is a round of individual student presentations related to the project and the project report. The presentation is followed by questions from the examiner, who is also the project supervisor. From the questions naturally flow joint discussions between the students and the internal and external examiners. The examination is conducted over an extended period of time, thus providing ample opportunity for the individual assessment of each student.
- Each student is given an individual grade, which is jointly decided by the internal and external examiners. The group is finally offered collective feedback on their project and their learning process.

Although the study programmes at Aalborg University follow these principles, research has shown that there is diversity in the implementation of the principles across the faculties and specific educations offered by the university (Kolmos et al. 2004). Furthermore, the principles of PBL at the university are continuously being developed to respond to the demands of advisory boards, employers and students. They must also meet challenges from governmental regulations (Krogh and Jensen 2013; Jensen and Krogh 2013; Laursen 2013) and international educational policy developments, such as the Bologna Process (Ravn and Jensen 2016; Jensen and Thomassen 2018).

In summary, the PBL principles mentioned create the overall framework for an interdisciplinary learning space. The scope of the curricular 'boundaries' for PBL projects are determined by the individual study programme, and it is then up to the students – supported by their supervisor – to take up the challenge of locating and defining the relevant problems and embark on (inter)disciplinary research processes.

2.5 PBL as a Pathway Towards Interdisciplinary Learning

In light of the demands placed on twenty-first century graduates to develop competencies to address and handle ill-defined problems, and considering the speed with which knowledge is emerging and becoming out-dated again, it seems relevant to investigate in detail whether *interdisciplinary learning* is indeed achieved through problem-based university education, and if so, what role interdisciplinarity might play in learning processes. In other words, we need to understand in greater detail if and how a problem-based setting enables interdisciplinary learning, and whether we need to design learning processes in particular ways to create and optimise interdisciplinary learning spaces.

The need to explore these questions is further reflected in the increasing number of higher education institutions adopting problem-based learning as their principal approach to student learning. The desire to transform pedagogies is often rooted in a desire to bring students in closer contact with 'real-world problems' and professions to enable a comprehensive contextualisation of university studies. In transforming into a PBL university or in adopting a PBL approach in specific study programmes, institutions consequently adopt an approach in which the actual learning processes are considered a strategy for contextualisation. PBL promotes interdisciplinary learning when students identify and delimit problems. It is in this process students must acknowledge the margins of disciplines and develop new vocabularies to adequately address the real world problems identified. Whether they delimit the project to only offer one particular perspective, or whether the problem calls for an interdisciplinary perspective to advance the understanding of the problem further, students need to defend their strategies and demonstrate their relevance. In this way, interdisciplinary learning presents itself as a possible part of many solutions that venture past the disciplinary boundaries of curricula.

As we have discussed, this interdisciplinary learning approach is possible when the identified problems are ill defined and not necessarily situated within a specific scientific paradigm. Instead, problems may be located within a politicised, uncertain, complex and to some extent undefined or unstable aspect of the world, and may be formulated around inputs from commentators, politicians, experts, scientists, citizens, professionals of different kinds etc.

The situated and contextualised character of a problem might initially and intuitively lend itself to a 'traditional' monodisciplinary understanding and solution, but by allowing and encouraging students to frame the problem differently, and by giving them the freedom to choose the theory and methods for investigating their problem, the possibility of innovative and experimental approaches emerges, together with imagination and creativity in dealing with the problem. In this light, a problem-based approach to learning obviously opens up learning spaces conducive for interdisciplinary learning; however, as also becomes clear in the above, this will only happen in so far as students are given both encouragement and opportunity, as problem-based projects may also be defined well within disciplinary boundaries (Stentoft 2017). Consequently, the supervisor comes to play an important role in keeping the problem 'open' for as long as possible by supporting students to remain in the ambiguous and frustrating phase of discovering new perspectives. In order to truly facilitate interdisciplinary learning, the supervisor must therefore also be curious about new framings and unconventional approaches in theory and research methods, and must accept and be able to manage some degree of uncertainty regarding the students' work and the learning outcome of their process.

As an example, we can imagine how a project on planning the construction of a bridge in an engineering programme may entail multiple engineering computations, theories and approaches; however, the problem equally calls for understanding of the law relating to the positioning and dimensioning of the bridge, and of social science research that explains the potential use of the bridge and its impact on surrounding communities. The possibilities for interdisciplinary learning are thus considerable, and making active decisions regarding the approach form a significant part of what is, in PBL, considered learning.

Opening problem-based projects towards interdisciplinary learning can be seen as a particular way of conceiving of science as a toolbox with many different tools, such as methods and theories, which students can make use of. This way of conceiving of the function of interdisciplinarity in PBL as a juxtaposition of scientific domains is determined solely by the framing and definition of the problem to be addressed. Or put in other words, this view of science is clearly a break from discipline-oriented teaching and learning, and it places heavy demands on both students and teachers as they are challenged to distinguish between mono-, multi- and interdisciplinary learning as the various disciplines involved in a problem-based project do not simply work in parallel as separate perspectives. Rather, in order to fully comprehend the problem at hand, disciplines need to be merged and become entangled in ways that lift the knowledge constructed through the project work to new levels of abstraction.

2.6 Concluding Remarks

The discussion above about the educational conditions that support interdisciplinary learning in problem-based higher education has pointed to a number of key issues which need careful consideration. Thus there is a necessity of reflection on the conditions for doing interdisciplinary PBL projects in relation to:

- The complexity and capabilities of diverse and interdisciplinary student groups.
- The different types of audiences that define the logic of what is considered scientifically relevant knowledge.
- The potentially highly ambitious content of the notion of interdisciplinarity in contrast to mono- and multidisciplinary approaches, as exemplified above.
- The assessment criteria of interdisciplinarity in problem-based learning.
- The key role of the supervisor in relation to interdisciplinary processes.
- The challenges and requirements facing students engaging in interdisciplinary and problem-based learning.

The following chapters of the book will address these issues further. We have only highlighted here what we believe are the key areas for further research in order to get a firmer grasp on the role of interdisciplinarity in PBL and to obtain the means for supporting the further development of pedagogies supporting interdisciplinary learning. We started out by describing how interdisciplinary learning, like all other concepts, does not necessarily benefit from tight definitions, but may be understood by tracing its uses, connections and contexts. We do, however, need to develop a more refined vocabulary about what it actually means for students to work in an interdisciplinary manner to produce a fuller picture of what is really at stake when we use the word in relation to PBL.

References

Askehave, I., Linnemann, P. H., Pedersen, J., & Pedersen, M. T. (eds) (2015). *PBL – Problem Based Learning.* Aalborg: Aalborg Universitet. http://www.aau.dk/digitalAssets/148/148025_pbl-aalborg-model_uk.pdf

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. *New Directions for Teaching and Learning, 68*, 3–12.

Bowden, J., & Marton, F. (1998). *The university of learning: Beyond quality and competence*. London: Routledge.

Dewey, J. (2005). *Demokrati og uddannelse.* Klim.

DeZure, D. (2010). Interdisciplinary pedagogies in higher education. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 372–386). New York: Oxford University Press.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge. The dynamics of science and research in contemporary societies*. London: Sage.

Illeris, K. (1974). *Problemorientering og deltagerstyring: oplæg til en alternativ didaktik*. Odense: Fyens Stiftstrykkeri.

Jensen, A. A., & Krogh, L. (2013). *Potentials for further development of PBL strategies at Aalborg University*. In L. Krogh & A. A. Jensen (Eds.), *Visions – challenges – strategies, PBL principles and methodologies in a Danish and global perspective*. Aalborg: Aalborg University Press.

Jensen, A. A., & Thomassen, A. O. (2018). Teachers' reflective practice in lifelong learning programs. In Z. Djoub (Ed.), *Fostering reflective teaching practice in pre-service training*. IGI Global.

Klein, J. T. (2012). A taxonomy of interdisciplinarity. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity*. Oxford: Oxford University Press.

Kolmos, A., Fink, F. K., & Krogh, L. (Eds.). (2004). *The Aalborg PBL model. Progress, diversity and challenges*. Aalborg: Aalborg University Press.

Krogh, L., & Jensen, A. A. (2013). *The development of PBL methodologies in Denmark and current challenges*. In L. Krogh & A. A. Jensen (Eds.), *Visions – challenges – strategies, PBL principles and methodologies in a Danish and global perspective*. Aalborg: Aalborg University Press.

Laursen, E. (2013). PPBL: A flexible model addressing the problems of transfer. In L. Krogh & A. A. Jensen (Eds.), *Visions, challenges and strategies: PBL principles and methodologies in a Danish and global perspective* (pp. 29–45). Aalborg: Aalborg University Press.

Lyotard, J. F. (1984). *The postmodern condition: A report on knowledge*. Manchester: Manchester University Press.

Majeski, R., & Stover, M. (2005). Interdisciplinary problem-based learning in gerontology: A plan of action. *Educational Gerontology, 31*(10), 733–743.

Mansilla, V. B. (2010). Learning to synthesize: the development of interdisciplinary understanding. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 288–306). Oxford: Oxford University Press.

Miller, C. A. (2010). Policy challenges and university reform. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 333–344). New York: Oxford University Press.

Nowacek, R. S. (2009). Why is being interdisciplinary so very hard to do? Thoughts on the perils and promise of interdisciplinary pedagogy. *College Composition and Communication, 60*(3), 493–516.

Ravn, O., & Jensen, A. A. (2016). PBL and the postmodern condition: Knowledge production in university education. *Journal of Problem Based Learning in Higher Education, 4*(1), 38–52.

Savin-Baden, M., & Major, C. H. (2004) *Foundations of Problem Based Learning*. Society for Research into Higher Education & Open University Press.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *The Interdisciplinary Journal of Problem-based Learning, 1*(1), 9–20.

Servant, V. F. C. (2016). *Revolutions and re-iterations: An intellectual history of problem-based learning*. PhD thesis, Erasmus University, Rotterdam.

Stentoft, D. (2017). From saying to doing interdisciplinary learning – Is PBL the answer? *Active Learning in Higher Education, 18*(1), 51–61.

Stentoft, D. (2016). Tensions and Co-existence: Exploring multi-facetted articulations of intentions of problem-based learning in higher education. *Academic Quarter, 14*, *67–79*.

Sternberg, R. J. (2008). Interdisciplinary problem-based learning: An alternative to traditional majors and minors. *Liberal Education, 94*(1), 12–17.

The Council of European Union. (2017). Council recommendation of 22 may 2017 on the European qualifications framework for lifelong learning and repealing the recommendation of the European Parliament and of the Council of 23 April 2008 on the establishment of the European Qualifications Framework for Lifelong Learning. (2017/C 189/03). *Official Journal of the European Union.*

Chapter 3
Trust Me, I'm 'The Doctor': Bridging Disciplinary Education and Interdisciplinary Professionalism

Patrik Kjærsdam Telléus

3.1 Introduction

Interdisciplinarity seems to find its greatest endorsement outside the university and away from traditional educational programs. PBL is a pedagogical approach that is applied at universities and integrated with educational programs. This undoubtedly carries the potential for disharmony, misunderstanding, and a wide range of other problems.

Medicine is a classical university educational program; in the profession or practice of medicine, however, the interdisciplinary perspective is easily traceable. In brief, students are trained in disciplinary medical programs, transforming them into physicians; subsequently, they are asked to practice medicine within a modern health care system with interdisciplinary tendencies and pursuits, such as patient-centred medicine, with supplementary responsibilities and overlapping tasks and capabilities. This presents the challenge of navigating and making sense of inconsistent and sometimes conflicting capabilities, norms, and traits; this is problematic with regard to expectations and evaluations of behaviour, procedures, and character from the society at large.

Because some regard PBL as having been conceived in the field of medical education, and as PBL is indeed relatively widely practiced in medical education, it seems logical to conclude that the field of medicine is a good place to investigate the challenges of disciplinary demands and interdisciplinary desires. Therefore, we start by getting to know 'The Doctor'.

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3.2 Getting to Know The Doctor

Everybody knows what a doctor is and what a doctor does. As children, we play the role of doctor, using our dolls, siblings, or grandparents as patients. As we grow up, we are surrounded by cultural images and characters portraying doctors. In addition, if these imaginary ones are not enough, we are confronted by the real thing during regular check-ups, while rushing to the hospital with a fever-stricken child, or when discussing treatment options for our dying parents. In all of our lives, from cradle to grave, The Doctor makes consistent guest appearances.

So, who is this Doctor? In a clear and simple way, The Doctor is one who takes care of the sick and the needy. He/she has the skills and knowledge to cure that which needs curing, and has the compassion and empathy to care for that which needs caring for. These skills are acquired through education and experience. The Doctor is a skilful and virtuous person, in whose capable hands we place our fate when necessary. This is the image we hold and project.

However, the world we inhabit is not a world of images. It is a world of people, with the associated complexity of actions, presumptions, emotions, collaborations, decisions, responsibilities, demands, and so forth. In this world, the concept of The Doctor is not gathered into one individual, but rather divided and collectively shared by many actors, professions, and institutions. However, there are also individuals who obtain university degrees in medicine and go on to practice the profession of medicine as doctors. These people are, on the one hand, merely a specific, but important, part of the modern structure of health care, or systemized health care. On the other hand, due to the name and history of their profession, they also face the expectations inherent in the general concept of The Doctor.

3.3 Educating Doctors: Part 1

In the education of doctors in our modern Western societies, emphasis is placed on training in the technical and analytical skills and the acquisition of scientific knowledge necessary to cure. For this purpose, higher education has developed the epistemic and disciplinary field of medicine and introduced the acquired degree and profession of the physician (Lempp 2009). For some time, various voices have decried the state of health care, claiming that the care dimension has been lost from professional medical practice (Toulmin 1982) or that, to put it another way, humanity is being lost during the doctor's transformation to physician (Wilson 2011; Wackerhausen 2002). Such arguments have led to a call for and the subsequent introduction of elements such as ethics, communication, and sociology into the curriculum of medical education (Brosnan and Turner 2009).

To continue with the concepts introduced above, these attempts are forms of (re-) introducing the idea of The Doctor into the education of physicians. This is not a

straightforward game to play, because educating physicians takes place within the discipline of medicine, while ethics, communication, and sociology are disciplines in themselves that reward individuals who study them with degrees in those fields. This creates the somewhat paradoxical and challenging situation of trying to have a plurality of disciplines within a singular disciplinary curriculum.

At the same time, it seems unfair to medical students to declare that their discipline must include or incorporate all these other disciplines. In other words, the idea of The Doctor transcends several disciplinarily defined fields of knowledge and competency, forming a holistic image that, from an educational point of view, demands more than medical study programs can reasonably unite under the traditional educational concept of the physician (Dijkstra et al. 2010).

The easy solution would be to claim that the dimension of care, or of humanity, does not need to be taught. It is simply regarded as naturally present. However, if that were the case, why would the issue have been raised in the first place? When we look for and ask for humanity in health care the 'naturalistic' stance is not enough. Instead we are faced with a complexity as broad and diverse as the complexity of the cure dimension (Holm 2011; Kotzee and Ignatowicz 2016).

As I have briefly sketched, the disciplinary education of physicians, even when such programs attempt to require some form of all-inclusive conceptualization, is unable to fully adhere to the professionally situated concept of The Doctor. In short, we have modern health care, consisting of disciplinarily trained professionals, where the dimensions of 'cure' and 'care' are represented by several different yet intertwined actors. This is often conceptualized as a multidisciplinary structure with well-defined and specified tasks for each profession. The most famous example is of course echoed in slogans such as 'doctors cure and nurses care' (Telléus et al. 2018). However, the 'wholeness' of the health care structure and its tasks, represented by the concept of The Doctor, is also unavoidably attached to the particular performance of the professional physician. This gives rise to criticism of physicians, due to inadequacies and misunderstandings. As a result, the finger circularly points (back) at the education of these physicians.

Here, educators face the challenge of constructing a medical education that adheres to the disciplinary training of physicians, since that is required by the health care structure, but that at the same time prepares medical students for the interdisciplinary demands that come with the concept of The Doctor. One way to do this, as we will see later, is by introducing PBL.

Fortunately, in the practice of modern systemized health care, this interdisciplinary perspective is already emerging. We see this as health care institutions move towards more cross-disciplinary teamwork, patient-centred medicine, and the flexible redistribution of previously stationary responsibilities and tasks (Brown et al. 2011; Engel and Prentice 2013). The same interdisciplinary perspective is also gaining strength with regard to health care research (Hesse-Biber 2016), and to some degree in the field of education (McNair 2005).

3.4 Interdisciplinarity and Disciplinarity

Dictionaries, like Merriam-Websters dictionary, The Oxford Dictionary, Thesaurus and The Cambridge Dictionary, all fairly unanimously define 'interdisciplinarity' as 'the involvement of two or more disciplines (or areas of knowledge, learning, etc.)'. To understand that definition, we need to understand what a discipline is.

In philosophy, there is a long tradition of criticism of the purity of the disciplinary conceptualization on the basis that 'objects in the world' appear to be anything but disciplinarily comprehensible, and on the basis of the disciplinary forgetfulness of practice (Quine 1978; Winch 1990; Bourdieu 2000). We can also note that most traditional disciplines break up into parallel tracks, creating a pluralism of disciplinary specializations, which blurs or complicates the unified epistemic subject (and often the assumed ontological object) of the discipline. One of the first to describe disciplines as not being defined by epistemic subjects as such, but rather defined through human activities and human cohesions, was the German sociologist Ludwig Fleck. In 1935 he described the idea of scientific disciplines, not from the perspective of a unifying object of study (i.e. an epistemic subject equivalent to an ontological object in the world), but in terms of unifying styles of mind/thinking and what he called thought collectives (Fleck 1997/1935).

Even though the criticism of disciplinarity results in the loss of some scientific authority in regard to the subject matter, the disciplinary perspective still remains important in terms of institutional and individual value, as an identification mark for acknowledgment of degrees, competencies, consistencies, values, structures, and labels. This is nicely summarized by Howard Gardner in his concept of the 'disciplined mind'. He states, '*The disciplined mind* has mastered at least one way of thinking – a distinctive mode of cognition that characterizes a specific scholarly discipline, craft, or profession' (Gardner 2006, p. 3).

Thus by disciplinary we mean an identifiable category that is expressed as a formally constituted part of the institution of science and science education, as well as in the form of a specific state of mind and scholarly competencies. There are, obviously, other uses of the term and other definitions (Turner 2006; Krishnan 2009) as well as criticism, with some commentators going so far as to proclaim the death of disciplines in the name of post-modern anti-disciplinarity (Forman 2012). Others, in the face of 'wicked' problems, are calling for new conceptions of scientific ventures like cross-disciplinarity and transdisciplinarity (Bernstein 2014). However, it appears that as long as we have educational institutions awarding degrees and structuring themselves according to departments and faculties, and as long as we have a work environment and workforce consisting of distinctively defined professions, disciplines and disciplinarity will remain.

3.5 Interdisciplinarity and Multidisciplinarity

According to the above-mentioned definition, 'interdisciplinary' means the involvement of at least two disciplines. In this sense, 'disciplinary' is not the opposite of 'interdisciplinary', although it is defined as being distinct from it. Therefore, we might benefit from considering another element of the definition and looking more closely at what exactly the 'involvement' of disciplines means. In order to do that, I will make use of the distinction between interdisciplinary and multidisciplinary.

Multidisciplinarity is defined in similar terms as is interdisciplinarity. However, in definitions of multidisciplinarity, instead of 'involving' we find terms like 'combining', 'drawing from', and 'making use of'; these verbs have slightly different meanings than 'involving'. The difference becomes clearer when we look at how multidisciplinary groups or teams are defined. From these we can conclude that multidisciplinarity is a composition of disciplines that adheres to and confirms the individual disciplines' particular knowledge domains, specialized skills, and competencies. A multidisciplinary team is composed of disciplinary experts.

The academics writing on these topics also explain the distinction between interdisciplinary and multidisciplinary as the latter being the juxtaposition of disciplines into some form of fractional, partially supporting or linking plural structure, while the former is the synthesis or merging of different disciplines to form a singularity (Frodeman 2014, p. 35). Buanes and Jentoft (2009) give a typical example of how the difference is interpreted: they describe multidisciplinarity as adding one perspective to another (one by one) and looking at one part at a time, while interdisciplinarity is characterized as 'building bridges' from 'a bird's eye' view or an integrating perspective. In their article there is also a poorly hidden normative tone implying that interdisciplinarity is deeper and more authentic, in essence, that it is better. This normative classification is also mirrored in classic typology of different forms of '-disciplinarity', showing interdisciplinarity to be of a higher order than multidisciplinarity (Stember 1991).

3.6 Interdisciplinarity and Problem Orientation

A distinctive element in the literature defining interdisciplinarity is the focus on problems (Stember 1991; Schmidt 2008). The claim is that the problems of the world do not fit neatly into the disciplinary categories of the departments and faculties of science. This is especially the case for such wicked problems as climate change, population growth, and food production. To face these real, not simply academic, problems, multidisciplinarity is not enough, since that is merely an analytical way of providing different perspectives on a particular object of study. Instead, the problems need to be viewed in a fresh, new fashion that is not tied to or guided by one particular perspective or analytical approach; the literature implies that such a new perspective will somehow immediately or 'naturally' grasp the

wholeness and the realness of the problem (Bernstein 2014; Buanes and Jentoft 2009; Frodeman 2014).

This further defining characteristic of interdisciplinarity, which we might recognize as being problem-oriented, is connected to the idea of the integration of science and reality. This is not simply a question of knowledge, but also a question of motifs, interests, practices, and even economy (Schmidt 2008). Frodeman (2014) summarizes all these elements in one concept, called audience, drawing a distinction between sciences that are enacted for their own sake, i.e. purely academic pursuits and evaluations (e.g. peer review), and sciences that are more applied and enacted for an audience outside academia. Some commentators, like Frodeman, can see that this interdisciplinarity of problem-orientation exists within classic disciplines, while others, such as Schmidt (2008), emphasize that the character of interdisciplinarity is most intense in new or more recent scientific ventures, such as bionics, econophysics, and neuroscience.

Regardless of the explicitness of this change in the processes and products of science, it is clear that talk of interdisciplinarity is also a semantic signal of a particular change. If one reads an older piece on forms of '-disciplinarity', such as Blackwell (1955) (where the term interdisciplinarity does not appear), then the definition of multidisciplinarity fits quite well with the characteristics of interdisciplinarity. Here multidisciplinarity is defined by a merging quality of different disciplines, at the top in a hierarchy of research knowledge and, most importantly, as being problem-oriented. The difference between the terms, however, is that what Blackwell's definition lacks, and what categorically distinguishes interdisciplinarity and multidisciplinarity in a scientific context, is the non-academic interest and the practical value of interdisciplinarity. This could be an indication that much of the discourse around or promotion of interdisciplinarity is defined by an ideological and normative motif, that is, having an agenda 'to change, to renew, and to re-structure science' (Schmidt 2008, p. 58).

To conclude this brief look at interdisciplinarity, allow me to summarize the four distinct characteristics of interdisciplinarity; (1) it is the merger or synthesis of more than one discipline; (2) it is a normatively distinct form of scientific knowledge acquisition; (3) it is problem oriented; and (4) it is embedded in, and integrated with, a non-academic reality.

3.7 PBL and Interdisciplinarity

PBL means problem-based learning, and although the notion covers a range of slightly different approaches to education, there are some common traits and defining characteristics. Amongst the traits that constitute PBL are: (a) problem orientation (b) centred on student activity, including the opportunity for free inquiry; (c) collaboration, such as teamwork; and (d) integration of theory and practice (Savery 2006; Krogh and Jensen 2013).

To these characteristics we add that PBL often emphasizes its relevance for society by working with non-academically defined problems in collaboration with entities outside academia. Furthermore, PBL has the ability to attract and educate students without scholarly backgrounds and traditions (Illeris 1974; Nørreklit 1978). What PBL offers its graduates in terms of cognitive competencies is viewed as better or at least more in tune with the needs of society as a whole than what the traditional higher education has provided (Kjærsdam and Enemark 1994; Laursen 2004).

Presenting PBL in this fashion, as many researchers do, it should be obvious that interdisciplinarity and PBL share numerous characteristics and motifs. By that token, the conclusion that interdisciplinarity and PBL are compatible, and that PBL should be used to support education in interdisciplinary perspectives and competencies, seems quite reasonable.

Further backing can be found if we read, for example, Mansilla and Duraising (2007), who give us an excellent survey of what values, competencies, and qualities are looked for and evaluated when students' interdisciplinary work is assessed. We find performative knowledge, free elaboration, collaboration, integration, purpose fulfilment, and so on, all of which are qualities that can also be found in texts describing PBL. In the thorough review and introductory article on PBL by Hung et al. (2008), the extensive overview of studies shows that PBL enhances competencies that adhere to the demands of interdisciplinarity, such as collaboration, problem-solving, cognitive congruence, and active involvement.

However, although there is clear evidence for the possibility that PBL can support interdisciplinarity, it is just as clear that in order for this to be the case further conditions must be met. In this the PBL approach within university education comes up against the more fundamental structures of university education, leading to difficulties such as developing a proper and adequate mode of analysis (as analysis is integrated with disciplinary thinking and framing) and evaluating and judging students' performance and outcomes (again, a discipline-specific undertaking).

3.8 Some Problems On and Under the Surface

As stated here, proponents of both PBL and interdisciplinarity claim that problem orientation is essential to their definitions. But to what extent are these problems alike, and to what extent do the problem orientations mirror each other in a university setting?

Interdisciplinary problems, which are sometimes referred to as wicked, tend to be conceptualized as too complicated for a single discipline to handle; the claim is that no single disciplinary perspective can discover or define the problem (Tomkinson et al. 2009). Following this line of reasoning, the problem often appears by way of its urgency, by its incomprehensible consequences, or by its emergence as deficits, flaws, or anomalies across a broad palate of knowledge domains (theories) and practices (Rittel and Webber 1973).

In many PBL activities the problem analysis is important (Holgaard et al. 2014). However, in order for this analytical process to support the interdisciplinary perspective, it needs to be less analytical in nature, instead adhering to a form of experienced and unbiased complexity. This poses a great, almost paradoxical difficulty for a learning process and educational environment, because the unknown factor, namely the uncertainty of the issue, relates both to the problem itself and to the conditions for its discovery. How is it possible to provide the PBL student with the experience of complex problems and/or the capacity to comprehend the vast domains of knowledge and practices involved in a problem? Furthermore, how can students be provided with tools for 'naming and framing' without these tools being part of (i.e. adequate for) that which is to be named and framed?

These issues are required to consider in order for the students to simply be aware of the problem itself. The real difficulties start when the problem has been found and formulated, and must be approached and worked with. Here it becomes evident that if the analysis has been done too well, that is, if it is too analytical, then the most obvious way to handle the problem will be a multidisciplinary approach. This will likely mean tackling the elements that compose the problem one by one and combining them to form a coherent answer to the problem, as any multidisciplinary professional team would do. Thus the interdisciplinary process of approaching and working with the problem as an integrated, intertwined, and bridging process is a real challenge for a PBL approach in an academic setting.

One way of maintaining the combination of the interdisciplinary and PBL in the problem orientation is to keep the problem 'real' (that is, not academic). However, this brings us to another problem: what Frodeman calls 'audience'.

Disciplinary science (and scientific education) has a clear audience, by way of departments and institutions, positions and peer-reviewed journals and so on, all creating an identifiable domain of knowledge and knowledge production. In contrast, interdisciplinary science's audience is far more unclear, unstable, and unsystematically put together, making knowledge and knowledge production far more difficult to recognize and acknowledge. However, while disciplinary science drowns itself in overproduction and endless repetition, the outcome of interdisciplinarity is more likely to be useful or, as Frodeman calls it, sustainable, as it ventures into new arenas, answers to a great variety of stakeholders, and is not ashamed of staining or contaminating its knowledge with temptations or ingredients other than its own purity. Basically, interdisciplinary science has a wider and more profitable audience, but at the same time this audience is rather capricious in nature (Frodeman 2014).

The motifs and pursuits of PBL, such as its desire to integrate more stakeholders, its claim of usefulness, its free inquiry, and its reluctance to take on a departmental domain, seem nicely compatible with this interdisciplinary audience. However, PBL is an academic training program, and its students require acknowledgment and evaluation as part of being certified as scholars.

If we were to bring in the audience for interdisciplinary science to supervise and evaluate PBL students, the problem would be that with this audience comes the same capriciousness, the same unclear and unstable assessment. This would make

describing performance criteria difficult, composing a relevant and appropriate curriculum challenging, and maintaining a unified comprehension of the degree and certification problematic. All this would make it difficult for students to navigate as students (of something) or trainees (to become something); that is, they would be unable to identify, or thereafter describe, the knowledge and competencies required and expected of them.

Therefore, in order for the assessment of students to be acknowledged and certifiable you need a scientific audience. This means first and foremost scientists who are disciplinarily trained, because these are the types of scholars we promote within academia. This presents great challenges since the scientists, in the supervision and evaluation of interdisciplinary PBL students, must locate and endorse competencies and epistemic values that they do not themselves represent. Therefore, in the practice of PBL scientific education it seems much easier, as with understanding a problem, to take a multidisciplinary approach. With such an approach, educators can teach, supervise, and evaluate from their known and acknowledged disciplinary positions within the multidisciplinary composition.

Although interdisciplinarity and PBL appear to be nicely compatible in terms of their defined motifs and processes, the further understanding and application of these motifs and processes appears to create some difficulties, particularly when viewed at the interface between a professional reality outside academia and the academic university setting. Thus the idea of merging or bridging an interdisciplinary reality or profession with a PBL education is faced with unexpected challenges, such as ambiguities with regard to working in a problem-oriented manner and a lack of rigorous structure in the assessment of progress and results. With these general findings in mind, let us return to The Doctor.

3.9 Educating Doctors: Part 2

As mentioned above, in considering medical education and the modern health care profession, building a bridge between the two through PBL and interdisciplinarity seems to offer an obvious route to success. In Chio and Pak (2006) the state of modern health care is clearly outlined. They claim that we are able to distinguish between different forms of disciplinary teamwork, by being better at establishing the particular concerns and contents as well as by better framing the objectives and clarifying the problem at hand. Thus, the categories of multidisciplinarity, interdisciplinarity, and transdisciplinarity are used to comprehend the professionalism of a collaborative health care service. When it comes to medical education, Chio and Pak argue that problem orientation and teamwork have greater learning potential than has been previously acknowledged, and that these two pedagogical tools are equivalent to aspects of the professional conduct of health care. This idea is of course a cornerstone of the medical PBL approach.

It is a well-known claim that the PBL model (in one of its forms) originated in the field of medical education, when McMaster University in Canada introduced

cases as part of its curriculum in 1969. The idea was for students to work together in small groups, focusing on scrutinizing and comprehending the cases – essentially, learning to define the problem of the case, rather than simply solving the problem the case posed. Thus from the very beginning, PBL, with its problem orientation and group work, was a good fit for medical education. In later work, emphasis on student-centred learning, learning styles, and deep learning also emerged as auxiliary categories, strengthening the claim that PBL is an ideal match for the needs of the profession (Lyon 2009; O'Toole 2012). Strong arguments have also been produced from empirical studies showing that PBL medical programs are able to train for communication skills, organizational skills, and practical competencies that enable a better match between school and work in comparison to non-PBL graduate programs (Prince et al. 2005; Hung et al. 2008).

Criticism of the PBL approach in medical education has centred on a lack of traditional disciplinary skills; along the same lines, the most important complaint is a loss of a scientific methodology and knowledgebase in the medical profession (Sobel and Levine 2001; Savin-Baden 2004). However, a recent study showed that medical students had a significant increase in their academic achievement scores in basic and clinical science from a post-PBL perspective, allowing the researchers to conclude that PBL is equal or superior to traditional methods of developing cognitive ability (Niwa et al. 2016). Although I doubt that this traditionally based criticism will cease, in general it seems that the PBL pedagogy allows medical students to develop competencies and acquire knowledge vital to their future professional roles in the modern inter-professional health care system and service.

However, this successful bridging is based on certain analytical and plural assumptions about PBL and interdisciplinarity on both sides of the university walls: that competencies and knowledge are essentially problem-solving skills. That medical students acquire a toolbox that can be applied in the clinical setting, such as when a physician carries out a clinical analysis using analytical tools to navigate between abstract general knowledge and the specific, situated 'data' or information at hand (Hung et al. 2008). That the physician is viewed as part of a team and a health care structure, and that training in communication and self-directed learning are skills that allow the physician to navigate in this systematic plurality by identifying the relevant rules, roles, and functions (Alcock 2013).

However, these assumptions of analysis and plurality only work when the audience expects an analysis and when the composition is a distinct plurality, such as a traditional disciplinary science expects and a multidisciplinary approach comprehends. Thus, the discussion of interdisciplinarity and PBL does not necessarily remove the difficulties I describe in the beginning of this chapter, namely the difficulties arising from the image of The Doctor. The audience, which expects to see The Doctor, is not simply expecting an analysis; and The Doctor is a comprehension of something whole, something singular, and not that of a plurality, regardless of how well systemized or structured it may be. This is what may be referred to as the medical version of the previously described general problems of understanding what problem-oriented means and requires, and how to inform and enact a valid assessment of results and progress.

These general problems, and their medical version, appear as the similarities between core concepts of PBL and interdisciplinarity are positioned at the interface between inside and outside the walls of academia. However, instead of being bridging concepts that unite education and profession, they have continuously challenged us. As we contemplate medical education and the health care profession, the challenge is further unfolded. It is a question not only of bridging education and profession, but also of building a bridge to the public. To put it in another way, the profession is not a closed circle. It cannot rely solely on its own clarification and judgment, as it is also enacted and performed together with an influential third party, the public, in the form of patients, their families, politicians, and the media at large.

3.10 Where Do We Go from Here, Doctor Who?

We have seen that the medical student is disciplinarily trained due to the scientific and academic nature of the education, allowing the student of medicine to become a physician. As a professional, the physician enacts his or her knowledge and capabilities as part of modern health care. Modern health care has interdisciplinary tendencies, creating challenges for the disciplinary physician. One way of bridging these difficulties is to enforce a plural structure with clearly defined roles and functions in which the physician's role and function can be comprehended in a disciplinary fashion. This is a sound analytical (and thus scientific) approach for the physician who can form a bridge between the education and the profession. However, there is a third party in this structure who does not view health care as a plurality, nor views the physician as a mere part of a greater whole. To denote this position, I have introduced the metaphor of The Doctor.

At the same time, we have seen how modern university education is challenged by demands and requirements placed on their programs from outside the university. This is often seen in terms of a professionalism that includes vital interdisciplinary elements, which the traditional university (and thus scientific) educational programs cannot match. Hence, we see the emergence of PBL as a university pedagogy that better matches these demands and requirements, which is arguably visible in the joint core concepts defining PBL and interdisciplinarity. However, looking more closely at some of these concepts, what seemed so similar was in fact quite problematic as a bridge between education and profession. To illustrate these challenges, I spoke of the enactment of problem orientation and the assessment of results and progress.

Now, the point of this analogical exercise is to show that it is not enough to simply introduce PBL in university medical education. We must do so with an eye to mitigating the overlooked challenges of the idea of The Doctor. These challenges may become clearer to us by relating them to challenges of a more general kind in the relationship between PBL education and professional interdisciplinarity. We can sum these up thus: medical educators are facing the challenge of educating students in disciplinary schooling for a (scientific) professionalism in an inter-professional

setting (the art of analysis and plurality), while at the same time letting them develop an (human) interdisciplinary aptitude (the art of synthesis and singularity). PBL may be one way to meet this challenge, but for it to be successful it must not oppose disciplinarity, but rather incorporate it. It must find ways to enact and acknowledge the interdisciplinary potential within this disciplinary epistemic structure.

The key to the success of such a venture is not the students but the staff. Much of PBL research focuses on students – their experiences, their development, their difficulties, and their achievements – or on semester structures, facilities, and curriculum. I propose that we look more closely at the staff. The staff is the torchbearer of the discipline and the most direct link between the scientific and educational enactments of a university. The staff at a PBL university is therefore constantly faced with juggling the different demands and attributes of PBL's interdisciplinary attempts and scientific disciplinary standards.

This means that alongside disciplinary knowledge and competencies, staff should also promote and facilitate an interactive, collaborative form of competency and a collective and uncertain or ill-defined form of knowledge. Frodeman (2014) refers to this as sustainable knowledge, and calls for what we might interpret as philosophical competencies applied in a socially committed, problem-oriented approach. I have described something similar to this perspective as a form of Socratic inquiry (Telléus 2013), and others talk of reflective reasoning on the basis of a form of open curiosity instead of a specifically targeted critique (Carcasson and Sprain 2016; McGreavy et al. 2016).

For medicine, this means medical educational programs applying PBL should ensure their staff is composed of teachers from different disciplinary backgrounds but is not strictly divided according to the needs of specific courses and exams. Rather, the programs should foster an integrated, dialogue-based structure in the usage and assignments of the staff. This could be the focus, for example, in sessions and processes on problem orientation. The staff should learn to respect and acknowledge the collaborative and collective perspective that PBL and interdisciplinarity confer, while at the same time remaining firmly planted in their own disciplines. This is certainly no easy task. However, the ability of the staff to do this is a key component in enabling students to simultaneously develop both their disciplinary and interdisciplinary characters. Perhaps the biggest challenge in this regard is for staff to realize that although they are, unavoidably, role models, they should encourage their students to grow into something different than themselves.

References

Alcock, G. L. (2013). Quantifying reflection: Developing reflective competencies by profiling student reflection on initial exposure to collaborative PBL learning. In L. Krogh & A. A. Jensen (Eds.), *Visions, challenges and strategies – PBL principles and methodologies in a Danish and global perspective* (pp. 299–312). Aalborg: Aalborg University Press.

Bernstein, J. H. (2014). Disciplinarity and transdisciplinarity in the study of knowledge. *Informing Science: The International Journal of an Emerging Transdiscipline, 17*, 241–273.

Blackwell, G. W. (1955). Multidisciplinary team research. *Social Forces, 33*(4), 367–374.
Bourdieu, P. (2000). *Pascalian meditations*. Cambridge: Polity Press.
Brosnan, C., & Turner, B. S. (Eds.). (2009). *Handbook of the sociology of medical education*. London: Routledge.
Brown, J., Lewis, L., Ellis, K., Stewart, M., Freeman, T. R., & Kasperski, M. J. (2011). Conflict on interprofessional primary health care teams – Can it be resolved? *Journal of Interprofessional Care, 25*(1), 4–10.
Buanes, A., & Jentoft, S. (2009). Building bridges: Institutional perspectives on interdisciplinarity. *Futures, 41*, 446–454.
Carcasson, M., & Sprain, L. (2016). Beyond problem solving: Reconceptualizing the work of public deliberation as deliberative inquiry. *Communication Theory, 26*, 41–63.
Chio, B. C. K., & Pak, A. W. P. (2006). Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. *Clinical and Investigative Medicine, 29*(6), 351–364.
Dijkstra, J., van der Vleuten, C. P. M., & Schuwirth, L. W. T. (2010). A new framework for designing programs of assessment. *Advancements in Health Science Education, 15*, 379–393.
Engel, J., & Prentice, D. (2013). The ethics of interprofessional collaboration. *Nursing Ethics, 20*(4), 426–435.
Fleck, L. (1997, org. 1935). *Uppkomsten och utvecklingen av ett vetenskapligt faktum – Inledning till läran om tankestil och tankekollektiv*. Stockholm: Brutus Östlings Bokförlag Symposion.
Forman, P. (2012). On the historical forms of knowledge production and curation: Modernity entailed disciplinarity, postmodernity entails antidiscplinarity. *Osiris, 27*, 56–97.
Frodeman, R. (2014). *Sustainable knowledge: A theory of interdisciplinarity*. New York: Palgrave Macmillan.
Gardner, H. (2006). *Five minds for the future*. Boston: Harvard Business School Press.
Hesse-Biber, S. (2016). Doing interdisciplinary mixed methods health care research: Working the boundaries, tensions and synergetic potentials of team-based research. *Qualitative Health Research, 26*(5), 649–658.
Holgaard, J., Ryberg, T., Stegeager, N., Stentoft, D., & Overgaard Thomassen, A. (2014). *PBL – Problembaseret læring og projektarbejde ved de videregående uddannelser*. Frederiksberg: Samfundslitteratur.
Holm, S. (2011). Who should decide the content of professional ethics. *Journal of Applied Ethics and Philosophy, 3*, 1–8.
Hung, W., Jonassen, D. H., & Liu, R. (2008). Problem-based learning. In J. M. Spector, J. G. van Merriënboer, M. D. Merrill, & M. Driscoll (Eds.), *Handbook of research on educational communications and technology* (pp. 485–506). Mahwah: Erlbaum.
Illeris, K. (1974). *Problemorientering og deltagerstyring – Oplæg til en alternativ didaktik*. København: Munksgaard.
Kjærsdam, F., & Enemark, S. (1994). *The Aalborg experiment: Project innovation in university education*. Aalborg: Aalborg University Press.
Kotzee, B., & Ignatowicz, A. (2016). Measuring virtue in medicine. *Medicine, Health Care and Philosophy, 19*, 149–161.
Krishnan, A. (2009). *What are academic disciplines? Some observations on the disciplinary vs. interdisciplinary debate* (Nation Centre for Research Methods Working Paper Series No. 3). Southampton: University of Southampton.
Krogh, L., & Jensen, A. A. (Eds.). (2013). *Visions, challenges and strategies – PBL principles and methodologies in a Danish and global perspective*. Aalborg: Aalborg University Press.
Laursen, E. (2004). Problem-based learning as a way of organizing learning and teaching at the university. In A. Kolmos, F. K. Fink, & L. Krogh (Eds.), *The Aalborg PBL model – Progress, diversity and challenges*. Aalborg: Aalborg University Press.
Lempp, H. (2009). Medical-school culture. In C. Brosnan & B. S. Turner (Eds.), *Handbook of the sociology of medical education* (pp. 71–88). London: Routledge.

Lyon, M. L. (2009). Epistemology, medical science and problem-based learning: Introducing an epistemological dimension into the medical-school curriculum. In C. Brosnan & B. S. Turner (Eds.), *Handbook of the sociology of medical education* (pp. 207–224). London: Routledge.

Mansilla, V. B., & Duraising, E. D. (2007). Targeted assessment of students' interdisciplinary work: An empirically grounded framework proposed. *The Journal of Higher Education, 78*(2), 215–237.

McGreavy, B., Druschke, C. G., Sprain, L., Thompson, J. L., & Lindenfeld, L. A. (2016). Environmental communication pedagogy for sustainability: Developing core capacities to engage with complex problems. *Applied Environmental Education & Communication, 15*(3), 261–274.

McNair, R. P. (2005). The case for educating health care students in professionalism as the core content of interprofessional education. *Medical Education, 39*, 456–464.

Niwa, M., Saiki, T., Fujisaki, K., Suzuki, Y., & Evans, P. (2016). The effects of problem-based learning on the academic achievements of medical students in one Japanese medical school, over a twenty-year period. *Health Professions Education, 2*(1), 3–9.

Nørreklit, L. (1978). *Problemorienteret forskningspraksis og den reale virkelighedskonstitution: En dialektisk realistisk belysning af problem – videnskab – samfund*. Aalborg: Skriftserie for videnskabsteori ved Aalborg Universitetscenter.

O'Toole, G. (2012). *Communication: Core interpersonal skills for health professionals* (2nd ed.). Chatswood: Elsevier/Reed International Books.

Prince, K., van Eijs, P., Boshuizen, H., van der Vleuten, C., & Scherpbier, A. (2005). General competencies of problem-based learning (PBL) and non-PBL graduates. *Medical Education, 39*, 394–401.

Quine, W. V. (1978). Facts of the matter. *The Southwestern Journal of Philosophy, 9*(2), 155–169.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in general theory of planning. *Policy Sciences, 4*, 155–169.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning, 1*(1), 9–20.

Savin-Baden, M. (2004). Understanding the impact of assessment on students in problem-based learning. *Innovations in Education and Teaching International, 41*(2), 223–233.

Schmidt, J. C. (2008). Towards a philosophy of interdisciplinarity: An attempt to provide a classification and clarification. *Poiesis & Praxis, 5*, 53–69.

Sobel, B. E., & Levine, M. A. (2001). Medical education, evidence-based medicine and the disqualification of physician-scientists. *Experimental Biology and Medicine, 226*, 713–716.

Stember, M. (1991). Advancing the social sciences through interdisciplinary enterprise. *The Social Science Journal, 28*(1), 1–14.

Telléus, P. K. (2013). On rational demand: A sensible answer to the request for ethical awareness within the Aalborg Model. In L. Krogh & A. A. Jensen (Eds.), *Visions, challenges and strategies – PBL principles and methodologies in a Danish and global perspective* (pp. 315–333). Aalborg: Aalborg University Press.

Telléus, P. K., Holdgaard, D. M., & Thørring, B. (2018). Physicians and caregivers *do* differ in ethical attitudes to daily clinical practice. *Clinical Ethics, 13*(4), 209–219. https://doi.org/10.1177/1477750918790005.

Tomkinson, B., Engel, C., & Tomkinson, R. (2009). *Dealing with global wicked problems: An inter-disciplinary approach* (Collected essays on learning and teaching: Vol. 2: A world of learning, pp. 24–32). Hamilton: Society for Teaching and Learning in Higher Education.

Toulmin, S. (1982). How medicine saved the life of ethics. *Perspectives in Biology and Medicine, 25*(4), 736–750.

Turner, B. S. (2006). Discipline. *Theory, Culture and Society, 23*(2–3), 183–186.

Wackerhausen, S. (2002). *Humanisme, professionsidentitet og uddannelse – I sundhedsområdet*. Copenhagen: Hans Reitzels Forlag.

Wilson, D. (2011). Creating the 'ethics industry': Mary Warnock, in vitro fertilization and the history of bioethics in Britain. *BioSocieties, 6*(2), 121–141.

Winch, P. (1990). *The idea of a social science and its relation to philosophy* (2nd ed.). London: Routledge.

Chapter 4
Beyond the Two Cultures. PBL and Transgressive Interdisciplinarity in the Techno-Anthropology Programme

Maja Hojer Bruun

4.1 Introduction

In 1959, in his famous and controversy-provoking lecture 'The Two Cultures', the British scientist, novelist, and civil servant C. P. Snow addressed what he considered an important problem in modern society and particularly in academia: intellectual life in the whole of the Western world had split into two distinct cultures that were separated by a 'gulf of incomprehension' and therefore could no longer 'think with wisdom' (Snow 1960). The 'cultures' are the 'scientific culture' of the natural sciences and the 'traditional culture' of the literary sciences, or, more broadly speaking, the humanities. The reasons they had grown apart were, according to Snow, to be found in the educational system. It had become too specialised and elitist, preventing scholars from talking to each other, from seeking mutual understanding, and thus from making sense of the world around them.

In a highly original discussion of academic disciplines and 'disciplinarity', set against the background of a surge of interest in interdisciplinary research at the turn of the twenty-first century, professor of social and political theory Thomas Osborne (2013, p. 84) asks, sarcastically, who would 'reveal themselves to be moronic enough', after several decades of actor-network theory, to resurrect the idea of the two cultures? There are several reasons why I use Snow's lecture[1] as a starting point for a discussion of PBL in interdisciplinary educational programmes. The two cultures must not be seen as cultures in any anthropological sense; however, there are different methodologies, epistemologies, and ways of knowing and doing things in academic work that matter and need to be addressed. These differences are

[1] For a discussion of the lecture itself and the reactions to it, see Collini (1993).

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reproduced in all kinds of organisations in which university students are later employed and use their academic skills.

Over the past decades, several new interdisciplinary fields and educational programmes have been created to bring together the modes of thinking in the natural sciences and the human and social sciences. These include entire international fields, such as public health science and environmental studies, and smaller initiatives at the national level, such as the Techno-Anthropology programme at Aalborg University, Denmark, which serves as a case in this chapter. The Techno-Anthropology programme was created in 2010 as a collaboration between the Faculty of Science and Engineering and the Faculty of Humanities, with the intention of enabling a new generation of scientists and professionals to take part in shared conversations among diverse professional groups and to work together on some of our time's great challenges, e.g. the transition to renewable energy, sustainable waste management, and healthcare for all, by bridging the human-technology gap (Børsen 2014). Epistemological differences are, on the one hand, taken for granted in the Techno-Anthropology programme, e.g. when students learn about different 'expert cultures', and on the other hand transgressed, e.g. when modules are taught and supervised by engineers, anthropologists, and philosophers of science working together.

Snow admitted that dividing anything into two parts is dangerous. I see the two cultures primarily as a metaphor, a shorthand for larger problems of mutual incomprehension, not only in academic circles but also in other societal institutions, problems that need to be addressed. I read the crude image of the two cultures optimistically, as an invitation for new departures, rather than as a road to essentializing differences. Thus, in this chapter I attempt to reach beyond the two cultures and focus on how engineering and anthropology can complement each other. The anthropologist Thomas Hylland Eriksen (2015) compares his own interdisciplinary collaboration – with a biologist, on selfishness – with the famous drawing that is at the same time a duck and a rabbit, or a 'duckrabbit', as sketched by Wittgenstein in *Philosophical Investigations*. Seen from different perspectives, in this case disciplinary perspectives, the drawing can appear either as a rabbit *or* a duck. The inability to see the 'duckrabbit' lies in the disciplines' limited phrasing of their questions. But in reality, Eriksen affirms, human beings and their social worlds are usually more like duckrabbits, not either or but both. For instance, it makes no sense to ask whether human beings are essentially selfish or altruistic, since selfishness always contains elements of altruism and vice versa. The aim of the Techno-Anthropology programme is to get beyond limited or dual approaches to socio-technical phenomena and to teach students how different – not merely two, but multiple – methodologies, epistemologies, and knowledge practices provide insight into different elements of the socio-technical duckrabbit.

In fact, Snow's lecture deals only superficially with the two cultures themselves; most of it is about the educational system and its effects on modern society. The problems of incomprehension, ignorance, and lack of mutual interest extend much further than a split between natural and human scientists. Snow accused *all* elitist academics at Cambridge and Oxford of being 'natural Luddites' and of not having honest interest in the benefits of technological development for society. They had

never, Snow claimed, been interested in the industrial revolution and the translation of scientific discoveries into industrial products, but were oriented exclusively towards pure science and were largely ignorant of how engineers make things work in the real world. They had no idea, he famously claimed, 'of how even the simplest things like buttons are actually produced'.

The educational system has changed a lot since Snow's days, for better and worse, both in regard to elitist and Luddite inclinations and the university's general interest in the application of science to industry and other sectors of society. Snow applauded the establishment of new universities in Britain in the 1960s and the integration of colleges of advanced technology with the university system. The founding of Aalborg University Centre in 1974 (from 1994 Aalborg University) echoed these developments. Aalborg University was conceived as interdisciplinary, with mandatory interdisciplinary courses for all first year students and an educational philosophy based on project-based PBL. In the Aalborg PBL model, students work with problems in real-life settings, often in collaboration with industry or other partners external to the university. Aalborg University thus seeks to bridge the gaps that Snow mentions: both the gap between disciplines and the gap between academic life and societal interests. Bridging these gaps is also the ambition of the BSc and MSc programmes in Techno-Anthropology. But the programme goes further by directly addressing interdisciplinarity and asking students to reflect on the ways in which science and scientific disciplines, as well as interdisciplinarity itself, have been historically produced.

Snow's lecture took place at the beginning of the Cold War, in the 'Sputnik years' characterised by modernisation and technological competitiveness. Large parts of the lecture are dedicated to comparing the British educational system with the American and the Russian systems to establish which was best equipped to meet the pressing need for technological development. The lecture also includes a whole section on how the contemporary scientific revolution would spread from rich to poor countries and help eradicate poverty in Africa, Asia, Latin America, and the Middle East. In short, a strong belief in modernity and progress radiates from Snow's lecture. Today, many speak of the 'fourth industrial revolution' or 'Industry 4.0' (Schwab 2017). The first industrial revolution employed steam engines and different kinds of mechanisation, the second revolution saw electricity and mass production, and the third computers and processes of automation. The fourth industrial revolution, ostensibly, brings together digital, physical, and biological systems, for instance with the Internet of Things, robots, artificial intelligence, genetic editing, and neurotechnical enhancement. All these developments are not only technologically challenging; they also call for new ways of social, economic, and cultural organisation. The term 'wicked problems' (Rittel and Webber 1973), encompasses complex technological-cum-social problems, such as universal healthcare and climate change. It emphasises that most problems are not just technological and cannot be solved by solely technological means, but rather require ethical and political debates and decisions. Techno-Anthropology students are encouraged to work on wicked problems. But wicked problems are also 'impossible problems' in the sense that they cannot be 'solved'. Thus, problem-based learning is not necessarily about 'solving' problems,

but rather about engaging a processual conception of problems whereby the *problematization* of particular situations may lead to new questions and new responses.

This chapter discusses, using the example of the Techno-Anthropology programme, how students in an interdisciplinary educational programme using a PBL approach can benefit from two different approaches to interdisciplinarity: a multidisciplinary mode where students learn to work with standard disciplinary ways of knowing and thinking, and a transgressive mode that allows students to develop new transgressive identities and subjectivities. Transgressive interdisciplinarity has the explicit goal to transcend 'antecedent disciplines' and to contest their epistemological and ontological assumptions in order to create new think- and work-spaces. My argument is that interdisciplinary educational programmes must be based on a strong awareness of the differences between modes of knowledge production and of defining and approaching problems. It is also important to be attentive to potentials and limitations of the different ways of knowing and doing things in order to bring the different modes of knowledge production into conversation and teach students to 'think with wisdom' in today's technological societies.

I build on Barry and Born's (2013) discussion of interdisciplinary research practices and what they call the 'agonistic-antagonistic mode' of interdisciplinarity to argue that students of Techno-Anthropology do not merely learn to reflect on epistemological differences between the 'cultures' of engineering and anthropology, the main two disciplines[2] central to the Techno-Anthropology programme. Rather, they engage in ontological and ethical endeavours that generate new transgressive knowledge practices and help to form new interdisciplinary think- and work-spaces. I start by laying out some of the differences between anthropology and engineering and the ways problems are conventionally conceptualised and approached in these disciplines. Students in the programme become acquainted with these disciplinary framings in what I call the multidisciplinary mode. I argue that anthropology and engineering are characterised by descriptive and prescriptive approaches to problems, respectively. In the next section, I provide more context about the Techno-Anthropology programme and how the students navigate the two modes of interdisciplinarity, which I call multidisciplinary and transgressive. In the last section I offer some examples of their concrete project work.

4.2 Anthropology and Engineering: Descriptive and Prescriptive Approaches to Problems

A look to history confirms that interdisciplinarity is not in fact a recent invention aimed at overcoming naturally existing disciplines. What we today understand as disciplines developed from interdisciplinary – or perhaps rather *un*disciplined – knowledge endeavours (Barry and Born 2013). Disciplines are the products of

[2] In spite of anthropology's and engineering's numerous and diverse sub-disciplines, I take the liberty in this chapter of presenting anthropology and engineering as 'disciplines'.

academic institutions and are reinforced by the organisation of university education into departments and faculties. Interdisciplinarity demands new institutional forms, policy interventions, instruments, materials, and research practices (ibid.). Engineering and anthropology are two of the disciplines that figure centrally in the Techno-Anthropology programme. Without going too deeply into the history of engineering and anthropology, both are relatively newcomers to universities and academic treatment. As Snow hinted in his lecture, engineering as the application of mathematics and the natural sciences was for a long time taught not in universities but in engineering colleges. In Denmark, the technical university DTU received university status in 1994, the same year that Aalborg University shifted from being a university centre to a university. The first anthropology programmes in the world were instituted at the beginning of the twentieth century in natural history museums and scientific expeditions (in Denmark in 1945 at the National Museum), which testifies to anthropology's hybridity and equally natural, material, social, and cultural concerns. In his institutional history of British anthropology, David Mills (2008) recounts the continuous negotiation between 'applied' and 'pure' approaches in the establishment of anthropology as a discipline, and how anthropology as a discipline sought to set itself apart from 'colonial administrators, amateur scholars, and museum curators'.

Taking my cue from Barry and Born's point that each interdisciplinary field must be analysed in its specific historic configuration, I outline below how engineering and anthropology are practiced in the Techno-Anthropology programme and are embodied by the group of researchers and scientists that teach in the programme. Anthropology is dedicated to understanding and describing human life in all its cultural variation. Since Bronislaw Malinowski (1922) formulated the principles of the ethnographic method for modern anthropology, anthropologists have sought to understand human lives through fieldwork and participation in contemporary local lives, from those of Trobriand islanders in the Western Pacific (ibid.) to Tanzanian refugee camps to urban American neighbourhoods, and even encompassing Laboratory Life (Latour and Woolgar 1986), Second Life (Boellstorff 2010), and other technologically mediated lives. Anthropology is based in a distinct contextualist and methodologically relativist philosophical stance that, in short, asks the anthropologist to take as little as possible for granted and to see and experience life from a native or insider point of view (Forsythe 2001). More than merely a study *of* people, contemporary anthropology means working and studying *with* people and acquiring local knowledge by sharing time and the conditions of their everyday life with them (Ingold 2011). This means that anthropological knowledge is always situated knowledge (Haraway 1988), or knowledge 'from somewhere', and does not lead to universal truths or judgements.

Anthropologists have made a virtue of not being normative in their descriptions of different cultures. Anthropology is the study of how life *is* – how it is experienced, practiced, or imagined by the people with whom anthropologists study – and not how it *should be*, according to the researchers' ideals or some general principle or model. Anthropology's phenomenological epoché (Jackson 1996) rejects an objective or rational approach to people's ideas and beliefs for the methodological sake of

understanding. Thus, an anthropological approach to a problem, or something that is considered a problem in the world, is to deconstruct it. To whom is it a problem? What *kind of* problem is it considered to be, according to the categorisations that are available in the present situation? Are there any alternatives, or muted or prohibited notions as to what else the problem could be? Anthropologists are trained to direct the same curious scepticism towards any solutions to the problem that may exist or emerge. Solutions can be seen as mechanisms of power through which notions of objectivity, rationality, or 'good' are expressed, and they demarcate particular spaces for action. Available solutions shape the way problems are perceived and create categories of what or who constitutes a problem (Jöhncke et al. 2004).

Engineering is the branch of science and technology concerned with the development and modification of engines, machines, structures, and other systems and processes using specialised knowledge or skills, typically for public or commercial use. Engineers take pride in applying their knowledge of science and mathematics and their empirical senses, practical skills, and logical thinking to find solutions to different technological problems (Holgaard et al. 2017). Like anthropology, engineering can be seen as a craft that requires not only intellectual scientific knowledge but also tacit knowledge, improvisation, intuition, language, and narratives (Forsythe 2001; Henriksen 2012). In many ways, study programmes in anthropology and engineering aim to teach candidates to 'think like' anthropologists and engineers, respectively, and to equip students with the knowledge and intellectual tools to do so. Both disciplines have diverse specialisations and cover a range of more or less applied approaches. In both disciplines there is a tendency for theories to be viewed primarily as tools, either to open our understanding of the world in all its complexity or to develop new practices and solutions for solving problems in the real world. The work of engineers is also situated and contextual, but even though epistemological reflections are part of engineers' professional practice, such reflections are not part of all engineering programmes' curricula.

Problem-solving and finding solutions lie at the core of engineering practice in all branches of engineering. Snow claimed that the natural sciences embody an optimism that scientific development leads to human progress, and that scientists have 'the future in their bones'. Engineers are born optimists; they are inclined to believe that aims can be met and problems can be solved until proven otherwise (Holgaard et al. 2017). They create models, test potential solutions, and attempt to predict how their inventions, designs, and constructions will perform. When engineers as inventors, designers, or innovators define and create technological objects, they simultaneously make hypotheses about the entities that make up the world into which their technological objects and creations are to be inserted (Akrich 1992). Whether or not they pay attention to this aspect of their work, engineers *inscribe* their visions of the world onto the technological objects they produce.

In the simplified view I adopt here, anthropology's approach to problems has largely been *descriptive*, laying out how problems and solutions are configured in the world without directly intervening to solve these problems, at least in the first phase of conducting fieldwork and seeking understanding. Engineers' solutions, on the other hand, are *prescriptive* of certain types of action, as their visions for the use of technological objects or systems are embedded in the objects or systems.

Both academic anthropology and engineering already address these rather simple and reductionist views. Postmodernist debates in anthropology have long challenged the notion of pure description, and anthropologists have in fact always been involved in different kinds of interventions, from the first colonial encounters to today's collaborative endeavours (Clifford and Marcus 1986; Faubion and Marcus 2009). Engineering faculties have built educational programmes where students linger on the problem analysis (Holgaard et al. 2017), and anthropology programmes have struggled with 'action, intervention, and decision-making barriers' (Hansen and Jöhncke 2013, p. 57)[3] that prevent anthropologists from turning achieved knowledge into concrete recommendations or plans for action. In the Aalborg PBL model, engineering students are already working with iterative processes of identifying complex problems, analysing these in context, and narrowing them before starting the problem-solving process, whereby they employ analytical skills from the humanities and social sciences (Henriksen 2012; Holgaard et al. 2017). Yet there are still some fundamental differences in the ways problems and solutions are approached and new knowledge is created that should not be glossed over but addressed, so that anthropology and engineering can complement each other. In the Techno-Anthropology programme this is done in two ways, which I call the multidisciplinary and transgressive modes of interdisciplinary learning.

4.3 Two Modes of Interdisciplinary PBL in Techno-Anthropology

The Aalborg PBL model involves problem-based project work over an extended period of time (usually one semester) where students work together in groups and direct their own learning process, including the iterative process of defining the problem on which they want to work (AAU 2015). Teaching takes the form of, on the one hand, guidance and facilitation of the problem-oriented group work and, on the other hand, courses, lectures, and seminars that support the students' group work by presenting theories and methods they can use in their project work. The goal of the Techno-Anthropology programme is to acquire competencies that allow students to 'participate in initiation, mediation, and facilitation of interdisciplinary team-based innovation processes' and 'participate in the management of complex work and processes related to the development of robust technological solutions that are professional and socially responsible' (Curriculum 2016). Most semesters include a project consisting of 15 ECTS (i.e. half of each semester's credits) on a theme outlined in the curriculum.

The first semester of the BSc programme offers a general introduction to problem-based learning, socio-technical understandings of technology, anthropology, and technology cases. The second semester topic bears the title 'Technology's Rationales', and the teachers are mainly engineers. In their group projects, the students work with the functions and institutional frameworks of particular sample

[3] All translations from Danish in this chapter are by the author.

technologies in a selected technology domain, for example energy systems. They learn to analyse a particular technology, such as wind turbines, to understand how this technology functions and to access relevant scientific and technological literature. They also learn to evaluate key processes of technology development, including institutional conditions, industrial dynamics, political regulations, and knowledge controversies. In the third semester, called 'Technology from an Anthropological Perspective', the students take a course in ethnographic methods and anthropological and socio-technical analysis, taught primarily by anthropologists and STS scholars, and carry out their first anthropological fieldwork exercises as part of their group project work. They spend a couple of weeks in an organisation or a company; among users, protesters or beneficiaries of technology; or among policymakers. They use anthropological methods to analyse the socio-cultural aspects of the production or use of a given technology, and to assess the technology's social, cultural, and ethical conditions and consequences.

Thus in the second and third semester the students work within the disciplines of engineering and anthropology and adopt a multidisciplinary approach (cf. Klein 2010). They learn how problems are addressed within different disciplinary frameworks and established knowledge practices, and they become acquainted with different modes of knowledge production and different genres of working, writing, and presenting problems and arguments. Furthermore, through readings and exercises they learn how engineers and anthropologists think and work, and they reflect on the disciplines' epistemologies and different types of knowledge production. A metaphor that students and teachers sometimes use for their acquired competencies is that they become 'liaison officers' with the ability to decipher and translate disciplinary thinking in different organisational settings. The metaphor of the liaison officer has associations with Isabel Stengers's (2011) notion of 'diplomacy' as a mode of knowledge production and as a new framework (Stengers speaks of 'ecology') for scientific practices. Both metaphors acknowledge borders and differences as well as exchanges across borders, but the function of Stengers's diplomatic knowledge is tied less to the diplomatic work between disciplines than to politics.

In the fourth to sixth semesters of the BSc programme, as well as in the MSc programme, students are expected to begin to develop new, techno-anthropological ways of working and thinking. Barry and Born (2013) distinguish among three modes of interdisciplinarity, namely (1) the 'integrative or synthesis mode', where interdisciplinarity is understood additively as the sum of disciplinary components, such as when social scientists are asked to add social factors to environmental research; (2) the 'subordination-service mode', where there is a clear hierarchy between different disciplines and, for instance, the 'correct' natural science definitions of problems are adopted; and (3) the 'agonistic-antagonistic mode', where the given disciplines and their epistemological assumptions are contested and transgressed. The agonistic-antagonistic mode has the explicit goal of transcending the 'antecedent disciplines' and contesting their epistemological and ontological assumptions. While I call the first two modes multidisciplinary, in that the disciplines are thought of as separate entities and as elements that can be combined or synthesised, the third mode is a transgressive mode of interdisciplinarity where students transcend disciplinary boundaries and create new think- and work-spaces.

In the first three semesters of the BSc programme, the interdisciplinary mode can be seen as either synthetic or hierarchical, depending on the semester project, but in the third year of the Techno-Anthropology programme students are expected to reflect antagonistically, or at least critically, on the production of knowledge in its different institutional and disciplinary framings, and to develop a truly new hybrid and relational understanding of technology and knowledge production. Technology is not understood as a fixed thing, or a phenomenon that is produced once and for all, nor are technologies understood only through socio-cultural frameworks; technologies are entangled socio-technical matters that involve an endless process of development and change, driven by a multitude of different actors, including the students themselves. The fourth and fifth semesters are called 'Design of an Intervention' and 'Technological Innovation through Intervention'; during these terms the students conduct another short fieldwork stint in an organisation, community, or workplace. At this chosen site or situation, they must design or closely follow an intervention, engage with relevant actors, and reflect on the processes, ethical issues, and methodological challenges they encounter as well as on their own role as student-researchers in the intervention.

In relation to the distinction between description and prescription presented in the last section, Madeline Akrich (1992) put forth another methodology, whereby technological objects are 'de-scribed'; that is, they are analysed in a direction opposite to the inscription by the engineer or designer. This kind of analysis demands a technical understanding of the technologies in question and of the social processes that produced them. According to Akrich and Latour (1992), it is possible to describe technologies in moments of crisis, when technology is broken, when it is moved to another location in time or space, or when experiments or interventions are set up. Participating in such situations and interventions, students of Techno-Anthropology also enter into processes of new technology inscription that are, ideally, based on a comprehensive understanding of technologies as hybrid socio-technical phenomena.

Below I will give some examples of how students of Techno-Anthropology use multidisciplinary and transgressive approaches to interdisciplinarity in their problem-based project work.

4.4 New Collaborations, New Knowledge Practices

One area of technological development that many students of Techno-Anthropology work in is the use of ICT (Information and Communications Technology) in the energy sector, especially the development of so-called 'smart' technologies that integrate digital systems in the electricity infrastructure to develop a 'smart grid'. Smart technologies and the smart grid demand and reinforce new social practices in relation to energy production and consumption, and thus lend themselves to Techno-Anthropological understandings of technology. The smart grid policy vision is that all energy production and consumption, heating, electricity, transport, and appliances are integrated in an Internet of Things that connects all households and

enterprises in a common infrastructure, enabling remotely or automatically controlled energy use. The term ‘smart’ glosses over larger complexities and wicked, or indeed impossible, problems, because no one really knows how smart technologies, with apps and digital platforms, accessible and visualised user data, flexible tariffs, and other techniques, can lead to better or more efficient energy practices.

Techno-Anthropology students have, over the last few years, worked on smart-grid systems in different ways in interdisciplinary projects. Several groups of students have conducted their projects on a particular international research and development project that develops and tests new smart-metre technologies to measure and visualise heating and indoor comfort in selected housing associations in Denmark and Sweden. The smart metres can read the inhabitants’ energy consumption remotely and visualise the data through different digital platforms available to individual residents, landlords, and service providers. These stakeholders can log on to the Internet or download apps that show their consumption – either real-time consumption data or aggregated data visualised with histograms. The goal of this technology is to reduce the inhabitants’ total energy consumption.

Groups of students in different semesters of the Techno-Anthropology programme have studied the smart metres, digital platforms, and related appliances in addition to the companies developing this technology, the smart-grid policy vision itself, and the organisational setup of the research project. One group explored the rationale behind the smart metres, which map households’ energy consumption and indoor climates through the collection of data, using a number of indicators such as temperature and humidity. According to the project’s logic, a visualisation of consumption data will lead to an understanding of the correlation between the data and the inhabitants’ everyday energy use, and will motivate them towards ‘more sustainable behaviour’. This particular logic, and the connections among visualisation, understanding, and behaviour change, is inscribed into the metres and visualisation platform, and prescribes certain behaviour (cf. Akrich 1992). The platform’s colour codes of green, yellow, and red, for good, less good, and bad, respectively, are designed to have persuasive effects on people’s behaviour (cf. Fogg 2003). Part of this inscription is a hypothesis about the entities, logics, and actions that make up a household and its heating consumption.

During their third-semester ethnographic fieldwork exercise, the students investigated how the metres and visualisation platforms were actually used by the residents in the housing associations. They visited a number of households and produced interviews and video tours of people’s flats. The students discovered that some of the residents, by mistake, had logged in to the metre manufacturer’s demo platform to look at their consumption measures instead of their personalised platform. In spite of this fundamental mistake, many of the residents had followed what they thought was their own consumption over time, and had in fact become aware of their own energy-related practices and had begun to change them, for example by adjusting their thermostats. When the students reported these results to the project management, and thus indirectly to the engineers, who were working from an established assumption about visualisation, understanding, and behaviour change, they opened a new way of understanding the relationships between technology and users,

where awareness and behaviour change are interrelated in ways different than designers assumed. In these two projects, the relationship between the involved disciplines can be characterised as hierarchical, because anthropological methods and epistemology dominated the fieldwork and analytical process, focusing either on the producers or users of the smart metres and their understanding of them.

A third student project linked to the same Scandinavian smart-metre development project transgressed the disciplinary frameworks for knowledge production and offered an example of the transgressive mode of interdisciplinary learning with PBL. The students organised a series of workshops with residents of one of the Danish housing associations and discussed, via games and cultural probes (Gaver et al. 1999), what indoor climate meant to them and what motivated them to participate in the smart-metre project. They found that, in addition to the incentive to save money on their energy bills, it was the feeling of being part of a collective, namely the housing association, and of exercising community co-determination that motivated the residents to participate in the project. This motivation extended to making the smart-metre technology work in their own settings and according to their local needs and conceptions of what constitutes good indoor climate and comfort. In the workshop, the students shared their knowledge interest with the residents, who became epistemic partners (Faubion and Marcus 2009) and changed the course of the students' project. New spaces for working and thinking emerged with the interventionist methods, and the technological object was transformed from 'being merely an object or product into something which (…) is locally situated, socially contextualized, encultured, and emotionally attached' (Barry and Born 2013, p. 23). The workshops, based on the principles of co-creation and participatory design, were in many ways antagonistic both to classical anthropological fieldwork and to engineering understandings of technology and technological development. In their project report the students wrote that as Techno-Anthropologists they sought to 'bring [their] technological literacy into the anthropology-driven design process by engaging [themselves] methodologically, and in this way to bridge the gap between experts, users, and artefacts'. Thus, one of the main achievements of the project was that it created a space for thinking and working with technology in new ways; in this sense the students of Techno-Anthropology should be likened more to constructors of *new spaces* than to liaison officers moving between separate 'territories' or 'cultures'.

4.5 Concluding Remarks

One of the typical pitfalls of interdisciplinary educational programmes is that students are defined by their shortcomings and deficiencies. This sometimes happens in the Techno-Anthropology programme as well, especially in those semesters where the students work in the multidisciplinary mode, with either one dominant discipline or a combination of different disciplinary elements; it is also especially likely to occur when students' work is assessed by teachers or examiners from the

'other discipline'. In fact, Techno-Anthropology students' teaching evaluations often bear witness to frustrating learning processes. It can be rather painful for the students to move from one semester to the next; they have just acquired an understanding of one disciplinary mode of knowledge production, with its quality standards, values, genres of communication and approach to the definition of problems, when they encounter new disciplinary demands and knowledge practices. It is, however, only through these encounters with and personal experiences of *difference*, and the students' active reflections on these experiences, that they get beyond a simplistic notion of two cultures and develop new, transgressive approaches. As a relatively new study programme, as well as a new research field, the students of Techno-Anthropology can be said to get much further ahead in the transgressive approach than their disciplinarily trained teachers, as they develop Techno-Anthropology as a professional identity. They themselves embody a new space for dialogue and thinking. The students' learning processes over time and their eventual embodiment of a transgressive mode of interdisciplinarity is a process full of frustration and feelings of failure, which are frequently reported in the first couple of semesters' student evaluations. The students report that they are disoriented and that they 'receive a lot of different messages', which is probably true. Also, working with wicked problems implies, as I have mentioned, working with impossible problems, that is, problems that cannot be solved. Over the course of the BSc programme and in the MSc programme, however, many students manage to rid themselves of the expectation that they can create 'new solutions'; instead they experience, like the group of students that organised workshops involving smart metres, experts, and users, that they can create new spaces for thinking, for asking new types of questions, and for challenging established understandings of culture and technology.

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References

AAU. (2015). *PBL. Problem-based learning*. Aalborg: Aalborg University.

Akrich, M. (1992). The De-scription of technical objects. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building societies*. Cambridge, MA: MIT Press.

Akrich, M., & Latour, B. (1992). A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building societies*. Cambridge, MA: MIT Press.

Barry, A., & Born, G. (2013). Interdisciplinarity. Reconfigurations of the social and natural sciences. In A. Barry & G. Born (Eds.), *Interdisciplinarity. Reconfigurations of the social and natural sciences*. London/New York: Routledge.

Boellstorff, T. (2010). *Coming of age in second life: An anthropologist explores the virtually human*. Princeton: Princeton University Press.

Børsen, T. (2014). Chapter 1: Identifying interdisciplinary core competencies in techno-anthropology: Interactional expertise, social responsibility competence, and skills in anthropology-driven design. In T. Børsen & L. Botin (Eds.), *What is techno-anthropology?* Aalborg: Aalborg University Press.

Clifford, J., & Marcus, G. E. (1986). *Writing culture: The poetics and politics of ethnography*. Berkeley: University of California Press.

Collini, S. (1993). Introduction. In *The two cultures. With an introduction by Stefan Collini*. Cambridge: Cambridge University Press.

Curriculum. (2016). *Curriculum for the master's program in techno-anthropology*. Aalborg: Aalborg University.

Eriksen, T. H. (2015). Want everybody should know about nature-culture. Anthropology in the public sphere and "the two cultures". In S. Beck & C. A. Maida (Eds.), *Public anthropology in a borderless world*. Berghahn: New York and Oxford.

Faubion, J. D., & Marcus, G. E. (Eds.). (2009). *Fieldwork is not what it used to be: Learning anthropology's method in a time of transition*. Ithaca: Cornell University Press.

Fogg, B. J. (2003). *Persuasive technology – Using computers to change what we think and do*. San Francisco: Morgan Kaufmann Publishers.

Forsythe, D. E. (2001). *Studying those who study us: An anthropologist in the world of artificial intelligence*. Stanford: Stanford University Press.

Gaver, B., Dunne, T., & Pacenti, E. (1999). Cultural probes. *Interactions, 6*(1), 21–29.

Hansen, A. L., & Jöhncke, S. (2013). *Omsat antropologi. En undersøgelse af det antropologiske arbejdsmarked i Danmark*. Antropologisk Analyse, Institut for Antropologi: Købehavns Universitet.

Haraway, D. (1988). Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies, 14*(3), 575–599.

Henriksen, L. B. (2012). The engineering project as story and narrative. In D. Jemielniak & A. Marks (Eds.), *Managing dynamic technology-oriented businesses: High-tech organizations and workplaces* (pp. 159–170). Hershey: IGI Global.

Holgaard, J. E., Petersen, L. S., Guerra, A., & Kolmos, A. (2017). Getting a hold on the problem in a problem based learning environment. *International Journal of Engineering Education, 33*(3), 1070–1085.

Ingold, T. (2011). *Being alive. Essays on movement, knowledge and description*. London/New York: Routledge.

Jackson, M. (1996). Phenomenology, radical empiricism, and anthropological critique. Introduction. In M. Jackson (Ed.), *Things as they are. New directions in phenomenological anthropology*. Bloomington: Indiana University Press.

Jöhncke, S., Svendsen, M. N., & Whyte, S. R. (2004). Løsningsmodeller. Sociale teknologier som arbejdsfelt. In K. Hastrup (Ed.), *Viden om Verden*. København: Hans Reitzels Forlag.

Klein, J. T. (2010). A taxonomy of interdisciplinarity. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity*. Oxford: Oxford University Press.

Latour, B., & Woolgar, S. (1986 [1979]). *Laboratory life: The social construction of scientific facts*. Princeton: Princeton University Press.

Malinowski, B. (1922). *Argonauts of the western pacific*. London: Routledge.

Mills, D. (2008). *Difficult folk? A political history of social anthropology*. Oxford/New York: Berghahn Books.

Osborne, T. (2013). Inter that discipline. In A. Barry & G. Born (Eds.), *Interdisciplinarity. Reconfigurations of the social and natural sciences*. London/New York: Routledge.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*, 155–169.

Schwab, K. (2017). *The fourth industrial revolution*. London: Penguin Random House.

Snow, C. P. (1960). *The two cultures and the scientific revolution* (The Rede Lecture 1959). Cambridge: Cambridge University Press.

Stengers, I. (2011). *Cosmopolitics II*. Minneapolis: University of Minnesota Press.

Chapter 5
Three Challenges for New Students Facing Problem-Based and Interdisciplinary Learning

Diana Stentoft

5.1 Setting the Scene

Dynamic societies; multifaceted challenges to the environment, health and stability; and ever-expanding access to information are all factors placing significant demands on the way we construct and deliver higher education. To meet these demands, the scope and aims of higher education have changed significantly over the past decades, from mono-disciplinary education towards well-defined professions to more hybrid and adaptable programmes where the exact nature of graduates' employment is uncertain and ever changing. Ramsden (2003) asserts that higher education must support students as critical thinkers, reflective learners and in being equipped to handle uncertainties and ever-changing scenarios. Thus universities can no longer exclusively be considered arenas where disciplines are handed down from professors to students. This is further reflected in the pressures facing the traditional role of the discipline. Where disciplines as defined through teaching and research were traditionally determinants for the production of knowledge and the organisation of the curriculum, the formation of knowledge today is not merely a matter for universities and disciplines. Instead, the emergence of problems and identification of needs for new applications have led research to move towards interdisciplinarity and transdisciplinarity (Weingart 2012). As Schon (1995) argues, practice must be recognised not only as an arena for applying knowledge but also as a place of knowledge generation; this in turn requires new institutional epistemologies in higher education. Thus on the educational side these changes pose challenges to pedagogy and curriculum, both in terms of adjustments to new ways of thinking and communicating knowledge and also in the way education incorporates knowledge produced outside of academia and at the intersections of disciplines.

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Because of its aspiration to bring real-life problems into higher education and research for scrutiny, resolution and analysis, a problem-based approach to learning has been adopted in many programmes and higher education institutions around the world. Problem-based learning (PBL) is often said to support interdisciplinary learning (e.g. Savin-Baden and Major 2004; Majeski and Stover 2005; Savery 2006). However, adopting PBL as a strategy for interdisciplinary learning poses significant challenges to the organisation of curriculum as well as to teachers and students; thus it cannot automatically be assumed that a PBL approach will lead to interdisciplinary learning (Stentoft 2017). To achieve interdisciplinary learning in a problem-based curriculum requires equipping the students with the ability to navigate and develop in educational spaces where disciplines do not constitute the key scaffolding component.

This chapter will discuss three key challenges facing students upon entering problem-based and interdisciplinary university education; challenging students through the uncertainties of problems, challenges arising from the uncertainties of project supervisors and challenging students through their own reflections. These challenges pertain both to the comprehension of uncertain disciplinary boundaries and to the adoption of working and studying processes necessary to handle disciplinary uncertainties and differing epistemologies. Following the explication of these challenges, the chapter will offer a discussion of strategies available for overcoming the identified challenges and for equipping and engaging new students to work with interdisciplinary learning processes in a problem-based setting. To clarify the intentions of the chapter further, it is relevant to note that problem-based learning in this chapter is taken to mean learning organised through extended periods when students work on projects (Kolmos et al. 2004), in contrast to case PBL. The organisation of the actual learning processes is one simple way of distinguishing project PBL from case PBL, as in the latter students acquire knowledge through working with simulated problems, whereas project PBL requires students to apply and integrate knowledge through work with real-world problems (Stefanou et al. 2013). This distinction is of great importance when discussing the role and nature of the problem as a catalyst for interdisciplinary learning and interdisciplinary higher education.

5.2 Challenging Students Through the Uncertainties of Problems

One of the key factors for engaging with and supporting interdisciplinary learning and curricula in higher education is that real-life problems rarely confine themselves to one disciplinary box (Petrie 1992). This observation may also provide the implicit argument for the assumption that PBL is equivalent to students engaging with interdisciplinary learning. However, little research has been done to explore how the interdisciplinary nature of real-life problems not only offers possibilities

for interdisciplinary learning but also poses significant challenges and places substantial demands on students and their learning processes.

Research into the role and nature of problems in problem-based learning has primarily been centred on one of two perspectives. Studies are typically either committed to exploring the function of the problem, i.e. what could be gained by addressing particular types of problems, or focused on the kind of knowledge constructed through addressing particular types of problems. Research into the function of the problem typically looks at how problems can be classified or categorised. Thus, Qvist (2004) identifies types of problems in problem-based projects across academic domains and demonstrates how particular classifications of problems would call for particular types of solutions and, consequently, ways of organising the project. Research into the knowledge constructed through examining particular problems typically aims to organise knowledge into particular categories. Through this kind of research, supervisors and curriculum developers may obtain insights, making it easier to manage educational activities and objectives as well as students' progress. Schmidt and Moust (2010), as well as Savin-Baden and Major (2004), have made considerable efforts to identify the role and function of problems; however, this research is predominantly concerned with what the problems may offer students in terms of building their knowledge. This kind of research is less concerned with what engaging with these types of problems and constructing this kind of knowledge may actually require of the student. Furthermore, past research has demonstrated how problems can be used to motivate students (Mauffette et al. 2004) and how problems may trigger students to address threshold concepts key to a particular discipline, thus moving students into new ways of thinking and knowing (Barrett et al. 2011). However, only to a very limited extent does existing research take into account the challenges and demands placed on students when they seek to address interdisciplinary, authentic problems in their problem-based education. It would seem that the inherent complexities and uncertainties of PBL are left on the margins of the literature.

As a consequence, the first obvious challenge faced by students in interdisciplinary and problem-based education is the challenge of delimiting their work through the problem rather than through traditional disciplinary boundaries. This means that students working in collaboration are tasked with investigating potential strategies, methods, theories and current findings across disciplinary domains, which separately or collectively may bring new understandings of and perspectives on the problem. In contrast to mono-disciplinary settings, students are here tasked with establishing an overview that often spans multiple academic fields and perspectives. Thus working from interdisciplinary problems places considerable demands on students' information literacy and competences to collect, analyse and determine the relevance of complex information. Perhaps such challenges relating to the uncertainties of problems are the reason students in problem-based learning programmes have been found to use university information resources and libraries significantly more than students from more teacher-directed programmes (Blumberg 2008).

For students learning from interdisciplinary problems, further challenges arise when the problem is not adequately described and delimited prior to actual scrutiny,

as is the case in PBL organised through projects. In these learning situations it is nearly impossible for students or anyone else to comprehend and manage the amount of information available and therefore to establish well-constructed criteria for what constitutes relevant and useful knowledge. This means that when learning takes its point of departure in interdisciplinary problems, students are required to address information originating in very different and often conflicting disciplinary domains. An example can be found in nursing education, where students may identify problems in wound healing in patients discharged following surgery. In order for the students to uncover the reasons for the lack of wound healing, they may have to examine the biomedical mechanisms of wound healing, the medical guidelines for care, patterns of patient behaviour when discharged, patients' socio-economic resources and issues of communication to and with patients and relatives about the care required for the wound to heal. These divergent issues relating to wound healing in post-surgery patients could be taught in various disciplinary courses; however, the interplay and full understanding of the specific and complex problem of troublesome wound healing in a particular hospital department only appear when this information is brought together through recognition of the problem itself, namely that many discharged patients experience complications relating to the healing of wounds following surgery.

Thus when students engage in interdisciplinary and problem-based learning through self-directed learning processes and extended project work they are faced with a set of demands or requirements in order to meaningfully and effectively navigate their work on problems. Students must be able to:

- Consider (by activating and integrating their prior collective experiences) from which disciplines and domains they may find disciplinary anchors (Barab and Landa 1997) that will allow them to establish a shared language, shared concepts and shared perspectives despite the fact that the problem does not in itself make these concepts and perspectives obvious.
- Adopt the critical position necessary for students to identify tensions and conflicts in the theoretical and methodological conceptions derived from various disciplines that may contribute to yielding new insights into the problem being addressed.

From these points it follows that students must be able to handle the uncertainties emerging from their own critical analysis as an integrated and constituting factor in realising a problem-based project oriented towards authentic, real-world problems. This further means that students are faced with learning situations where the road to learning is solely determined by, on the one hand, the problem to be addressed and, on the other, their ability to handle the academic and scientific uncertainties presented by this problem. In other words, how well students work with problems demanding an interdisciplinary approach is not simply determined by the degree to which the students have access to and can comprehend relevant knowledge. It is equally a matter of students being inventive and creative in working with that unstructured knowledge in ways which cannot be pre-determined or even fully anticipated in the curriculum or by project supervisors. This process both requires

and develops advanced epistemological beliefs in students (Ivanitskaya et al. 2002) as they comprehend potentials and conflicts. However, this development will only be realised in so far as students are offered adequate scaffolding not only of learning pertaining to absorbing new scientific knowledge, but also of the learning necessary to organise and navigate processes that turn uncertain and ill-defined problems into comprehensive, interdisciplinary and well-presented projects. Obviously, project supervisors play a significant part in how students develop and strategize about problems; from this follows the second challenge to interdisciplinary and problem-based learning: the difficulty students may encounter when the university teacher is no longer an oracle of knowledge but a supervisor equally confronting the uncertainties of the problem.

5.3 Challenges Arising from the Uncertainties of Project Supervisors

A key barrier to interdisciplinary education is the retaining of university teachers as disciplinarians rather than interdisciplinarians. This is evident in the organisation of university faculties, departments and research groups as well as in the structures, scopes and requirements often stipulated for obtaining research funding. It is further evident in the evaluation and assessment of the performance of the individual researcher and teacher, which are often based on criteria related to specific disciplines (Pfirman and Martin 2010). Such criteria include the definition of relevant publication channels, measuring teaching performance based on specific teaching traditions of a particular discipline and assessing the performance of the individual based on his or her ability to attract particular grants and external collaborations. As a result, university teachers wishing to involve themselves in interdisciplinary education and research are faced with the challenge of balancing being assessed based on criteria anchored in specific disciplines and finding meaning through engaging in interdisciplinary education and research. These contrasts are brought into sharp relief in the actual teaching and supervision situations in interdisciplinary education, where the teacher or supervisor may be torn between fully supporting the development of an enabling, uncertain and interdisciplinary learning space and the risk of being considered by colleagues and faculty as remiss in delivering the discipline. Moreover, most university teachers and supervisors have themselves been educated in mono-disciplinary programmes and as such are influenced by their socio-cultural backgrounds. Not surprisingly, research has further demonstrated that university teachers, on the one hand, recognise the value and relevance of interdisciplinary learning and see it as a way for students to recognise the boundaries and limitations of disciplines. Yet on the other hand, teachers emphasise the complexities of engaging with research domains resting on very different logics, methodologies and epistemological beliefs than their own (McClam and Flores-Scott 2011). This may be problematic, as in practice one key role of the teacher (and supervisor)

of interdisciplinary learning is to assist students in unpacking the diverse contributions of different epistemologies and disciplines to the solution of interdisciplinary problems (DeZure 2012).

In problem-based project supervision this tension is particularly evident, as the problem is defined by the students in collaboration with the supervisor, which means that supervisors cannot be allocated only to projects located within their field of expertise. Although supervisors bring experience and often years of practice as supervisors to the collaboration with students, they are equally challenged by interdisciplinary problems, perhaps even more so than the students. The supervisor must, on the one hand, retain credibility and act as part of the scaffolding of students' interdisciplinary learning; on the other hand, the supervisor is expected to relinquish power to the students and ultimately to the problem, which defines the PBL learning space (Savin-Baden and Major 2004). Thus, maintaining authority, opening interdisciplinary learning spaces, accepting uncertainties and navigating outside one's own field of expertise and disciplinary zone of comfort place heavy demands on the PBL supervisor. These demands also bring challenges for students as they deal with the uncertainties of their supervisor, the teacher they have been brought up to consider their anchor and deliverer of knowledge and direction.

The structures and intentions of PBL organised through projects therefore present significant challenges to the project supervisor, as the problem and associated epistemologies to be unpacked are not clearly defined at the commencement of the project. That is, project supervisors are allocated to project groups even before the students embark on the demanding task of delimiting the problem; thus, that the project supervisor is an expert with clear perspectives to offer on the problem is not a given. For many students, adapting to new conceptions of what a supervisor/teacher is and how he or she may contribute is challenging and requires a reconceptualisation of what it means to learn in higher education. It also requires that the supervisor offers significant support for the process, for example, in the students' development as self-directed learners and in building students' confidence in their own judgement on scientific problems and their solutions. Essentially, it all comes down to a realisation that learning and learning processes in interdisciplinary and problem-based project work are much more complex than the situations most university teachers encountered during their own education. Teaching in a PBL setting is not really a question of understanding a discipline or knowing the literature. Rather, it is an uncertain process that requires entirely different teaching and learning strategies.

Consequently, despite universities adopting a PBL approach through the implementation of extensive projects, and despite students defining their problems and striving towards interdisciplinarity in their projects, uncertainties will prevail as long as the majority of PBL supervisors are recruited from research groups and departments organised around specific disciplinary boundaries. As a result, even first-year students are challenged, not only through encounters with multiple epistemologies and methodologies, but also by the limitations of the perspectives of their project supervisors. To overcome these challenges, research conducted by McNair et al. (2011) suggests that increased focus should be placed on the identities

developed by students and faculty around interdisciplinary learning processes, and that more should be done to support development of such identities in higher education.

5.4 Challenging Students Through Their Own Reflections

Above, it has been established that students in interdisciplinary problem-based learning are faced with significant challenges when they address problems not defined by disciplines and when they encounter teachers and project supervisors who may be equally challenged by the uncertainties of the problem. The third challenge to students is the requirement for continuous reflection and development of the capabilities to handle such uncertainties as a team. A prerequisite for learning in teams in situations of uncertainty is reflective dialogue, defined as dialogue that

> ...engages the person at the edge of their knowledge, their sense of self and the world as experienced by them. Thus their assumptions about knowledge, themselves and their world is challenged. By this we mean that the individual is at the edge of their current understanding and the sense of meaning they give to and with the world. Existing assumptions about knowing, acting and being are challenged. Learning becomes reflectively critical when the emergent ideas are related to existing senses of knowledge, self and the world and a new understanding emerges. (Brockbank and McGill 2007, p. 65)

From this definition it follows that students in interdisciplinary and problem-based project teams need to adopt and be supported in developing strategies that enable reflective dialogue to emerge in their teams. This is in line with Ivanitskaya et al. (2002), who emphasise that interdisciplinary learning both requires and develops meta-cognitive competencies in learners. Furthermore, it has been argued that in order for students to navigate uncertain terrain and complex situations, they need support in the learning processes of setting their learning objectives, reflection, and giving and receiving feedback. Thus they need to develop capabilities that reach beyond traditional academic competencies to also include the ability to adjust to changing contexts, construct new knowledge and assess and improve performance (Fraser and Greenhalgh 2001). For students, then, the challenge in interdisciplinary and problem-based projects is to establish and manage processes that underpin reflective dialogues, constructive feedback, performance assessment and, not least, the construction of new knowledge based on the collective experiences and existing knowledge of the team. To establish and maintain such processes places considerable demands on the ways in which project teams organise and manage their collaboration. Students must actively seek to ensure reflective dialogues challenging the boundaries of their knowledge and taking place at the intersections of disciplines. Embedding such activities into learning processes may, for many new students, stand in sharp contrast to their previous experiences of learning as an individual and mono-disciplinary activity. As a consequence, students new to problem-based and interdisciplinary learning in higher education encounter their education with an urge for new knowledge, skills and competencies related to their

choice of education. However, in interdisciplinary and problem-based settings they will also soon realise a need for competencies related to learning, communication and collaboration. Without them, it could be argued, students' learning is coincidental, and the gains from their university education are jeopardised. The final part of this chapter will discuss these issues in more detail.

5.5 Strategies Enabling Problem-Based and Interdisciplinary Learning

As seen above, when entering into interdisciplinary problem-based education, students are confronted with at least three significant challenges, and they must develop strategies to overcome these challenges if they are to gain from the educational setting. Students must learn how to accept and process the differing perspectives and conflicting epistemologies often tied to interdisciplinary and real-world problems. They must find ways to appreciate that the uncertainties that arise from working with authentic problems are not theirs alone, but are shared to some degree by their project supervisor, and that this significantly influences the role of the supervisor and the objectives of supervision. Finally, students must find strategies for organising their own collaborative reflections and ways of constructing and negotiating knowledge during the entire PBL project period to ensure the construction of sound arguments and that relevant discussions are incorporated into the final project document.

In the first challenge, we saw how students in interdisciplinary and problem-based education are faced with complex and uncertain problems that require an interdisciplinary perspective in order to be thoroughly addressed. Real-world problems can in this sense be characterised as idiosyncratic cases requiring specific investigations and never fitting the nomothetic knowledge of disciplines, yet the resolution of problems will most often require knowledge derived from specific disciplines (Krohn 2010). Consequently, it appears essential for students working with real-world problems to learn to distinguish types of knowledge and to recognise the contributions and limitations of disciplinary knowledge in interdisciplinary projects. This requires a sound comprehension of research paradigms and the philosophy of science, though this is not needed for the sake of delimiting research according to discipline, and from this deducing method and methodology. Rather, comprehensive understandings of the possibilities and limitations of research paradigms will serve as a remedy through which tensions and potentials for knowledge related to the idiosyncratic problem may be reflected upon. In such a setting the very idea of knowledge is no longer that of something directly acquired from the teacher or offered by books. Instead, students need to be able to recognise the premises of the knowledge with which they work and which they construct, and they also need to account for the emergence and contributions of particular knowledge tied to a particular problem. Relating this to project-oriented and problem-based learning, it

is important to realise that students' development of skills and competencies relating to reflections on the nature of knowledge and the research paradigm cannot be assumed to happen as a default consequence of working with interdisciplinary problems. Developing such skills requires attention and guidance, and it is therefore necessary to incorporate the acquisition of interdisciplinary competencies, and their consequences for research, into the curriculum through learning objectives, activities and modules. It is also necessary to ensure that both teachers and project supervisors possess the competencies necessary to support students from the very moment they venture into interdisciplinary education. Based on empirical findings, Drezek et al. (2008) have suggested a model for advancing students' understanding of interdisciplinarity and changing their epistemic beliefs through three stages, first students find comfort in disciplines, then they begin to explore disciplinary boundaries and in the final stage they integrate disciplines while crossing boundaries. In stage three of this model, students develop a reflective and critical awareness of the processes of constructing knowledge when working with interdisciplinary problems. The model was developed from a graduate programme deliberately incorporating interdisciplinarity into the curriculum. However, in many PBL universities around the world students encounter interdisciplinarity at the beginning of their undergraduate degree when they are first introduced to collaborative projects. There is nothing to suggest that a particular kind of maturity is required before students undergo the development sketched in the model. Navigating conflicting epistemologies is no less complex or uncomfortable in the early years of university education and the need for concrete activities and modules connecting theories of science to the handling of interdisciplinary problems is obvious. To this end students' understanding of different paradigms becomes essential for their competencies to navigate comfortably with uncertain problems.

In addition to curricula offering activities and support for students to develop the academic competencies necessary to handle and address interdisciplinary problems, students also rely on competencies to manage their individual, collective and complex learning processes. Much literature is available to help university teachers and supervisors develop strategies and initiatives intended to support students in their development of meta-cognitive and collaborative capabilities (e.g. Brockbank and McGill 2007; Bowden and Marton 1998; Boud et al. 2001; Davies and Barnett 2015). However, surprisingly little research has been carried out on the possibilities and limitations of the PBL project supervisor in higher education. This means there is limited support from research when higher education institutions offer professional development for PBL supervisors and often focus in such activities are on the role of students rather than the role of the supervisor. To address how the second challenge of supervisors' uncertainties of problems may impact students' learning there is a need to highlight the role of the supervisor both in interaction with students and in professional development activities and more research into these aspects is highly relevant.

Collaboration on interdisciplinary learning and in PBL settings is a social and often emotional enterprise requiring capabilities to manage group dynamics, resources and learning processes. One central line of reasoning in favour of

collaborative learning processes in PBL is that real-world problems are too complex for any one individual to address without the resolution being too reductionistic and limited in scope (Kelson and Distlehorst 2008). This complexity, as we have seen above, is no less predominant in interdisciplinary education; thus it is essential that students not only develop individual competencies as interdisciplinary learners, as argued above, but also that they be offered opportunities for developing the capabilities to collaborate and to design their project work in ways that enable dialogic reflections (Brockbank and McGill 2007) and the opening of collaborative interdisciplinary learning spaces. This means the curriculum must include scaffolding strategies supporting the collaborative elements of problem-based interdisciplinary learning. These include support of students' social, emotional and academic development into reflective interdisciplinary learners. This can be in the form of specific activities integrated into curriculum such as introductory courses on PBL and learning as is the case at Aalborg University. It can also be through focussed teacher and supervisor feedback to the individual and the group. Regardless of approach more extensive research into the specific complexities of interdisciplinary learning and PBL outlined above and how these can be adequately addressed in educational practices is needed. Clearly, pedagogical approaches encompassing these complexities and offering scaffolding that may somehow compensate for the uncertainty and discomfort faced by students new to the game still have a way to go to be fully developed.

5.6 Concluding Remarks

This chapter has demonstrated how entering into interdisciplinary and problem-based learning as a new student can be both overwhelming and demanding. It challenges students in entirely new ways, both in terms of conceptions of science and knowledge and in perceptions of what it means to learn in higher education. The chapter has pointed to three specific challenges that, it is argued, must be addressed through both curriculum and pedagogical interventions if students are to realise their full potential in interdisciplinary and problem-based settings. These challenges pertain to the handling of differing and sometimes conflicting epistemologies when working with real-world problems, handling the uncertainties of supervisors and handling processes of dialogue, reflection and feedback in collaborative groups. The chapter further argues that higher education institutions can support student development of the necessary capabilities by being intentional about the role and use of theories of science and research paradigms in interdisciplinary PBL, as well as by emphasising the necessity for students to develop meta-cognitive competencies and take an active stand on issues of learning how to learn. The question, however, remains, whether such initiatives are enough to give students both the confidence and the capabilities to tackle the uncertainties and complexities of the problems they will continue to meet in their future professions.

References

Barab, S. A., & Landa, A. (1997). Designing effective interdisciplinary anchors. *Educational Leadership, 54*(6), 52–55.

Barrett, T., Cashman, D., & Moore, S. (2011). Designing problems and triggers in different media. In T. Barrett & S. Moore (Eds.), *New approaches to problem-based learning revitalising your practice in higher education* (pp. 18–35). New York: Routledge.

Blumberg, P. (2008). Evaluating the evidence that problem-based learners are self-directed learners: A review of the literature. In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp. 199–226). New York: Routledge.

Boud, D., Cohen, R., & Sampson, J. (2001). *Peer learning in higher education*. London: Kogan Page.

Bowden, J., & Marton, F. (1998). *The university of learning: Beyond quality and competence*. London: Routledge.

Brockbank, A., & McGill, I. (2007). *Facilitating learning in higher education*. Maidenhead: Open University Press.

Davies, M., & Barnett, R. (2015). *The Palgrave handbook of critical thinking in higher education*. New York: Palgrave Macmillan.

DeZure, D. (2012). Interdisciplinary pedagogies in higher education. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 372–386). Oxford: Oxford University Press.

Drezek, K. M., Olsen, D., & Borrego, M. (2008). *Crossing disciplinary borders, a new approach to preparing students for interdisciplinary research*. 38th ASEE/IEEE Frontiers in Education Conference, Saratoga Springs, NY.

Fraser, S. W., & Greenhalgh, T. (2001). Coping with complexity: Educating for capability. *British Medical Journal, 323*, 799–803.

Ivanitskaya, L., Clark, D., Montgomery, G., & Primeau, R. (2002). Interdisciplinary learning: Process and outcomes. *Innovative Higher Education, 27*(2), 95–111.

Kelson, A. C. M., & Distlehorst, L. H. (2008). Groups in problem-based learning (PBL): Essential elements in theory and practice. In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp. 167–184). New York: Routledge.

Kolmos, A., Fink, F. K., & Krogh, L. (2004). *The Aalborg PBL model*. Aalborg: Aalborg University Press.

Krohn, W. (2010). Interdisciplinary cases and disciplinary knowledge. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 31–49). New York: Oxford University Press.

Majeski, R., & Stover, M. (2005). Interdisciplinary problem-based learning in gerontology: A plan of action. *Educational Gerontology, 31*(10), 733–743.

Mauffette, Y., Kandbinder, P., & Soucisse, A. (2004). The problem in problem-based learning is the problems: But do they motivate students? In M. Savin Baden & K. Wilkie (Eds.), *Challenging research in problem-based learning* (pp. 11–25). Maidenhead: Society for Research into Higher Education & Open University Press.

McClam, S., & Flores-Scott, E. M. (2011). Transdisciplinary teaching and research: What is possible in higher education. *Teaching in Higher Education, 17*(3), 231–243.

McNair, L. D., Newswander, C., Boden, D., & Borrego, M. (2011). Student and faculty interdisciplinary identities in self-managed teams. *Journal of Engineering Education, 100*(2), 374–396.

Petrie, H. G. (1992). Interdisciplinary education: Are we faced with insurmountable opportunities? *Review of Research in Education, 18*, 299–233.

Pfirman, S., & Martin, P. J. S. (2010). Facilitating interdisciplinary scholars. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 387–403). New York: Oxford University Press.

Qvist, P. (2004). Defining the problem in problem-based learning. In A. Kolmos, F. K. Fink, & L. Krogh (Eds.), *The Aalborg PBL model* (1st ed., pp. 73–76). Aalborg: Aalborg University Press.

Ramsden, P. (2003). *Learning to teach in higher education*. London: RoutledgeFalmer.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *The Interdisciplinary Journal of Problem-Based Learning, 1*(1), 9–20.

Savin-Baden, M., & Major, C. H. (2004). *Foundations of problem based learning*. Maidenhead: Society for Research into Higher Education & Open University Press.

Schmidt, H., & Moust, J. (2010). Designing problems. In H. van Berkel, A. Scherpbier, H. Hillen, et al. (Eds.), *Lessons from problem-based learning* (pp. 31–45). Oxford: Oxford University Press.

Schon, D. A. (1995). The new scholarship requires a new epistemology. *Change, 27*(6), 27–34.

Stefanou, C., Stolk, J. D., Prince, M., Chen, J. C., & Lord, S. M. (2013). Self-regulation and autonomy in problem- and project-based learning environments. *Active Learning in Higher Education, 14*(2), 109–122.

Stentoft, D. (2017). From saying to doing interdisciplinary learning – Is PBL the answer? *Active Learning in Higher Education, 18*(1), 51–61.

Weingart, P. (2012). A short history of knowledge formations. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 3–14). Oxford: Oxford University Press.

Chapter 6
Supervising the Interdisciplinary PBL Project

Scaffolding an Open-Ended Space of Scientific Possibilities

Ole Ravn

6.1 Introduction

The aim of this chapter is to discuss the scientific preconditions for establishing higher education interdisciplinary project work in a problem-based learning (PBL) setting. This discussion is relevant to the everyday practice of university students' group work on project reports. In such project work, there is an emphasis in many PBL educational environments on using scientific approaches and methods in an interdisciplinary fashion to help solve the specific contextual problems raised by the groups.

The question pursued in this chapter concerns what types of theory of science dialogue and reflection are needed between a supervisor and a group of students in order for students to master an interdisciplinary approach in their project work. Before establishing a more precise aim, I begin by outlining what the key concepts of 'PBL-setting', 'theory of science' and 'interdisciplinary project work' mean in the following text.

PBL can mean many things in higher education; sometimes it even covers other terms in addition to problem-based learning, such as 'project-based learning'. In some university traditions it relates to weekly assignments, and in others it refers to full semesters of focused work on a project and an associated problem. There can be many different kinds of reasons for using PBL as an educational mode, ranging from a teaching and learning philosophy to the goal of improving the retention of students to existing ideas about effective, useful or active learning.

In this article, the educational framework referred to as PBL is a full-semester problem-oriented (synonymously, problem-based) group project undertaken by two to five students. The product of this group work is a project report of anything from

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40 to 100 pages, depending on the specific module of the education and whether the project report will be the main focus of a final exam at the end of the semester.

The curriculum can also entail limitations regarding the broader theme or topic to be worked upon, within which the group must develop their own problem formulation (a question to be researched for the report). The number of supervisors connected to the group's project work can vary, but here we will assume that there is one main supervisor guiding a group of students in their working processes and project writing.

PBL in this chapter is thus defined along the lines of the so-called Aalborg PBL model. For more information on this context, see the AAU PBL Principles (2015) and Kolmos et al. (2007) for a general discussion, or Vital et al. (1995) for an example of PBL in a specific field. For conceptual work on the model, see for example Illeris (1974) as one of the original sources on PBL in the Danish tradition, or Hernández et al. (2015) for a socio-cultural learning perspective.

Having introduced the notion of PBL in the context of this chapter, we now turn to the notion of 'theory of science'. Theory of science is, generally speaking, an arena where we discuss and debate the proper ways to do science, as well as, for example, what distinguishes science from other areas of life. In the academic world, it can be a somewhat contentious issue, as what good science is and how it should be conducted is subject to significant debate. Here, the meaning of theory of science is close to the commonly used 'philosophy of science' and follows a Scandinavian tradition of using "videnskabsteori" as the normal reference for reflections about all sciences (see for example Collin and Køppe 2014; Krag and Pedersen 1991).

The theory of science arena includes debates about the relationship between quantitative and qualitative research, the use of mathematical tools in research and the proper approach to researching human behaviour, to mention just a few of the more salient aspects. The point to be highlighted here is that consensus is very seldom found in debates on proper scientific approaches and methods across the borders of classical scientific fields, such as physics, sociology, psychology, chemistry, law, medicine and so on. Yet even within these classical disciplines – and possibly within a particular department of, for example, medicine – it can still be quite challenging to find common ground regarding the proper scientific approach to a problem to be worked on in a particular setting.

This description of the complex and diversified views on scientific methods relates to the last key term to be addressed, namely 'interdisciplinary project work' in higher education. Interdisciplinarity sometimes refers to various forms of knowledge production that occur when working across the structural boundaries of the 'normal' organisation of the sciences. This structure consists of, for example, the faculties – the humanities, natural science, social science, medicine – but also exists at the level of the departmental structure typically seen within faculties of particular fields of study, for example in the departments of biology, chemistry, physics and so on. We shall return to this whole picture of science shortly, but it should be added that in the last 50 years or so many new and less established sciences, like tourism, nano-technology, innovative learning processes, techno-anthropology and so on, have emerged, leaving the pure structure of the classical sciences behind as argued by for example Lyotard (2004) and discussed in Ravn and Jensen (2016).

In these complex and constantly developing conditions in the scientific landscape, interdisciplinary project work in higher education obviously draws on more than one classical science. However, working within a field like techno-anthropology would not necessarily be interdisciplinary in the sense of crossing the institutional borders of that scientific area.

A more reasonable take is that interdisciplinarity in PBL project work entails the active choice and use of methods and approaches used in different scientific fields – independently of them being more or less cross-disciplinary in a historical or institutional sense. In a PBL setting, where groups of students are supposed to develop their own problem formulation and develop their own multifaceted approach to addressing the very specific problem they have chosen to work on, this definition of interdisciplinarity functions well. A variation of this that connects it closer to the supervisor's role in a PBL setting defines interdisciplinary project work by the existence of a project group's open-ended space to make a choice among scientific approaches and methods in their work with the chosen problem.

Therefore, the question is, how can a group of educators develop and sustain this open-ended space of scientific possibilities?

The chapter takes as its working hypothesis that interdisciplinary project work, according to the above definition, demands that students master a significant number of skills in relation to working across scientific fields. This in turn places a significant number of tasks on the supervisor in order to facilitate and support an interdisciplinary approach for their groups of PBL students. The aim of the chapter is to outline the ideal situation for supervisors to develop in their cooperation with a group of students in order to achieve interdisciplinary project work. In the form of a problem statement, it can be phrased as:

How can supervisors scaffold an interdisciplinary, open-ended space for students' project work in a PBL setting?

The development of an answer to this problem can be divided into three steps. First, a historically important dichotomy in the conception of the interrelations among the sciences will be developed. This dichotomy revolves around the notion of science as *describing* the world around us vs. science as *constructing a language* to talk about the world around us. The first notion will be developed in relation to a positivist philosophy of science and the second notion will be explained in relation to the later Wittgenstein's conception of language.

These two notions will enable us to establish a vocabulary through which a theory of science point of departure can be set for students' interdisciplinary project work. However, highlighting this dichotomy will also demonstrate how complicated and debated these requirements may be in terms of supervising students towards interdisciplinary project work that touches upon the complexity of relations among the sciences.

Building on the developed dichotomy, a vocabulary will be constructed around Wittgenstein's notion of a language game in order to conceptualise what would be required of students to work interdisciplinarily in the outlined sense of working in an open-ended space of scientific possibilities.

Finally, the above approaches will be used to establish an argument for a set of important practices in the supervision of PBL groups to facilitate interdisciplinary project work.

6.2 A Dichotomy in Conceptions of Interdisciplinarity

In the following I will try to outline what different theory of science foundations for supervision could look like. Obviously, many different issues and themes could be relevant, but when the interest is focused on interdisciplinarity, the question about the unity of science rises above the others in importance.

Agazzi and Faye (2001), for example, consider this question as editors of the book *The Problem of the Unity of Science*. They discuss, among many other issues, how reductionism towards a fundamental science has been a traditional point of entrance for the debate. C.P. Snow (1993), in his classic *The Two Cultures,* showed that, at the very least, a massive gap exists between the science of the humanities and the natural sciences. In addition, it has always been a main concern for the logical positivist programme in the theory of science to establish a unity of science based on a strong foundation that could secure the certainty of knowledge developed in all fields of science. Here we shall follow this positivist line of thought and, later on, contrast it with a perspectivist understanding of science.

The notion of the unity of science in the logical positivist movement has been outlined in different ways from different sources. A historically interesting outline can be found in Neurath (1938); however, here I will briefly attempt to follow the arguments of the earlier Wittgenstein in his first principal work, *Tractatus* (Wittgenstein 1922), which established him as a key figure in the development of the positivist endeavour in the first part of the twentieth century. These will be contrasted with Wittgenstein's later views, opposing his earlier thinking, with an emphasis on the role of language in science.

The key conception of science in the positivist interpretation is that the role of science is to *describe* the facts that exist in the world. Descriptions of a part of the world can be deemed true if one can establish a correlation between a linguistic representation of a certain state of affairs and an empirical observation that this state of affairs is actually the case; otherwise a sentence will be considered false (Wittgenstein 1922). In this sense, science is about establishing a growing pool of sentences about the world that are positively true, and another one containing all the statements that are false.

In this view of science, mathematics and logic have a privileged position, as these have tools that can express what our sentences mean in the clearest possible way, which is necessary to establish exactly what is true and what is false.

The relationship between the sciences is a fairly straightforward matter. Actually, there is only one way to do science in principle – it may be that we have not developed this approach in detail, based on an exact use of definitions and logical language combined with empirical observations. However, the ideal is clear – there

is in principle only one science, namely Science with a capital S – and the actual landscape of science, with all its complexity and diversity, is the result of historical circumstances that have not yet been resolved and translated into a clear mathematical-logical approach in the use of concepts and empirical verification of what is true and what is not.

A telling example of this way of thinking is the Danish philosopher Jørgen Jørgensen's work on the connections between biology and psychology in one of his principal works, *Psykologi paa biologisk grundlag* [Psychology on a Biological Foundation] (Jørgensen 1963). In this work, Jørgensen makes the effort to establish psychology on top of the more certain and better-developed knowledge – according to the positivist agenda – of biology. In biology, empirical and experimental methods have been more uniformly developed to support the certainty of knowledge. The idea is that building the central psychological concepts on top of this verified biological knowledge will provide a better foundation for the development of psychology. At the end of the day, physics is the ideal to strive for, where experimental procedures are well defined and propositions of knowledge are clearly formulated in mathematical terms.

The picture presented here of knowledge resembles a tree with physics at the bottom of the trunk and the less well-formulated sciences appearing as we approach the branches and leaves, where the humanities, for example, have rather uncertain, non-general and ambiguous concepts for describing the world.

In short, logical positivism, as fuelled by the early positivist movements of the late nineteenth century and the linguistic theoretical work of, among many others, Rudolf Carnap and the early Wittgenstein, produced a view of science where interdisciplinarity is really a matter of missing translation. If we work well enough and long enough, we will eventually approach a unified science in the form of unified descriptions of the proper scientific methodologies to describe the world in all its complexity.

Interdisciplinarity therefore is something that is highly valued in the logical positivist tradition, but only in the sense of eventually eliminating it. If you take the unified scientific positivist approach, you are already working interdisciplinarily. If you encounter inconsistencies between scientific approaches or established facts in different existing fields of science, the proper approach is to try to eliminate these diversities. And finally – as in the example of Jørgensen's work on psychology – if you are looking for the nature of this proper approach, look to physics, with its mathematically precise general theories about the causal effects in the world.

A completely opposite understanding of what science is and how the different sciences are related was developed by the later Wittgenstein. Wittgenstein turned against most of his earlier ideas about the workings of science as part of his development of a philosophy of language that revolves around the idea that scientific language is embedded in specific practices (Wittgenstein 1997). The main task of language is not to describe what is factual in the world – not even in the sciences. Language does indeed have descriptive aspects, but first and foremost language is part of practices that, again, are part of the life forms of human beings.

I will not go into the deeper arguments for this line of thinking, that is, Wittgenstein's arguments about rule following, the impossibility of private languages and so on, here. The reader should see Wittgenstein (1997) for his outline of a general philosophy of language, (1979) for more on the issue of certainty in science and (1978) for his discussion of the roles of logic and mathematics in science. Instead, I will develop some of Wittgenstein's key concepts that relate to our interest in the relationships among the sciences.

The later Wittgenstein developed the notion of a 'language game' to portray the basic characteristics of all our language usage, including the languages we use in science (Wittgenstein 1997, p. 11e [23]). A language game can be about many things – about solving equations, cooking dinner, hosting a party, playing soccer at school and so on. A language game is a set of activities or practices where the spoken and written language is intertwined with certain actions in the game – doing such and such with an equation or an oven if such and such is said or done, and so on.

Language games have family resemblances, and we can think of language games as clustered in sub-language games that have many family resemblances (Wittgenstein 1997, p. 32e [67]). The obvious example for us to pursue here is, of course, the language game of science.

The language game of science consists of numerous types of practices about how to proceed under different circumstances in different scientific communities. Some of the language games of science share more resemblances than others – for example, the language games of mathematics and physics have resemblances in their practices in relation to the use of mathematical expressions in the approach to working scientifically.

Other sciences have other types of resemblances related to the way research papers are written, the way communities of scientists are organised, the focus on interviews in acquiring knowledge about human experiences and so on. In this way, Wittgenstein portrays the language game of science as what we could interpret as a network of a multitude of different scientific practices that each more or less resemble other practices both inside and outside the language games of science. In this way, a language game of a specific scientific community becomes a complexity of practices in this very specific environment; these practices typically have more resemblances with the practices of groups of colleagues from the same faculty at the same university, but also a lot of resemblances with other scientific communities in comparison to other fields of practices, such as art or politics.

Thus, the later Wittgensteinian concept of science represents a contrast to the logical positivist position presented above. It asserts that there is no special foundation in mathematics or logic for science to rest on. These sciences are human languages like all others. It shows how the sciences together form a centre-free network of practices with numerous family resemblances that connect and divide the scientific approaches developed so far in history. This portrays a specific science as a way of talking about the world or a problem, including specific practices to be followed in relation to methods, theories, experiments, interviews and so on.

6.3 Interdisciplinary Project Work as a Language Game

As explained in the introductory section, the aim is now to gain inspiration from the later Wittgensteinian vocabulary of language games, as well as his view of the relationships between different sciences, in order to understand what this entails for students working on interdisciplinary projects. In the next section, this will be used as a background to discuss some conditions that are needed for supervising towards an open-ended space for students' interdisciplinary project work.

A first point of note is that, in contrast to a positivist stance, science is about constructing languages, as opposed to describing facts about the world. For a PBL supervisor and project group, this means that succeeding with a project is not only about gathering evidence from empirical work or experiments of some sort (both of which are, however, likely to be an element in the scientific approach of the project), but rather about building a vocabulary of key notions related to the chosen problem formulation, which can establish what we could think of as a language game about the exact problem being addressed.

Taking up the metaphor of a language game means paying attention to the idea that interdisciplinarity is about constructing a new sub-language in science that draws on different notions and practices from specific sciences to obtain insights across 'normal' scientific boundaries. An example could be a project that integrates social psychological approaches to learning while at the same time drawing on biological vocabulary and ways of experimenting, producing other types of insights (other types of languages to use) into the specific focus area of the students' project report.

Thus, interdisciplinary project work can be interpreted as a production of knowledge that is unique to a very specific and contextualised problem formulation, which means that it could be the only scientific approach with exactly this particular setup. This does not mean that it is a completely novel approach, or that it floats around on its own outside any mono-disciplinary practice. It rather means that it is a unique construction establishing connections to a number of scientific practices – with which it shares family resemblances – in the form of a number of scientific concepts, approaches, practices, ways of proving and ways of referring to resources.

Another point relates to the idea that no word, sentence or concept has a precise meaning outside the context in which it is used. In the scientific landscape, this means, for example, that the concepts of 'interview', 'experiment' or 'argument' do not have meanings in themselves. Further, we would enter into a fruitless pursuit of certainty by trying to define once and for all the meaning of, for example, 'interview', 'experiment' or 'proof' (see Wittgenstein 1979 for a full deconstruction of this pursuit). According to the later Wittgenstein, the meaning of a word is its use – and this of course has a massive influence on a project group's work regarding the key terms used in the specific context of exactly this project work. Even in a mono-disciplinary project, it can be demanding to clarify what exact uses are to be made of the key concepts in a written report, but in an interdisciplinary project the necessary level of reflection would entail even more focus on this issue.

A third point relates to another Wittgensteinian idea about the workings of our language and is a consequence of the above point that is related to the idea that 'meaning is use'. Every time we use words, approaches and practices we also play with them.

This means that we are actually developing, making adjustments to and establishing the meaning of scientific approaches and practices as we are practising them, applying them in a new contextualised setting. Obviously, an average student project report will not have a big impact on the way the scientific community understands what an experiment is, no matter how much or how well the group reflects on this or uses experiments across disciplines in a unique way. But this is also not the point. The point is rather that playing the game of science means that, at a small scale – unless you have massive power in the game of science, as some institutions and people do – a student project will change the way in which the supervisor refers to the notion of 'experiment' in the future and the way students themselves understand this concept and enact it in their future workplaces or research settings. In this way, project work can be understood as the active construction of meanings and uses of concepts and approaches that will be carried by the participants through the project work processes into new settings in the on-going game of what it means to conduct science.

This point leads to a highly interesting dichotomy between what education in the sciences should look like and how it is best conducted. The Wittgensteinian concept of what science is and how the sciences are related leads to the picture that a PBL approach lets students, in cooperation with a supervisor, 'play' (hence the term 'language game' or *sprachspiel*) with what it could mean to conduct qualified science in the unique context of the problem formulation. That is, to take on the task of participating in the development of science with each new project – on a small scale, probably, but nonetheless with a very significant condition for the entire approach to producing a PBL project report.

Education thereby becomes not just about an introduction to approved and well-established procedures, as underscored by, for example, the Kuhnian idea of 'normal science education', but also about the debates and different understandings of what science is and how it can and should be practised and developed.

6.4 The Supervisor and the Interdisciplinary Project

Having presented some of the key notions of a Wittgensteinian-inspired framework for conceptualising PBL project work, it is time to return to the problem statement: How can supervisors scaffold an interdisciplinary, open-ended space for students' project work in a PBL setting? Here 'open space' was defined as the project groups' free reign to make a choice among scientific approaches and methods in their work with their chosen problem.

The role of the supervisor is clearly crucial for establishing the interdisciplinary project as defined here, this task requires defining the proper scientific approach in

addressing a unique contextualised problem, and students will necessarily need guidance to tackle this challenge. The task now is to pinpoint several ideas that can guide the supervisor's approach to scaffolding an interdisciplinary project process.

The themes highlighted in answer to the problem posed will be (1) *going beyond their own scientific comfort zone*, (2) *reflecting with the students on what the conditions for doing (interdisciplinary) science are*, and (3) *pushing for transparency in the explanation of the project's scientific approach*.

Given the open-ended space for interdisciplinary project work, supervisors need to be comfortable with the idea of *going beyond their own scientific comfort zone*. Unless a supervisor is highly skilled in many different scientific approaches and is used to mingling and mixing them, they will be confronted in most PBL projects with a non-expert role. This can be quite a problematic role to take on, and as a supervisor it can be tedious to put oneself on par with the project group in some areas. This, however, is a necessary requirement if the goal is to establish the conditions for the interdisciplinary development of a project.

One can think of certain models of matching supervisors to PBL projects that suit the supervisor's special expertise. However, anybody who has supervised long-term PBL projects knows that the focus of the projects shifts several times during the project work process; it must do so to benefit the learning processes in the group (Olsen and Pedersen 2003, pp. 39–43).

Another possibility is to have more than one supervisor connected to each group and in that way enlarge the number of expertise resources that the group has available. However obvious this idea may sound, it does have certain drawbacks, such as the fact that the practical combination of supervisors with groups can be like a puzzle and, in addition, be very expensive in terms of the actual workload for the group of supervisors. On top of this – and most importantly – these possible solutions to the problem of available expert advice in some ways go against the idea of working within the open-ended space of scientific approaches and possibilities. The idea here is that the project group should choose an approach that fits the problem formulated and not be too hindered by paying tribute to specific scientific traditions or particular supervisors' areas of expertise in their approach.

The requirements of the supervisor, therefore, in practice become the ability to open the space of scientific possibilities even beyond their own field of expertise and beyond their own scientific comfort zone. Therefore, a key skill for being a supervisor in interdisciplinary PBL projects is a research qualification. Being a researcher means that a supervisor has been trained in a variety of scientific practices and is confident in using different types of scientific approaches depending on the subject matter at hand. It is also clear that the more knowledge the supervisor has about the entire landscape of scientific approaches and practices beyond their own field, the more capable they will be in supervising groups of students in an interdisciplinary approach.

The above requirement about being able to go beyond one's own area of top expertise in the supervision process points to another requirement when supervising interdisciplinary projects. Students will always demand clear answers to what they are actually supposed to do, regardless of whether they have been educated in a

specific mono-disciplinary agenda or in an open space for interdisciplinary work. Therefore, there is a requirement for the supervisor to *reflect with the students about what the conditions for doing (interdisciplinary) science are*.

This requirement could be considered an important and occurring event in any supervision of students. However, according to Kuhn's concept of a 'scientific paradigm' and the educational structure under normal scientific conditions, the case is rather that there is very seldom any reflection on what science is in the scientific community as such, and therefore also not in the supervision and teaching of students (Kuhn 1970, pp. 46–47). Normal science education activity is, in essence, about socialisation into a given mono-disciplinary paradigm, where students are taught how to proceed under given circumstances and in the face of specific problems, as well as how to correctly address any problem in this discipline systematically, and so on.

Thus, interdisciplinary PBL project work becomes a work process that goes against the stream. It potentially challenges the way we are used to doing things and it can be interpreted as a challenge to a mono-disciplinary paradigm. Under these circumstances, the supervisor needs to discuss with the group that this is what is going on, that traversing the normal boundaries of one scientific community means to understand the landscape of science in a specific way. It means to play with and develop what science can do and should be. There should be joint reflection on why an interdisciplinary approach can be beneficial, as well as how it can be problematic and possibly troublesome, when parts of a project are partly unsupported by a supervisor's specialised field of expertise. In addition, it should be jointly discussed what preconditions the PBL interdisciplinary project has when it is used to interrelate several scientific fields and approaches in one project. Eclecticism is a popular negative word, and students may feel uneasy when referring to different scientific vocabularies within one project context. Wittgenstein's concept of the landscape of the sciences is one possible approach to arguing the importance of talking scientifically about the world from a pluralistic perspective, but there are many other ways to defend the benefits of a multidisciplinary and interdisciplinary approach to a specific problem, such as the broader idea of perspectivism (see e.g. Giere (2006) or Callebaut (2012) for a specific discussion of scientific perspectivism in the era of 'big data').

A third point that I will highlight relates to the need for supervisors to *push for transparency in the explanation of the project's scientific approach*. This is a follow-up idea from the previous discussion of reflections on science in an interdisciplinary setting. For any outside reader of an interdisciplinary project report it is of vital importance that the reasoning behind the scientific approach be transparent both with regard to the overall approach (the design of the scientific argument in the report in its main parts) but also in every detail, that is, not taking the meaning of concepts or key notions for granted, but rather explaining them in their own right in this particular language construction. This is a task that is easier said than done, yet it is an important part of the supervisor's special tasks outside the mono-disciplinary environment to push for transparency and to let students take very little for granted in explaining the scientific rationale behind their approach to the problem.

6.5 Concluding Remarks

With the inspiration from a Wittgensteinian concept of science and language, a focus has been placed on the idea that each science – or rather scientific environment – first and foremost represents a specific way to talk about the world from a certain perspective.

The role of the supervisor in relation to interdisciplinary projects was found to hinge upon the supervisor's ability to go beyond their own scientific comfort zone, reflect with the group on what the conditions for doing (interdisciplinary) science are and push for transparency in the explanation of the project's scientific approach. Many other aspects could be considered important, but these are some of the ones that predominantly emerge from the theoretical perspective chosen in this chapter.

These aspects point to features or attitudes that are connected with a supervisor's tasks in interdisciplinary PBL settings. They concern the ability to work on the border of one's own experiences as a researcher, which again demands quite a lot of *openness* towards a group of students about one's own areas of expertise – and this means taking a more vulnerable position, namely as a supervisor who will not have direct expert answers to all questions.

At the same time, the ability to discuss the interdisciplinary open space with students means playing the game of challenging the traditional borders of science and opening the space for exploring new approaches and perspectives on a specific matter. This demands a certain *boldness* on behalf of the supervisor because this step concerns moving beyond the dominating paradigm about the right ways to proceed and the silence that can accompany this dominance.

Finally, the push for transparency relates very much to this process of moving beyond a mono-disciplinary paradigm, which opens a field of *creativity* for both supervisor and students to explore new ways of practising science.

With these final remarks, it is clear that an open-ended space for interdisciplinary project work is not something that can be applied as a quick fix. It is tightly connected to how we think about what science is, about the relationships among the different sciences, and about the openness, boldness and creativity of the supervisor in a collaboration with a group of students. For every supervisor who tries to open this space for students there are abilities that can be continuously developed; this will demand quite a lot of determination to develop, in contrast to simply leaning on tradition.

References

AAU PBL Principles. (2015). *Principles of problem and project based learning – The Aalborg PBL Model*, edition 2.0 – Briefly describes nine principles of PBL at Aalborg University. Located on this address: http://www.en.aau.dk/about-aau/aalborg-model-problem-based-learning

Agazzi, E., & Faye, J. (Eds.). (2001). *The problem of the unity of science*. London: World Scientific Publishing.

Callebaut, W. (2012). Scientific perspectivism: A philosopher of science's response to the challenge of big data biology. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences., 43*(1), 69–80.
Collin, F., & Køppe, S. (2014). *Humanistisk videnskabsteori*. Copenhagen: Lindhardt and Ringhof.
Giere, R. (2006). *Scientific perspectivism*. Chicago: The University of Chicago Press.
Hernández, C. H., Ravn, O., & Valero, P. (2015). The Aalborg University PO-PBL model from a socio-cultural learning perspective. *Journal of Problem Based Learning in Higher Education, 2015*, 16–36.
Illeris, K. (1974). *Problemorientering og deltagerstyring. Oplæg til en alternativ didaktik*. Copenhagen: Munksgaard.
Jørgensen, J. (1963). *Psykologi paa biologisk grundlag*. Copenhagen: Munksgaard.
Kolmos, A., Fink, F. K., & Krogh, L. (Eds.). (2007). *The Aalborg PBL model – Progress, diversity and challenges*. Aalborg: Aalborg University Press.
Krag, H., & Pedersen, S. A. (1991). *Naturvidenskabens teori: en indføring i naturvidenskabernes og teknologiens filosofiske problemer*. Copenhagen: Nyt Nordisk Forlag Arnold Busck.
Kuhn, T. S. (1970). *The structure of scientific revolutions* (2nd ed.). Chicago: The University of Chicago Press.
Lyotard, J. F. (2004). *The postmodern condition: A report on knowledge*. Manchester: Manchester University Press.
Neurath, O. (1938). Encyclopaedism as a pedagogical aim: A Danish approach. In *Philosophy of science* (Vol. 5). Williams and Wilkins Company.
Olsen, P. B., & Pedersen, K. (2003). *Problemorienteret projektarbejde – en værktøjsbog*. Copenhagen: Samfundslitteratur.
Ravn, O., & Jensen, A. A. (2016). PBL and the postmodern condition: Knowledge production in university education. *Journal of Problem Based Learning in Higher Education, 4*(1), 38–52.
Snow, C. P. (1993). *The two cultures*. London: Cambridge University Press.
Vital, R., Christiansen, I., & Skovsmose, O. (1995). Project work in university mathematics education – A Danish experience: Aalborg University. *Educational Studies in Mathematics, 29*(2), 199–223.
Wittgenstein, L. (1922). *Tractatus logico-philosophicus*. London: Kegan Paul/Trench/Trubner & CO., LTD..
Wittgenstein, L. (1978). *Remarks on the foundations of mathematics* (3rd ed.). Oxford: Basil Blackwell.
Wittgenstein, L. (1979). *On certainty*. Oxford: Basil Blackwell.
Wittgenstein, L. (1997). *Philosophical investigations*. Oxford: Blackwell Publishers. (First published 1953). Brackets [] signify paragraph numbers in the original version.

Chapter 7
Toward an Interdisciplinary Learning Community of PBL Supervisors and Students

Lisa R. Lattuca

Although practitioners and scholars have been searching for recipes for successful interdisciplinary teaching and learning for decades, the research literature on interdisciplinary education has lagged far behind the interest in curricular and pedagogical practice. The literature on problem-based learning is comparatively robust, but as Diana Stentoft notes in her chapter, it provides very limited guidance on how to create and deliver successful interdisciplinary PBL experiences for university students and their instructors.

In the absence of targeted research on interdisciplinary PBL, we can rely on both experiential knowledge and on the body of knowledge on learning to analyze the situations PBL instructors encounter and to craft curricular and pedagogical strategies to support student learning. In my contribution to this volume I do a little of both, as I synthesize ideas from the chapters in this section and suggest some possible responses to the shared concerns the authors raise. These are, specifically, the question of how to engage domain (subject matter) knowledge, the challenge of identifying and managing competing disciplinary epistemologies and ontologies, expectations regarding expertise, and the role of curriculum and instruction in a PBL context. These recurring themes, perhaps unsurprisingly, lead us to consider the experiences, roles, and expectations of both PBL staff and PBL students, since it is the quality of the teaching-learning nexus that drives the questions and insights of the authors in this section.

The authors of these four chapters send the collective message that for interdisciplinary PBL to succeed, instructors need knowledge of disciplinary approaches to inquiry and problem solving, a corollary set of intellectual and instructional dispositions and skills, and a set of teaching practices that reflect those dispositions and skills. As the authors of these chapters note, staff may not come pre-equipped with

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these dispositions and skills. Consequently, I focus this commentary, in part, on how professional learning opportunities might build (at least some) of the requisite staff knowledge, skills, and confidence that these experienced PBL instructors argue are needed to manage the intellectual and emotional uncertainty, and the complexity of teaching interdisciplinary problem solving, in their programs. My comments, however, also consider the students' experiences in PBL courses, since any academic plan must attend not only to what supervisors decide and do, but also to how students interact with the curriculum and instruction provided.

As a first step toward addressing the questions and challenges raised in the foregoing chapters, I make an assertion: educators, in general, need basic knowledge of learning processes to address the cognitive and contextual challenges identified in these chapters. This need to focus on learning is evident in the shared and complementary insights of the authors of these chapters, and it is consonant with the PBL method in general. Although one of my goals is to make attention to this element of PBL practice explicit in efforts to prepare and support both PBL instructors and their students, I am cognizant of the variability in educators' understanding of learning itself. Moreover, while I and others might prefer that all university staff have deep knowledge of learning theory and research, depth may not be necessary for useful pedagogical improvements to occur. Basic knowledge, and a desire to know more, may be sufficient for initial efforts.

7.1 Learning, Simplified

One of the things we know with certainty about human learning is that our prior learning experiences have consequences for our present and future learning (e.g., Ausubel et al. 1978; Lee 2016; Resnick 1987; Schuell 1986; Shavelson 1974; Vygotsky 1978). Prior learning experiences shape not only the individual's understanding of content, but also the emotional responses to that content and the learning experience (e.g., Weaver 2006), as well as beliefs about the self as a learner (Bandura 1991). No matter where educators and learning scientists place themselves on a spectrum of theoretical positions that view learning as primarily a cognitive, sociocognitive, or cultural process, they would agree that what humans experience, and the meanings they make of those experiences, affect how they approach the learning tasks they face in the future. None of this negates, of course, the role of imagination, invention, and innovation in learning experiences in schools, work, and other settings; rather, it acknowledges that even as humans have agency to think and act in new ways, they rely on what they already know – and how they understand it – to make sense of new information and to navigate new experiences and problems.

Previous experience, of course, does not always yield successful learning in the face of new and different problems. Misconceptions about scientific phenomena, for example, are quite common in students of all ages (Bransford et al. 2000); such misconceptions can also be found in students' understandings of activities such as writing (Bloxham and Campbell 2010; Bloxham and West 2004). Indeed,

disciplinarity is often presented as a potential barrier to interdisciplinary thinking and collaboration. (The chapters in this volume are merely some recent examples!) As someone who studies teaching and learning, I immediately frame this problem in terms of learning: what individuals have learned (and potentially misunderstood) in prior schooling and professional experiences about their own disciplines and fields, and about those of others, may interfere with their ability to recognize the affordances of knowledge, skills, and approaches that do not conform to their learned and preferred understandings of scientific inquiry and what counts as "real" knowledge. Miller and Mansilla (2004) identify stereotypes about other fields as a source of misconceptions that can impede interdisciplinarity. They further identify "perspective-taking" as a more advanced stage of thinking, in which individuals instead are able to imagine, understand, and even anticipate a different way of thinking. Scholarship on interdisciplinarity suggests that prior knowledge can also interfere with individuals' ability or willingness to see the limitations of their preferred ways of thinking and doing academic work (see, for example, Huutoniemi et al. 2010; Klein 1990; Lamont 2010).

If we know that prior experience and learning of all kinds (i.e., cultural, social, domain-based, etc.), both inside and outside our classrooms and institutions, shape future learning, we should engage that prior learning, because leaving it unattended may prove to create an invisible barrier to new learning. Yet we must be cautious as we consider the students in our care. It is their knowledge, not our assumptions about their knowledge, that needs to be addressed, and the literature on interdisciplinarity may fuel assumptions about the disciplinary experiences of students and instructors that require some friendly interrogation. For example, the conceptualization of academic disciplines as bounded and codified bodies of knowledge rather naturally leads to the assumption that academics' prior experiences are heavily disciplined and have occurred in spaces that strictly define knowledge and skills into particularistic realms of meaning and activity (which we call disciplines, fields, and professions). This assumption about educational and professional experiences may or may not reflect the experiences of all our colleagues, and it can distract us from attending to the sense that *they* make of their unique experiences. A corollary assumption is that both students and staff feel compelled to attend to established boundaries of knowledge, and to the languages, tools, and strategies for problem solving they encompass.

Recent scholarship on interdisciplinarity and disciplinarity actually challenges these generalizations. First, disciplines, fields, and professions – or more accurately the individuals in these communities – are not necessarily in consensus regarding the boundaries and methods of their own academic territories (see, for example, Abbott 2002; Lattuca 2001). In fact, for some academics, these boundaries may be quite malleable (e.g., Abbott 2002; Kellert 2008) and time-bound (e.g., Light and Adams 2017); research evidence indicates significant scholarly boundary crossing (e.g., Frickel and Ilhan 2017; Jacobs 2013; Leahy and Moody 2014, Porter and Rafols 2009; Wuchty et al. 2007). To promote innovation, universities have also used institutional arrangements such as joint academic appointments and cluster hires that encourage such boundary crossing (e.g., Sa 2008), supported boundary

organizations that enable cross-disciplinary collaborations (e.g., O'Mahoney and Bechky 2008), and incentivized interdisciplinary partnerships among faculty members and with partners outside the university (e.g., the M-Cubed initiative at my home institution, the University of Michigan). Light and Adams (2017), Jacobs (2013), and Leydesdorff and Shank (2008) argue that interdisciplinarity itself may be temporal; interdisciplinarity and disciplinary may be best understood as different states of knowledge organization reflective of a dynamic process of knowledge production. However, Kellert (2008) opines, "whereas disciplines may be fluid, multiple, or even fractal in practice, such a condition is far from their professed ideology" (p. 30).[1] One challenge for the PBL instructor, then, is to move past the rhetoric to deal in the realities of their academic community and classroom.

Both staff and students increasingly arrive at our higher education institutions with some, often significant, interdisciplinary experiences. In the US, the number of interdisciplinary degree programs is on the rise; the number of interdisciplinary undergraduate programs increased dramatically between 1975 and 2000 (Brint et al. 2009), and funding agencies such as the U.S. National Science Foundation both encourage and support the creation of interdisciplinary doctoral programs. In addition, the number of academic sub-specializations has grown as disciplines subdivide and, as Jacobs (2013) notes, "spill past the previously understood borders of the field" (p. 53). It is not surprising, then, that what individuals count as disciplinary knowledge can be quite particularistic, a consequence of that individual's experiences in particular academic programs, institutions, and scholarly communities (Lattuca 2001). So although it may be useful to default to the aggregate when we discuss academic disciplines and fields in general, when we are discussing learning – whether of students or staff – we should, in contrast, recognize that individuals have different life and professional experiences, and varying motivations and goals. While socialization into and experience within a discipline generally tends to inculcate preferences for particular ways of thinking, at the level of the individual, prior experiences of different kinds can create pathways for learning.

As a consequence of these observations, I believe it may be fruitful to refocus our attention. While we can begin with the possibility that strong attachments to disciplinary knowledge and skill sets can interfere with interdisciplinary learning (or even the willingness to undertake it), we must also recognize that students and staff may also have experiences that can facilitate interdisciplinary interactions, practices, and learning. Even if we come to understand that these prior experiences are not naturally facilitative of interdisciplinary thinking, we should, as an educational principle, attend to them if we are to scaffold future learning effectively. It will be helpful, then, to reframe the challenge to interdisciplinary PBL: rather than assume some generalized discipline or disciplinarity as the impediment, we can consider both the affordances and limitations of an individual's current knowledge base and expertise, and how their prior learning and experience can be engaged to promote further learning.

[1] Indeed, the professed ideology may be quite powerful when it comes to evaluative processes such as peer review (see Lamont 2010).

Classrooms are always places where we are in the process of working toward what is *not yet known*. My focus on the potential affordances of prior learning and experience is consonant with a PBL approach in several ways. First, a critical component of the PBL process is identifying what is not yet known about a problem or issue. PBL students must ask, "What knowledge is needed to advance collaboratively determined and self-directed learning activities?" Some of the needed knowledge may be knowledge of how others in a PBL group view the problem and from where their understandings come. This leads to a second alignment, which is that a PBL approach encourages us to think about students as strategic resources for peer learning. What one knows or can imagine can be a scaffold for others' learning. Finally, while the task of uncovering and engaging students' prior learning can be a challenge in lecture courses, PBL has an inherent advantage due to the close and sustained interactions between supervisors and students that are a hallmark of PBL courses. Such interactions enable attention to and examination of the particular experiences and understandings of individual students and how these may be influencing students' individual and joint conceptual framings and questions, information gathering and interpretation, and peer interactions. PBL is, by design, a collective and collaborative learning experience, but it is shaped by the individuals engaged in this effort. A key pedagogical task is to motivate and shape both group and individual efforts to accomplish the collective learning goal.

7.2 Learning, Complicated

In reading these chapters, and in considering how to join this conversation, I found the authors' insights into what PBL staff members need to know and how they might come to know it quite useful. Maja Hojer Bruun, Ole Ravn, Diana Stentoft, and Patrik Telléus identify a set of learning goals that I summarize as follows. Both instructors and students need to understand the affordances and constraints that accompany the application of disciplinary knowledge to complex, real-world, interdisciplinary problems. They need to build confidence in their ability to address a problem and let go of the need to be the expert or else cede responsibility to some other expert. They need to share expectations for what the learning experience will entail for all parties; in particular, they need to situate supervisor and students as co-learners in a given problem space, whose shared goal is to create the conditions through which they can collaboratively interrogate and eventually define a problem, and co-construct a knowledge base and inquiry approach that will yield a means of addressing that problem. The authors' exploration of these ideas informs my response, partial though it may be, to their educational concerns and desires.

In their individual chapters, these authors challenge the assumption that simple exposure to interdisciplinary problems and problem solving will lead to learning, and point to the need for intentionality in teaching and learning. Patrik Telléus, for example, argues that learning a new disciplinary view of a problem does not necessarily result in the ability to grasp the wholeness or realness of the problem.

Moreover, a disciplinary analysis of the problem can lead problem-solvers to abandon interdisciplinarity and instead find a way to address the problem in a multidisciplinary fashion. Telléus argues that this is what professional teams in the healthcare arena are accustomed to doing: "tackling the elements that compose the problem one by one and combining them to form a coherent answer." In contrast to this typical approach, he argues for a less "academic" approach to interdisciplinary problems, recommending a process that is "less analytical in nature, instead adhering to a form of experienced and unbiased complexity."

Such unbiased complexity seems to rest, as Diana Stentoft suggests, on a particular stance toward disciplinary knowledge. Students working on real-world problems, she contends, must know about the relevant disciplines. However, learning to distinguish between different types of knowledge is not enough; they must also recognize how disciplinary knowledge can both contribute to an interdisciplinary project and limit understanding of and approaches to a specific problem. To accomplish this, Diana argues, students need to understand different research paradigms and philosophies of science. The goal is not to encourage students to delimit the scope of inquiry according to a discipline, but instead, she argues, "to recognise the premises of the knowledge with which [the disciplines] work and which they construct" as well as to "account for the emergence and contributions of particular knowledge tied to a particular problem." Reflecting on her work in Aalborg's Techno-Anthropology program, Maja Hojer Bruun argues that productive transgressions of disciplinary boundaries can occur when "students experiences and reflect on the different philosophies and knowledge traditions involved in their project work."

Ole Ravn shares a similar understanding of the role of what he refers to as a "theory of science" in promoting interdisciplinary problem-based learning. Taking Stentoft's argument a step further, he offers the Wittgensteinian concept of language games as a means of promoting reflection and dialogue about disciplinary knowledge and its role in interdisciplinary problem solving. To view science as a language game, he explains, students must conceive of any particular discipline or field as "a way of talking about the world or a problem" as well as a set of specific methodological and theoretical practices to be followed. Students engaged in serious dialog and reflection on this idea will come to see "how the sciences together form a centre-free network of practices with numerous family resemblances that connect and divide the scientific approaches developed so far in history." Earlier, I offered a similar view of academic knowledge and inquiry as various, continuous, and evolutionary. When science is viewed in this way, Ravn suggests, education becomes a process that reveals "different understandings of what science is and how it can and should be practised and developed."

Knowledge of research paradigms is a necessary start, but Telléus observes that it may be equally necessary to promote the skills of interdisciplinary collaboration and problem solving. Invoking the work of scholars who have explored disciplinarity and interdisciplinarity, he argues that staff – and presumably students – must come to understand disciplines not simply as "the epistemic subject", but as communities of individuals who share (at least to some extent) beliefs and norms related to inquiry. He recognizes the assessment challenge that this approach will produce

in the medical education programs that use PBL. Indeed, Michele Lamont's (2010) study of interdisciplinary scientific review panels revealed that for the panel members, the process of evaluating proposals was "deeply emotional" as well as "culturally embedded" (p. 8). Her work here and elsewhere raises questions of self-concept and identity as well as academics' concerns about how others define them as scholars (Boix Mansilla et al. 2016).

All the authors in this section raise questions about the preparation of staff who can teach effectively in interdisciplinary PBL programs. Telléus argues that these programs should be composed of teachers from different disciplinary backgrounds who also "respect and acknowledge the collaborative and collective perspective that PBL and interdisciplinarity confer." Stentoft reminds us, however, to look also toward curricula, courses, projects, and activities that might be developed to build students' abilities to "engage meaningfully and collaboratively" with interdisciplinary problems and projects. While PBL poses a pedagogical challenge to instructors, who must learn to facilitate learning through coaching, guiding, and co-constructing knowledge with students, it also poses a curricular – and therefore a staff-development – challenge as well. Hojer Bruun's description of the approach of staff in her program is thus particularly helpful, shedding light on the importance of "asking students to reflect on the ways science and scientific disciplines, as well as interdisciplinarity itself, have been historically produced." Like other authors writing in this section, she argues that an awareness of the "potentials and limitations of the different ways of knowing and doing things" will help students learn to "think with wisdom" about wicked problems.

I end this synthesis with Hojer Bruun's discussion of the Techno-Anthropology curriculum because it makes a point about student learning that I think is relevant to staff learning, as well. Students' immersion in engineering and anthropology, and the intellectual whiplash that occurs as they experience very different modes of knowledge production, quality standards, communication practices, and values, are, she argues, essential to their learning: "[it is] only through these encounters with and personal experiences of *difference*, and the students' active reflection on these experiences, that they get beyond a simplistic notion of two cultures and develop new, transgressive approaches." This brings me to a recommendation for an approach to staff development and a design-based educational research project that may contribute to both the success of interdisciplinary PBL in practice and the research literature required to inform its curricular and instructional approaches.

7.3 Learning Collectively

The chapters in this section all speak to an essential task of interdisciplinary PBL, specifically the construction – through a complementary set of social practices – of communal knowledge. The need for shared social practices, including language and communication and inquiry practices, assumes a set of shared values and goals and a social structure, a community, that accepts and sustains those values, practices,

and goals. In the case of interdisciplinary PBL, the existence of this community is not a given. This may be, as Telléus argues, because the variety of PBL problems and the availability of staff in any given year makes it impossible to develop a system in which staff are assigned only to those teams that require their personal disciplinary/interdisciplinary expertise. Furthermore, as I contend above, the learning experiences and knowledge of particular supervisors and students will inevitably be, at least to some extent, idiosyncratic. So how do supervisors of PBL teams develop, as Ravn requests, the "ability to open the space of scientific possibilities" beyond their own areas of expertise and intellectual comfort zones? How do they come to know about scientific approaches and practices beyond their own fields, as Ravn argues they must, if they are to effectively supervise students in interdisciplinary problem-solving experiences?

In various ways, the authors of these chapters suggest that interdisciplinary PBL requires a community of instructors who share intellectual dispositions and instructional methods that effectively support students' interdisciplinary inquiries. Such a community of experienced practitioners could share what they have learned about successful teaching practices, but in the current context, PBL supervisors are typically dispersed across the university. The pool of available supervisors also changes over time, and as I have suggested, they are variously "disciplined" in their thinking. How could these instructors begin to develop a shared understanding of their educational goals around interdisciplinary PBL, a language for talking with one another and with students, and a set of proven educational practices that scaffold students' learning and build their confidence in their own instructional practice? In the next section, I consider how a joint curricular effort might bring students and staff into a discussion of modes of inquiry that might provide the foundation for the content and pedagogy to come. That this effort would result in a true learning community is not a given, but it offers such a possibility.

Before I present an example of how this might happen, I offer a caution. I do not teach in a PBL program, so I must rely on teaching experiences that I think are analogous, if not synonymous. For roughly a dozen years, I have been teaching an experiential team- and project-based course in qualitative research methods. As I read the chapters in this section and the many references to the foundational role that a knowledge of disciplinary, epistemic, and ontological frameworks plays in these interdisciplinary PBL experiences, I thought often about this course and how I prepare graduate students to collaboratively conceptualize and conduct a small-scale "pilot" study using qualitative methods. In recent years, students with bachelor's and master's degrees in such diverse fields as education, sociology, engineering, chemistry, women's studies, theology, sports management, art history, psychology, public policy, mathematics, and information sciences have enrolled and formed project teams. Although these students have different educational backgrounds, most come armed with knowledge of advanced statistical methods and beliefs about "rigorous" research. Yet very few have a basic understanding of the history and evolution of inquiry in the sciences and social sciences. Even fewer have studied the history of research in their own field. Teaching these diverse groups of students requires that I bring them to a place where groups of three or four can productively

collaborate on a semester-long research project through which they build and apply their learning about qualitative research methods.

I begin this course with readings and discussion about the history of "science" from roughly the thirteenth century to the present (from an admittedly Western perspective). It is a "big-picture" approach in which the goal is to identify and consider broad patterns in how people have thought about "research" over time. The first time I tried this approach, I did so with dozens of butterflies in my stomach. As a scholar interested in interdisciplinarity, I read about the evolution of scientific inquiry, about postmodernism and poststructuralism, and about specific "turns" in the disciplines (e.g., the interpretative turn in sociology, the cultural turn in psychology). I am not an expert in the history, social studies, or philosophy of science. I am, however, knowledgeable enough to lead students through this "big picture" exercise. Using readings and actively engaging students in a discussion of those readings through some basic but critical questions, I find I can bring students from different fields of study to a basic understanding of the questions about human inquiry that lead us to qualitative research methods – and of their affordances and limitations.

My confidence in my ability to traverse this wide territory, as students asked questions and answered mine, and as we jointly constructed an inquiry "timeline", increased with successive iterations of the course.[2] I have not yet found the perfect readings, so I continue to search for new options. I still get butterflies before I teach this class session, and I am sometimes challenged to first understand and then formulate a useful response to a given student's question. I have also learned, however, that I can ask students questions about their questions to unearth the assumptions, often disciplinary and epistemological in nature, that motivate their question. Identifying these assumptions and foundations allows me to respond more effectively. And, happily, peers from different disciplines have things to share with one another. I have learned to use the students in the course to check assumptions, provide examples, counter stereotypical claims, and sometimes very usefully advance our discussion.

Also happily, students in this course are generally quite interested and engaged in this class session, despite the heavy dose of reading from fields with which they are unfamiliar. Perhaps it is because it occurs early in the term, when they are "fresh" and eager to begin, but the session also seems to bring some clarity to earlier, disconnected experiences. Many students have commented over the years that they wished they had had this foundation earlier in their studies. This introduction to modes of inquiry, their histories, and their characteristic assumptions makes students' assumptions about "good" research visible to them (and to me), and it prepares a pathway for the next readings and discussions of epistemology and ontology in different approaches to inquiry (i.e., positivist, postpositivist, interpretivist, critical). To bring these discussions "home" for students, and to ensure they apply these new understandings rather than just acknowledge them briefly, I assign a short paper in which students engage the concepts of objectivity and subjectivity by considering

[2] To be sure, this timeline is an imperfect description, as this exercise makes clear that different inquiry paradigms overlap and co-exist in time.

their own "positionality" vis-à-vis their research interests. Readings that explain the need for reflexivity in research practice contribute to this effort, and students typically recognize the necessity of, and absence of, such reflective practice in what are perceived to be more objective forms of inquiry. During the course, the students and I build on this foundation, and we periodically revisit what we learned in this introductory section as the students encounter, through their project work, different aspects of qualitative research during the course of the term: positionality (or subjectivity) and the role of the researcher, the use of theory and theorizing, the interpretation and evaluation of evidence, and the kinds of claims and conclusions one can draw on the basis of different forms of evidence. It is not unusual for students to disagree during their group-project work, so I have to facilitate a conversation. I assure them that disagreements are both inevitable and useful; negotiating disagreements and new understandings can improve their work if they approach them with the open-mindedness expected of a researcher and scholar.

My approach to introducing qualitative inquiry is both an attempt to provide students with knowledge most do not yet have about the history and evolution of scientific inquiry and to engage their prior knowledge. I know, for example, that students who come with strong training in quantitative research methods will struggle with discussions of the positionality and identity of the researcher (and the researched) and the critiques of method that postpositivist, post-structural, and critical perspectives lodge. Most have never carefully considered the questions about inquiry that these perspectives raise. Other students struggle with the question of whether research findings that are not generalizable have any value. Yet many of these same students are also personally and/or intellectually aware that social identities – gender, ethnicity, religion, nationality – shape people's experiences of the world. When these personal beliefs meet the assumptions of traditional scientific social science research, many students find themselves reflecting on how their beliefs about the centrality of identity align, or do not align, with assumptions about scientific neutrality, rationality, and objectivity. Different bits of their learning – often previously tucked away (metaphorically and neurologically) in different parts of their brains – meet and require attention. If I ignore the prior learning that students bring to this classroom rather than intentionally engaging it, that prior knowledge (and the emotions it invokes) can be an obstacle, so my goal is to find the affordances in students' prior experiences that can aid us in the learning process. This requires discussion, sharing, and dialogue – which are possible in smaller, interactive classrooms that privilege group learning and learning-focused out-of-class interactions.

While this instructional approach has been effective for the vast majority of students I teach, I am aware that students' initial learning is tentative and in need of further scaffolding. Many students struggle with the subjective nature of interpretation, but working in teams to collect and analyze interview and observation data makes abstract discussions concrete – and typically motivates students' interest in validity and evaluation criteria. The pedagogical approach also sets an expectation for a collaborative and constructivist learning experience that includes the identification and interrogation of how our assumptions shape the questions we ask and how

we ask them. In addition to producing a final "proposal" for a research project based on what they have learned in the "pilot study," I ask students to write reflective memos, typically used in qualitative research to aid data collection and analysis, in which they are asked to make their learning apparent to me by connecting what they have learned from the instructional resources we use to their projects. My assessment of their work is focused as much on the quality of their learning throughout the term, evidenced by their ability to apply lessons learned and recognize missteps in the process of doing research, as it is on the final project. This pedagogical aspect of the course may also resonate with PBL staff who are concerned with educating students as intentional and lifelong learners rather than with simply producing "right" answers.

The reflections in the foregoing chapters and on my own teaching experience led me to consider the kinds of curricular and pedagogical support that could facilitate the interdisciplinary learning of PBL students and staff. The chapters in this section suggest that instructors need a way to introduce new university students preparing to engage in interdisciplinary PBL to the history of ideas about human inquiry and the assumptions underlying them. In my course, I can focus primarily on social science research methods, explaining how these are influenced by inquiry in the natural and physical sciences. PBL staff may not have this option, and may have to work together to determine how to introduce students with different intellectual and personal histories to a broader array of research traditions. Such a collaboration, however, would likely be preferable to solitary instructional efforts such as the one I undertook, assuming it would enhance collaborators' understanding of research methods with which they are less familiar and lead to robust approaches to building such knowledge among new PBL students. Such collegial interactions should also build supervisors' confidence in their ability to facilitate the learning that the authors in this section view as foundational.

A learning community of PBL instructors could also build knowledge together through reading and joint teaching and by observing and reflecting on successes and challenges as they teach this content. Additionally, as supervisors engage students in thinking through the affordances and limitations of different modes of inquiry, they will also be modeling the kind of reflective practice students are expected to develop in PBL courses. Finally, in the spirit of building a strong practice base and sharing their learning with others, I would encourage staff to study the effects of the approaches they co-create, use what they learn about their students' learning to refine their approach, and share their research with others to begin to build the larger community's pedagogical knowledge of interdisciplinary PBL.

7.4 Learning and Teaching Intentionally

In my commentary I have tried to make the case for a curricular response to the challenges of teaching interdisciplinary PBL. To be clear, I define curriculum broadly as an academic plan that links curricular content, teaching approaches,

instructional materials, and assessment (Lattuca and Stark 2009). A curriculum is more than its content; it is a plan for action. In addition, my research also recommends a curricular approach. Because there is a limited body of research that systematically assesses the effects of interdisciplinary study on the learning and development of students, I turn to a large-scale study that my colleagues and I conducted. Relying on a sample of more than 5000 undergraduate engineering students and 1100 engineering instructors in 120 U.S. engineering programs at 31 institutions, we found that students who reported a strong *curricular* emphasis on interdisciplinary topics in their engineering programs also reported greater confidence in their interdisciplinary skills (Lattuca et al. 2017). In this study, curricular emphasis was measured as emphasis on understanding and applying knowledge from fields outside their own to an engineering problem and on understanding how different problem contexts (e.g., cultural, environmental, economic) shape engineering solutions. My colleagues and I interpreted these findings as highlighting the need for intentional guidance as well as focused and repeated practice in interdisciplinary thinking and practice.

A PBL curriculum is particularly well positioned to provide this sustained engagement in, and supervision of, interdisciplinary thinking, collaboration, and problem solving. Yet the authors in this section are troubled because, in their experience, a PBL curriculum does not necessarily translate into the development of interdisciplinary learning and habits of mind. They suggest that variations in supervisors' levels of preparation in and commitment to interdisciplinary ways of thinking, openness to interdisciplinary inquiry, and ability to facilitate interdisciplinary conversations contribute to this problem. With some of these authors, I agree that professional development for PBL supervisors is indicated, and I have offered a suggestion for how PBL staff might self-organize this effort. But the other group of learners to which we must attend is the new cohort of PBL learners who come to university with prior, and varied, learning experiences that shape their expectations of courses, teachers, and learning. I argue that these students, not just their supervisors, need a thoughtful and substantive orientation to the variety of inquiry approaches in the disciplines at the outset of the interdisciplinary PBL experience on which they are embarking. Rather than approach this learning task individually, I believe PBL staff will benefit greatly from a collaborative approach to designing, delivering, studying, and refining an orientation that prepares students to engage fruitfully in PBL. Their disciplinary affiliations and their observations about the challenges and successes of PBL instruction are resources for learning, as are books, articles, and other colleagues. In the spirit of PBL, I offered some resources for consideration – from ideas about learning to examples from my own teaching – but leave the form of the orientation curriculum up to the members of the learning community.

A learning community of PBL instructors would simultaneously address the needs of staff and of students. Staff need foundational understandings of disciplines other than their own so they can help students recognize these ways of thinking, their affordances, and their limitations. They also need curricular resources and pedagogical strategies that can be used to promote interdisciplinary thinking among

students. Engagement in this professional learning community would build both capacity and confidence among staff who are variously prepared for the cultivation of interdisciplinary thinking and problem solving among university students. PBL supervisors who recognize when and how disciplinary frames and inquiry traditions are shaping students' understandings and efforts can help their students develop metacognitive awareness of how their approaches to an issue or problem affect their own and others' learning. Such teachers can also model the reflective thinking that is characteristic of self-directed learners (Hmelo and Lin 2000) and conducive to collaborative, interdisciplinary learning.

The chapters in this section, as well as my commentary, can serve as catalysts for further discussion and dialog among staff acquainted with the processes, challenges, and pedagogy of PBL. There is no one solution to the pedagogical challenges revealed here, but there are promising directions for curricular and pedagogical action. There is also much to be learned if educators jointly search for useful responses.

References

Abbott, A. (2002). The disciplines and the future. In S. Brint (Ed.), *The future of the city of intellect: The changing American University* (pp. 205–230). Stanford: Stanford University Press.

Ausubel, D. P., Novak, J. D., & Hanesian, H. (1978). *Educational psychology: A cognitive view* (2nd ed.). New York: Holt, Rinehart and Winston.

Bandura, A. (1991). Social theory of self-regulation. *Organizational Behaviour and Human Decision Process, 50*, 248–287.

Bloxham, S., & Campbell, L. (2010). Generating dialogue in assessment feedback: Exploring the use of interactive cover sheet. *Assessment & Evaluation in Higher Education, 35*, 291–230.

Bloxham, S., & West, A. (2004). Understanding the rules of the game: Marking peer assessment as a medium for developing students' conceptions of assessment. *Assessment and Evaluation in Higher Education, 29*, 721–733.

Boix Mansilla, V., Lamont, M., & Sato, K. (2016). Shared cognitive-emotional-interactional platforms: Markers and conditions for successful interdisciplinary collaborations. *Science, Technology & Human Values, 41*(4), 571–612.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academies Press.

Brint, S. G., Turk-Bicakci, L., Proctor, K., & Murphy, S. P. (2009). Expanding the social frame of knowledge: Interdisciplinary, degree-granting fields in American colleges and universities, 1975–2000. *The Review of Higher Education, 32*(2), 155–183. https://doi.org/10.1353/rhe.0.0042.

Frickel, S., & Ilhan, A. O. (2017). Disciplinary and interdisciplinary change in six social sciences: A longitudinal comparison. In S. Frickel, M. Albert, B. Prainsack, & B. (Eds.), *Investigating interdisciplinary collaboration: Theory and practice across disciplines* (pp. 148–169). New Brunswick: Rutgers University Press.

Hmelo, C. E., & Lin, X. (2000). Becoming self-directed learners: Strategy development in problem-based learning. In D. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp. 227–250). Mahwah: Erlbaum.

Huutoniemi, K., Klein, J. T., Bruun, H., & Hukkinen, J. (2010). Analysing interdisciplinarity: Typology and indicators. *Research Policy, 39*, 79–88.

Jacobs, J. A. (2013). *In defense of disciplines: Interdisciplinarity and specialization in the research university*. Chicago: University of Chicago Press.
Kellert, S. H. (2008). *Borrowed knowledge: Chaos theory and the challenge of learning across disciplines*. Chicago: University of Chicago Press.
Klein, J. T. (1990). *Interdisciplinarity: History theory, and practice*. Detroit: Wayne State University Press.
Lamont, M. (2010). *How professors think: Inside the curious world of academic judgment*. Cambridge, MA: Harvard University Press.
Lattuca, L. R. (2001). *Creating interdisciplinarity: Interdisciplinary research and teaching among college and university faculty*. Nashville: Vanderbilt University Press.
Lattuca, L. R., & Stark, J. S. (2009). *Shaping the college curriculum: Academic plan in context*. San Francisco: Jossey-Bass.
Lattuca, L. R., Knight, D. B., Ro, H. K., & Novoselich, B. J. (2017). Supporting the development of engineers' interdisciplinary competence. *Journal of Engineering Education, 106*(1), 71–97. https://doi.org/10.1002/jee.20155.
Leahey, E., & Moody, J. (2014). Sociological innovation through subfield integration. *Social Currents, 1*(3), 228–256.
Lee, C. D. (2016). Examining conceptions of how people learn over the decades through AERA presidential addresses: Diversity and equity as persistent conundrums. *Educational Researcher, 45*(2), 73–82.
Leydesdorff, L., & Schank, T. (2008). Dynamic animations of journal maps: Indicators of structural change and interdisciplinary developments. *Journal of the American Society for Information Science and Technology, 59*(11), 1810–1818.
Light, R., & Adams, J. (2017). A dynamic, multidimensional approach to knowledge production. In S. Frickel, M. Albert, B. Prainsack, & B. (Eds.), *Investigating interdisciplinary collaboration: Theory and practice across disciplines* (pp. 127–147). New Brunswick: Rutgers University Press.
Miller, M., & Mansilla, V. B. (2004). *Thinking across perspectives and disciplines*. Boston: Harvard Graduate School of Education.
O'Mahoney, S., & Bechky, B. A. (2008). Boundary organizations: Enabling collaboration among unexpected allies. *Administrative Science Quarterly, 53*(3), 422–459.
Porter, A., & Rafols, I. (2009). Is science becoming more interdisciplinary: Measuring and mapping six research fields over time. *Scientometrics, 81*(3), 79–45.
Resnick, L. (1987). Learning in school and out. *Educational Researcher, 16*(9), 13–20.
Sa, C. (2008). Interdisciplinary strategies in U.S. research universities. *Higher Education, 55*, 537–552.
Schuell, T. (1986). Cognitive conceptions of learning. *Review of Educational Research, 56*, 411–436.
Shavelson, R. J. (1974). Methods for examining representations of a subject matter structure in students' memory. *Journal of Research in Science Teaching, 11*, 231–250.
Vygotsky, L. (1978). In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.), *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
Weaver, M. R. (2006). Do students value feedback? Student perceptions of tutors' written responses. *Assessment and Evaluation in Higher Education, 31*, 379–394.
Wuchty, S., Jones, B. F., & Uzzi, B. (2007). The increasing dominance of teams in production of knowledge. *Science, 316*(5827), 1036–1039.

Part II
Practising Interdisciplinarity in Problem-Based Learning

Chapter 8
Opening the PBL Game: Problem Construction in Interdisciplinary Project Work in Multicultural Groups

Kirsten Jæger and Annie Aarup Jensen

8.1 Introduction

This chapter adopts a cultural perspective on problem-based learning by understanding it, in the context of multicultural interdisciplinary project groups, to be an 'epistemic game' (Collins and Ferguson 1993; Markauskaite and Goodyear 2017a) rooted in a specific epistemic culture. It also investigates the strengths, challenges, rules, and constraints of this game and asks which parts of such a game might be particularly difficult for students raised in non-Western academic/epistemic cultures to play. It takes a specific interest in the opening of the game, namely the problem construction process.

To understand an activity as an epistemic game involves seeing the activity as an interplay of rules, resources, and creativity: "A game is a form of action that entangles rules of thought and rules of culture with affordances and constraints, symbolic inscriptions and the physical world" (Markauskaite and Goodyear 2017a, p. 396). Already Collins and Ferguson (1993) pointed out that disciplines are characterized by *different* epistemic games. Markauskaite and Goodyear (2017a) emphasize that students need to learn the epistemic games played in their disciplines, fields, and professions. The multitude of epistemic games existing both internally (within disciplines, professions etc.) and across disciplinary and professional boundaries call for epistemic fluency on the part of students. Markauskaite and Goodyear's typology of epistemic games demonstrates that epistemic games differ vastly in terms of purpose, goal, and involved knowledge. Recognizing

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which epistemic game one is supposed to play in a given setting is a basic but also crucial skill to master both within educational and professional contexts (Markauskaite and Goodyear 2017b). Epistemic games not only come in many varieties, they also exist at several levels in the sense that some games are nested within more comprehensive games (for example, 'research games' are sub-games under 'propositional games'). In this chapter, we understand problem-based learning and its implementation in group-organized project work as an overarching epistemic game comprising diverse sub-games. Firstly, the interdisciplinary nature of PBL activates different disciplinary games. Secondly, projects may involve professional engagement requiring students to integrate certain professional games, and thirdly, it has become clear that different educational cultures (as they are represented in multicultural project groups) also foster different epistemic games and associated participation capabilities. The challenge of learning to play the epistemic games of a new university culture has been studied in many contributions on student mobility and multicultural groups, even if the notion of the epistemic game is not explicitly linked to the experience of foreign students. However, understanding this experience as equivalent to being asked to play a game without knowing the rules effectively conveys an intuitive sense of foreign students' challenges at, for example, a PBL university (e.g. Gram et al. 2013).

The outcome of the problem construction process – the *problem* – is a much-celebrated epistemic object in the PBL literature. The problem is the key to good project work. Furthermore, it is expected to support and guide the process of choosing and delimiting the field of research, the literature and theory to be studied, the methods to be applied, and the focus of empirical studies, if relevant.

> I think it's helpful because you know what you are going to do. Because you have a problem here, and what you do is try to find way to solve it. So everything you do is related to the problem. And then you try to find a way, like case study, interview or something, and our group, we go to the library and we try to find a theory related to how to solve this problem. And you know what you want to do. (Chinese master's degree student, Aalborg University)

A particular feature of this epistemic object is that, once constructed, it will define the rules for the rest of the game, in terms of both disciplinary perspectives and constraints. Metaphorically speaking, until the research problem is constructed it remains undecided whether the game will be chess or poker – or perhaps a combination of the two. The unique openness of the problem construction process in interdisciplinary project groups presents a challenge to all students, but specifically to students raised in non-Western epistemic cultures; hence, there is interest in exploring the characteristics of the problem construction process in multicultural interdisciplinary groups.

The chapter takes its point of departure in an account of the problem construction process and the arguments for the inherent learning potential in 'free' problem construction as practiced at some PBL universities. This chapter refrains from an extensive discussion of interdisciplinarity per se but notes the increase in interdisciplinarily organized research and higher education (e.g. Barry and Born 2013; Jacobs 2013). It is interested in interdisciplinarity as it emerges in the encounter between different disciplinary cultures (Becher 1994; Collins and Ferguson 1993) in the project group.

Finally, the chapter addresses how the initiation of a PBL project as an epistemic game involving the temporary suspension of disciplinary rules and constraints seems to privilege students raised in Western academic cultures because of their familiarity with the unarticulated cultural values and assumptions inherent in the open problem construction process.

In this chapter, the generic and somewhat simplified notion of the 'Western university' will be deployed. This notion implies another simplification: that we can meaningfully talk about *non-Western* universities and academic traditions, such as the Confucian tradition. Recognizing that the context of globalization precludes the development of isolated, 'indigenous' academic traditions, the literature investigating higher education from sociocultural and international perspectives refers to the origin of the Western university as a historical process involving the university traditions of Germany, France, the UK, and the US (e.g. Shin 2012). During the colonial period, the British, French, and German university traditions left their mark on the educational systems of colonized countries, including various countries in East Asia. However, in these countries, Western educational ideas met a strong tradition of higher learning institutions (Shin 2012), enabling the continued development of academic traditions that retained their distinct cultural characteristics in the postcolonial period despite Western influence. Consequently, a significant body of literature has studied the intercultural relationships between Western and non-Western university traditions, not least in relation to international student mobility (e.g. Biggs 1998; Chalmers and Volet 1997; Deng 2011; McMahon 2011; Tian and Low 2011).

First and foremost, the chapter presents a conceptual exploration of the combination of multiculturalism and interdisciplinarity in PBL project groups. Its main points, however, are illustrated using statements from Chinese master's degree students describing their encounters with interdisciplinary project work in multicultural groups. These statements were collected as part of a study on the experiences of Chinese students at a Danish PBL university (Gram et al. 2013; Jæger and Gram 2015). All the quotations are from students who were enrolled in various English language master's degree programs. Finally, the chapter will explain and demonstrate how interdisciplinarity can be approached from a cultural angle.

8.2 Open Problem Construction and its Learning Potential

Several scholars have argued that disciplines develop their own epistemic cultures, norms, values, and jargons (e.g. Collins and Ferguson 1993). As such, the disciplines are helpful frameworks that guide scholarly inquiry towards new insights and in-depth understanding of relatively well-defined areas (Jacobs 2013). Our dependence on specific epistemic cultures in the form of the disciplines reflects a much more fundamental dependency on language itself, in particular on our mother tongue, as it provides us with the categories, concepts, and systems that both enable

and constrain thinking. Individuals are influenced by their previous experiences regarding the meanings of signs and symbols, and use language without explicit consciousness of its embedded logical distinctions (Dewey 1910/1991),

> Propositions, sentences, bear the same relation to judgments that distinct words, built up mainly by analyzing propositions in their various types, bear to meanings or conceptions; and just as words imply a sentence, so a sentence implies a larger whole of consecutive discourse into which it fits. As is often said, grammar expresses the unconscious logic of the popular mind. *The chief intellectual classifications that constitute the working capital of thought have been built up for us by our mother tongue*. Our very lack of explicit consciousness in using language that we are employing the intellectual systematizations of the race shows how thoroughly accustomed we have become to its logical distinctions and groupings. (Dewey 1910/1991, p. 175)

Overcoming linguistic, cultural, and epistemic boundaries in multicultural, multilingual, and interdisciplinary project groups requires meticulous inquiry into the mutual understandings of both theoretical concepts and everyday discourse. It is only through discussion of specific understandings of words and concepts that it will be possible to determine to what extent there is agreement on the meaning of a problem. Despite the challenges that open problem construction presents to the students, many programs consciously choose this approach because of its learning potential. Open problem construction is an important pedagogical characteristic of Aalborg University's PBL approach (see also Jensen and Lund 2016), and implies that the students should experience the problem as being relevant to them and feel a sense of ownership of their project. Open problem construction also emphasizes the authenticity of the research and learning process, as students are motivated by their own curiosity, no answers are given, and in some cases students come up with creative answers and innovative solutions to real-world problems. The ideal is that students are thus transformed from knowledge consumers to knowledge producers through their research processes; as is the case in all research, it is critical that the research effort is centred on a suitable research question. In PBL, formulating the problem corresponds to formulating the research question, and in order for the problem to guide or direct the students' work it has to be stated very carefully, with attention given to every word. Thus the process of defining the problem and formulating it in precise terms offers some of the most challenging and potentially rewarding learning processes of problem-oriented project work (Illeris 2015). The reason this process is considered important from a learning perspective is that it requires group members to contribute actively to the social learning process and enter into discussions, negotiate meaning, participate in selection processes, and compromise. Active participation in the demanding process of finding the right way to formulate the problem, which may involve both positive and negative experiences and can be daunting for students, may lead to transformative learning, that is, a change in the learner's identity (Illeris 2015). The following statement highlights the role of problem formulation in guiding the group's learning processes and enhancing the quality of learning:

> I believe a good problem formulation is the beginning of success. Actually, our group spent almost half of our project time on trying to formulate a proper problem last semester. Seeking a problem itself is a learning process, and following the problem to conduct further

> study is a more focused, more critical, and deeper learning. (Chinese master's degree student, Aalborg University)

This student notes the time and effort spent on seeking and formulating a problem and argues that this is a dynamic process. During the process of narrowing down and attempting to grasp problems through problem formulation, students must deal with problems that are often ill defined or ill structured, thereby gaining understanding of the open-ended nature of the research process and the potential interdisciplinarity involved. Communication and the exchange of ideas, dialogues, discussions, and negotiation of meaning are important tools for students in the problem formulation process; even if the group is composed of students of the same nationality and with the same mother tongue, through such active engagement they will find that their fellow group members may understand concepts and express their ideas differently than they do themselves (Jensen 2015). Also, students trained in different educational cultures and disciplines will not necessarily have a shared meta-language at their disposal that would allow them to take misunderstandings to a different communicative level in order to sort them out.

8.3 Interdisciplinarity in Project Groups

Problems are not neutral or indifferent to disciplinary frameworks. Many problems only become apparent to the disciplinarily trained eye and are closely connected to a specific discipline's knowledge base and methods. Yet some problems are interdisciplinary in the sense that they defy disciplinary categorization and definition. Understanding problems as actively generated by both human actors and the social and material environments (or 'apparatuses') in which they are embedded, Barry and Born (2013) note that science increasingly generates problems that defy disciplinary categorization. Thus, interdisciplinarity is legitimized not through the *additional* gains it may bring in terms of social or public accountability or innovation, but through a 'logic of ontology' responding to the emergence of problems that resist fragmentation into parts that can be approached within the disciplines:

> The logic of ontology is manifest in those interdisciplinary practices that are oriented towards the generation of hybrid or relational objects that cannot be broken down into distinct natural, technical, and social components. Conversely, it may be that it is the hybridity or relationality of the problem that resists the efforts of disciplinary practitioners to distil them into distinct natural and social fractions. (Barry and Born 2013, p. 18)

Barry and Born analyse such trends in the institutional organization of research. However, similar trends can be observed in the organization of higher education, where the number of interdisciplinarily defined programs has mushroomed in recent years. By engaging in socially pertinent problems such as security, risk, climate change, and peace and conflict, such programs assume the ability of students to draw on various areas of disciplinary expertise in order to address program-relevant questions. Whereas interdisciplinary collaboration among groups of researchers has been investigated

theoretically and empirically within the framework of social epistemology (e.g. Andersen and Wagenknecht 2013), empirically based knowledge on *students*' interdisciplinary knowledge production and knowledge collaboration is almost non-existent.

Some work has been done on the investigation of epistemic practices in student groups (where the students share a disciplinary background). Damsa and Andriessen (2012) explored 'shared epistemic agency' in a student group writing a bachelor project. The group's activities demonstrated the students' ability to produce a 'knowledge object' and simultaneously develop themselves individually and collectively, illustrating the intertwined character of collective knowledge production and individual learning. The study highlights the students' continuing efforts to ensure *shared* points of departure and plans for future work, engaging in what Damsa and Andriessen term 'regulatory processes', which are characteristic of shared epistemic agency. Following the same course of study, which gave them the same set of constraints, and, ironically, knowing little about the topic under investigation contributed to the group's successful shared epistemic agency. In graduate-level education, students' *diverse* knowledge backgrounds (including theoretical concepts and methods) may actually hinder the formation of shared epistemic agency that the construction of an epistemic object, such as the problem framing the group's research, requires. Disciplinary differences as obstacles in the problem-finding process are illustrated in the following quote:

> At the very beginning, every member was influenced by the information which they have already known or been familiar with, and thought in their own ways (…) Other than this choosing topic problem, we also had work dividing problems. Because of our different majors in our bachelor studies, everyone wanted the project's approach close to his major. One member, who used to learn economy wanted very much to write the whole paper in economy direction, so he tried to convince us to only write about the economic relations between China and African countries. But as everyone knows, that of course when we talk about the relationship between countries, we cannot only touch the economic field. (Chinese master's degree student)

The organization of education as interdisciplinary problem-based learning in project groups invites students to play a new and different epistemic game (compared to disciplinarily organized programs), in which the rules will be defined by the problem, as described above. Collins and Ferguson (1993) coined the term 'epistemic game' and defined it as 'the rules and strategies that guide inquiry'. More recently, Goodyear and Markauskaite defined epistemic games as "patterned ways of creating knowledge" (Markauskaite and Goodyear 2017b, p. 564) emphasizing the importance of a learner's mastery of the discipline's or the profession's approved forms of inquiry. Disciplines have their own epistemic games because these "patterned ways" create different 'epistemic forms' (ideal types of research results). In other words, different disciplines apply different methods and arrive at qualitatively different kinds of results. For example, one social science discipline may pursue the confirmation (or rejection) of a hypothesis, while another attempts the production of a 'thick description' based on ethnographic data. Some produce stage models, others produce hierarchical models, and some look for 'basic elements' (Collins and Ferguson 1993).

Had the above-mentioned student, who majored in economics, been able to sway the opinion of the other students, the project would most likely have produced the results – or the epistemic forms – characteristic of an economics program project. Understanding that this was not expected of students in an international relations program, the student quoted above insisted on having multiple disciplinary perspectives represented in the project.

On the one hand, the notion of epistemic games emphasizes the boundaries between disciplines and can help us understand the depth of disciplinary differences (see also Fish 1994). On the other hand, the notion can also be applied at different levels and in different contexts and, according to Goodyear and Zenios (2007), individuals can learn to recognize and participate in a variety of different epistemic contexts. Goodyear and Zenios emphasize the link between epistemic games and epistemic cultures and, interestingly, the importance of epistemic fluency for interdisciplinary and intercultural collaboration:

> Epistemic fluency allows one to perceive these games and engage in them. Epistemic fluency allows one to recognize, appreciate and understand the subtlety and complexity of a belief system that one has not encountered before, whether that belief system is associated with a religious or ethnic community, or a scientific or professional community. It is important to inter-cultural and interdisciplinary understanding and capability. (Goodyear and Zenios 2007, p. 358)

8.4 The Epistemic Game of PBL and the Multicultural Challenge

Universities instituting PBL as a general and universal approach to teaching and learning across faculties and programs introduce an overarching epistemic game that students play regardless of their disciplinary affiliation: they manage their own work; they work collaboratively; and their inquiry takes its point of departure in a student-defined problem of relevance to the program. Across programs, a certain similarity in terms of the produced epistemic objects is expected. General introductions guide students in how to make good problems and problem formulations resulting in a ‘project report’, a genre common to Danish PBL-organized universities. Hence, we may see PBL as instituting its own epistemic culture with the capability of spanning multiple disciplinary epistemic cultures. Problem-based learning invites students to play a new epistemic game, in which distinct disciplinary epistemic forms should be accessed flexibly as required by the problem itself. In order for PBL to function as an overarching epistemic culture it must, like successful multicultural societies, find a balance between cultural (disciplinary) distinctiveness and intercultural sharing. Hence, interdisciplinary project work calls for epistemic fluency, both in terms of the versatility in multiple cultures that Goodyear and Zenios (2007) address and as an intimate knowledge of PBL as an epistemic culture.

Although problem-based learning has spread to most parts of the world (e.g. Schweisfurth 2011), it is important to be aware of certain inherent norms and values

in PBL that may be more accessible and understandable for students raised in Western academic cultures. These have led some scholars to express a certain pessimism regarding non-Western students' participation in PBL-organized learning activities (Chalmers and Volet 1997). Other scholars have reached more optimistic conclusions: differences in terms of educational background and culture certainly influence student learning, but can also be dynamic resources serving as a point of departure for the acquisition of new approaches to learning (Gram et al. 2013). Still, asking students from various parts of the world to engage in self-defined, novel, and largely unexplored problems as *critical*, *independent*, and *anti-authoritarian* learners, and asserting that this will foster learning, is considered challenging by students accustomed to class-based, teacher-controlled learning and assessment. Thus the question remains as to how cultural difference, understood as socialization into different educational cultures, affects students' ability to engage in the problem construction process.

Arguably, the ability to think critically is a prerequisite for a successful outcome of the problem construction process. Constructing the problem implies questioning received knowledge as it is conveyed to the student in teaching, in textbooks, and through mainstream media. Problem-based learning considers learners not as compliant consumers of imparted knowledge but rather as critical co-constructors discovering unexpected angles and focusing on the gap between what is known and what is yet to be investigated in order to answer the problem formulation. Ideally, a successful problem formulation in itself represents a critique because it postulates the insufficiency and inadequacy of existing knowledge.

The question, however, is *how* received knowledge is questioned; in other words, which forms of criticality are students expected to enact in problem-based learning?

The answer depends on the context. In early conceptualizations of PBL, criticality was understood as the ability of students to recognize their own precariousness (but also their own interests) in a capitalist society haunted by economic crises and high levels of unemployment (Illeris 1981). This notion of criticality was reflected in the requirement that addressed problems should be both *authentic* (self-experienced in some sense) and *exemplary* (indicative of structural inequality). This conceptualization of criticality reflects what Fuchs and Sandoval (2008) term 'Marxist critique' in their investigation of communication and students' understanding of the concept of critique. Recognizing the multifaceted nature of criticality, they suggest that the notion of Marxist critique must be supplemented with other criticality concepts: the positivistic notion of critique and critique rooted in postmodernist theory. The various concepts of critique legitimize different forms of criticality ranging from celebrating the critical exchange of opinions for its own sake, through critical deconstructive inquiry into established discourses and practices, to calls for radical change. Interestingly, Fuchs and Sandoval find that all three forms of criticality are expressed in their data, albeit to varying degrees.

These findings show that criticality as an expected competence in PBL is not only closely associated with dominant Western intellectual traditions (positivism, postmodernism, and Marxism); in practice, it also takes multiple forms, so that for

students who are unfamiliar with Western educational traditions it becomes difficult to interpret *how* one is expected to enact criticality. This became evident in a study of Chinese master's degree students at Aalborg University (Gram et al. 2013). They rapidly identified classroom criticality as an *unfamiliar* cultural technique, a skill mastered by Western students but not by themselves. However, they were able to acquire the criticality 'skill', enabling them to perform as well as their Western peers in the classroom:

> Sometimes we do not appear as active as foreign students since we are not used to break in when the lecturer is speaking, which is considered as a little bit impolite in China. Besides, this critical thinking mode does not go along with the way we are educated back in China. But since we are aware of the differences and everyone wants to learn something during the lectures, we also develop this critical ability gradually and some of us can give quite good comments in the lectures as well. (Chinese master's degree student, Aalborg University)

That students from non-Western educational cultures can acquire the skills of and even excel in critical classroom interaction confirms the understanding of cultural influence as dynamic and adaptable to new cultural contexts. Furthermore, this challenges studies of, for example, Confucian learners' difficulties with group and problem-based learning (Woodward-Kron and Remedios 2007). Initially, non-Western students may not be familiar with the cultural practice of 'doing criticality', but they will acquire this skill, especially if the learning environment provides the opportunity. But does the PBL problem construction process demand a form of criticality that differs from the 'criticality-as-a-skill' understanding in the quote above? Another student who addressed criticality in PBL articulated a more complex concept of the role of criticality in multicultural groups:

> On the one hand, students are required to study critically and stick to their own opinions; on the other hand, they have to apply the theories or knowledge they learn from classes into the project and try to solve the problem. Obviously, it is really a challenge, especially for Chinese students who are accustomed to absorb what professors say without reflection. (Chinese master's degree student, Aalborg University)

This student recognizes the challenge of 'taking in' the imparted knowledge and at the same time articulating an academic and professional stance that is clearly one's own, as opposed to a reproduction of the positions taught by the professor. Criticality in this sense is not (merely) a skill, but rather a defining element of a specific form of student subjectivity in which the student is both a learner and an independent and respected member of the academic community. This specific form of student subjectivity has its historical roots in the Western university tradition harking back to the Humboldtian research university, situating the student as a peer from whom we expect knowledgeable, independent, and challenging contributions. The Humboldtian research university has served as a model for university development throughout Northern Europe. Characteristic of the Humboldtian research university is the unity of research and teaching, perhaps illustrated most concretely in the German *Seminar*, a pedagogical form that has inspired university pedagogy in the Scandinavian countries (Dysthe and Webler 2010). In the *Seminar*, students participate as researchers, presenting their own research and receiving extensive

feedback from teachers and peers. Dysthe and Webler describe the Humboldtian university pedagogical approach as 'a pedagogical regime where lectures, seminars, laboratory courses, excursions, etc. were seen as support to students' independent pursuit of understanding and knowledge, more than means of transmitting and imparting knowledge' (Dysthe and Webler 2010, p. 251). Obviously, the *Seminar* pedagogy was developed for the elite university and became less meaningful in the reality of the mass university, where seminars may be held for a large number of students, leaving little room for feedback on individual, independent research. However, PBL or PBL-like pedagogical forms have provided an opportunity for a revival of Humboldtian principles:

> Problem-based, work-based, case-based and project-oriented teaching and learning methods proved far better able to connect theory and practice than traditional teaching methods. These variations of cooperative learning in groups resemble the Humboldtian idea of learning communities. (Dysthe and Webler 2010, p. 258)

The Humboldtian university tradition and the pedagogic forms inspired by it define the teacher-student relationship in a way that presents additional challenges for learners raised in non-Western educational contexts. In a reflection of the basis of the PBL tradition's concept of student-led learning in the Humboldtian research university, the teacher/supervisor encounters the student respectfully, eager to learn how precisely this individual conceptualizes the field's concepts and theories. Out of respect for each individual's autonomy, the PBL supervisor enables the student to make qualified choices but leaves the actual choosing to the student and his/her peers in the group. However, non-Western students may experience the emancipating, individualizing supervisor who encourages independent and anti-authoritarian thinking as 'cold' and disengaged:

> And we asked a supervisor and he said, 'Whatever you choose is okay', and then we have a lot of discussions to decide which one to choose. Yeah, in the beginning it's quite difficult, but when we decided which one to choose then it's gonna be really good. Yeah, it's quite fine that only at the beginning we don't know ... We are totally lost. We don't know which way to go. (Chinese master's degree student, Aalborg University)

PBL supervisors not only expect students to take an independent, critical stance and to draw on this stance in the problem construction process, they also expect students to actively communicate positions, arguments, and criticisms. Furthermore, the basis of the problem construction process is the free exchange of perspectives and ideas, communicated as individual contributions to an inquiry on a broader topic, in the pursuit of the precise problem to be engaged. However, multiple contributions to the international education literature address the problem of international students' 'silence' in multicultural group work, a silence that has consistently been associated with passivity and a low level of engagement (Harrison and Peacock 2010). Studies that include the voices of international students find this silence to be a reaction to a complex set of issues ranging from language barriers and cultural backgrounds to experiences of hostility and discrimination (Wang 2012).

Key principles in PBL practice – especially the principle of asking students to define their own research problem – clearly emanate from a Western academic tradi-

tion. Despite its virtues, as clarified above, this practice and its underlying rationale are not always understandable to non-Western students and can cause difficulties and frustrations. The quotes indicate that one reason for experienced difficulties in the encounter with the unstructured, somewhat chaotic, and challenging problem construction process is the *implicit* character of the educational rationale for letting students struggle on their own to build the framework around their learning process in the form of a good problem. The unregulated and unstructured problem construction process simultaneously epitomizes prominent Western educational ideals, such as individualism, autonomy, authenticity, and criticality, and manifests these cultural values as self-evident everyday practices that require no further explanation. On the one hand, the freedom and looseness of the problem construction process frustrates many students raised in non-Western educational cultures; on the other hand, it (potentially) offers some of the most rewarding learning experiences to the participants.

8.5 Concluding Remarks

Engagement in self-managed problem construction requires epistemic fluency and some understanding of the cultural values underlying this pedagogic principle. Furthermore, the literature on multicultural student groups has discovered certain conditions that improve the chances of successful outcomes of multicultural interdisciplinary group work. Group composition plays a major role: unregulated group formation often results in the segregation of domestic and international students. Some form of intervention, for example in terms of requirements for group composition, will enhance multicultural collaboration. Secondly, the problem construction process is often associated with lengthy face-to-face discussions requiring students to be fluent English-language communicators. Although such discussions evidently embody the cultural values of the free exchange of ideas and opinions, they may also be perceived as intimidating or perhaps simply a waste of time. Using a variety of discussion platforms will enable students who are not well versed in face-to-face group discussions to state their opinions. (For an interesting study of the exclusion of non-English speakers from group decisions, see Leki (2001)). Finally, students who master the language of instruction and who are familiar with the epistemic culture of the institution will always be privileged. Being privileged can motivate students to marginalize other students in order to maintain their privileged status (Harrison and Peacock 2010). However, privilege can also be used as a resource, enabling students who are fluent in the epistemic culture and in the applied language to play the role of mediators and strengthen their skills in interdisciplinary and intercultural collaboration. Such skills are becoming increasingly recognized, in professional life as in the university, as explained by Spencer-Oatey and Dauber (2016):

> [The ability to] adapt one's use of language to the needs of one's interlocutor … is a capability that many companies are now looking for in their new recruits. Developing this competence requires practice over time, and mixed national group work at university offers an ideal opportunity to hone such capability. (Spencer-Oatey and Dauber 2016, p. 13)

Working in interdisciplinary and multicultural project groups both requires and contributes to intercultural understanding and epistemic fluency. This calls for more research in problem-based learning that recognises the multicultural reality of contemporary universities and that sees this reality as a resource for future development of problem-based approaches to higher education.

References

Andersen, H., & Wagenknecht, S. (2013). Epistemic dependence in interdisciplinary groups. *Synthese, 190*, 1881–1898. https://doi.org/10.1007/s11229-012-0172-1.

Barry, A., & Born, G. (Eds.). (2013). *Interdisciplinarity. Reconfigurations of the social and natural sciences*. London/New York: Routledge.

Becher, T. (1994). The significance of disciplinary difference. *Studies in Higher Education, 19*, 151–161. https://doi.org/10.1080/03075079412331382007.

Biggs, J. (1998). Learning from the Confucian heritage: So size doesn't matter? *International Journal of Educational Research, 29*(8), 723–738. https://doi.org/10.1016/S0883-0355(98)00060-3.

Chalmers, D., & Volet, S. (1997). Common misconceptions about students from South-East Asia studying in Australia. *Higher Education Research and Development, 16*(1), 87–99. https://doi.org/10.1080/0729436970160107.

Collins, A., & Ferguson, W. (1993). Epistemic forms and epistemic games: Structures and strategies to guide inquiry. *Educational Psychologist, 28*(1), 25–42.

Damsa, C., & Andriessen, J. (2012). Shared epistemic agency for knowledge creation: An explorative case study. In A. Moen, A. I. Mørch, & S. Paavola (Eds.), *Collaborative knowledge creation: Practices, tools, concepts* (pp. 203–218). Sense Publishers. https://doi.org/10.1207/s15326985ep2801_3.

Deng, Z. (2011). Confucianism, modernalization, and Chinese pedagogy. An introduction. *Journal of Curriculum Studies, 43*(5), 561–568. https://doi.org/10.1080/00220272.2011.617837.

Dewey, J. (1910/1991). *How we think.* New York: Prometheus Books.

Dysthe, O., & Webler, W.-D. (2010). Pedagogical issues from Humboldt to Bologna: The case of Norway and Germany. *Higher Education Policy, 23*, 247–270. https://doi.org/10.1057/hep.2010.9.

Fish, S. E. (1994). Being interdisciplinary is so very hard to do. In S. E. Fish (Ed.), *There's no such thing as free speech* (pp. 231–242). New York: Oxford University Press.

Fuchs, C., & Sandoval, M. (2008). Positivism, Postmodernism, or Critical Theory? A case study of communication students' understanding of criticism. *Journal for Critical Education Policy Studies, 6*(2), 112–141.

Goodyear, P., & Zenios, M. (2007). Discussion, collaborative knowledge work and epistemic fluency. *British Journal of Educational Studies, 55*(4), 351–368. https://doi.org/10.1111/j.1467-8527.2007.00383.x.

Gram, M., Jæger, K., Liu, J., Qing, L., & Wu, X. (2013). Chinese students making sense of problem-based learning and Western teaching – Pitfalls and coping strategies. *Teaching in Higher Education, 18*(7), 761–772. https://doi.org/10.1080/13562517.2013.836096.

Harrison, N., & Peacock, N. (2010). Cultural distance, mindfulness, and passive xenophobia: Using Integrated Threat Theory to explore home higher education students' perspectives on 'internationalisation at home. *British Educational Research Journal, 36*(6), 877–902. https://doi.org/10.1080/01411920903191047.

Illeris, K. (1981). *Modkvalificeringens pædagogik – Problemorientering, deltagerstyring og eksemplarisk indlæring*. København: Unge Pædagoger.

Illeris, K. (2015). Transformative learning in higher education. *Journal of Transformative Learning, 3*(1), 46–51.

Jacobs, J. (2013). *In defense of the disciplines. Interdisciplinarity and specialization in the research university*. Chicago: Chicago University Press.

Jensen, A. A. (2015). How does it feel to become a master's student? Boundary crossing and emotions related to understanding a new educational context. In B. Lund & T. Chemi (Eds.), *Dealing with emotions. A pedagogical challenge to innovative learning* (pp. 61–80). Rotterdam/Boston/Taipei: Sense Publishers.

Jensen, A. A., & Lund, B. (2016). Dealing with insecurity in problem oriented learning approaches – The importance of problem formulation. *Journal of Problem Based Learning in Higher Education, 4*(1), 53–70. https://doi.org/10.5278/ojs.jpblhe.v4i1.1554.

Jæger, K., & Gram, M. (2015). (Self) Confidence or compliance. Students' experience of academic quality in study-abroad contexts. *Learning and Teaching: The International Journal of Higher Education in the Social Sciences, 8*(3), 37–59. https://doi.org/10.3167/latiss.2015.080303.

Leki, I. (2001). "A narrow thinking system": non-native-English-speaking students group in group projects across the curriculum. *TESOL Quarterly, 35*(1), 39–67. https://doi.org/10.2307/3587859.

Markauskaite, L., & Goodyear, P. (2017a). Professional epistemic games. In L. Markauskaite & P. Goodyear (Eds.), *Epistemic fluency and professional education* (pp. 395–434). Dordrecht: Springer Netherlands.

Markauskaite, L., & Goodyear, P. (2017b). Teaching and learning for epistemic fluency. In L. Markauskaite & P. Goodyear (Eds.), *Epistemic fluency and professional education* (pp. 553–594). Dordrecht: Springer Netherlands.

McMahon, P. (2011). Chinese voices: Chinese learners and their experiences of living and studying in the United Kingdom. *Journal of Higher Education Policy and Management, 33*(4), 401–414. https://doi.org/10.1080/1360080X.2011.585739.

Schweisfurth, M. (2011). Learner-centred education in developing country contexts: From solution to problem? *International Journal of Educational Development, 31*(5), 425–432. https://doi.org/10.1016/j.ijedudev.2011.03.005.

Shin, J. C. (2012). Higher education development in Korea: Western university ideas, Confucian tradition, and economic development. *Higher Education, 64*, 59–72. https://doi.org/10.1007/s10734-011-9480-5.

Spencer-Oatey, H., & Dauber, D. (2016). The gains and pains of mixed national group work at university. *Journal of Multilingual and Multicultural Development*. https://doi.org/10.1080/01434632.2015.1134549.

Tian, J., & Low, G. D. (2011). Critical thinking and Chinese university students: A review of the evidence. *Language, Culture and Curriculum, 24*(1), 61–76. https://doi.org/10.1080/07908318.2010.546400.

Wang, Y. (2012). Mainland Chinese students' group work adaption in a UK business school. *Teaching in Higher Education, 17*(5), 523–535. https://doi.org/10.1080/13562517.2012.658562.

Woodward-Kron, R., & Remedios, L. (2007). Classroom discourses in problem-based learning classrooms in the health sciences. *Australian Review of Applied Linguistics, 30*(1), 1–18. https://doi.org/10.2104/aral0709.

Chapter 9
Developing Successful Group Processes in Interdisciplinary Projects

Chunfang Zhou and Lone Krogh

9.1 Introduction

Problem-based learning (PBL) has over the decades been recognised as a popular pedagogical strategy (Hmelo-Silver 2004). In PBL at Aalborg University, students' learning is based on complex, real-world problems that do not have a single correct answer. Students work collaboratively in groups to identify what they need to learn in order to solve a problem. They engage in self-directed learning and integrate new knowledge while solving the problem, defined by them within the framework of the curriculum. They reflect on what they have learned and the relevance and effectiveness of the strategies and research methodologies employed. The teacher acts as a facilitator of the learning process rather than as a knowledge provider (Zhou 2012). Thus, PBL has been considered as a response to the growing challenge of industry practices where high levels of interdisciplinary collaboration and the ability to manage the challenges arising from it are required.

Interdisciplinary learning, which is one aspect of PBL strategy (Savin-Baden 2000; Zhou 2012; Krogh and Jensen 2013a), involves crossing professional discipline borders (Hansson 1999; Zhou 2012; Krogh and Jensen 2013b). Therefore, when developing a measure of interdisciplinary competence development, the relevant dimensions of teaching and learning should be considered. These include awareness of professional and disciplinary perspectives, appreciation of disciplinary perspectives, appreciation of cross-disciplinary perspectives, recognition of disciplinary limitations, interdisciplinary evaluation, ability to find common ground, reflexivity, and integrative transversal competences (Lattuca et al. 2013; Lattuca 2002). In other words, interdisciplinarity

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integrates disciplinary contributions and thus minimises the borders between the separate contributions of individual disciplines. The process of achieving integration requires identifying, evaluating, and rectifying differences between disciplinary insights in order to achieve new understandings at a higher level. Such cognitive achievements are not possible without the synthesis of disciplinary methods, knowledge, or insights into something new (Aram 2004; Wenger 2006).

Recent studies have suggested that interdisciplinary learning brings both benefits and challenges to learners (Zhou 2012; Lattuca et al. 2013). On the one hand, compared with disciplinary learning, interdisciplinary learning provides learners with more opportunities to integrate new knowledge into previously acquired knowledge, which makes learning more effective (Gero 2013). It is also expected that interdisciplinary learning may increase the learner's motivation to learn due to the interest it sparks. On the other hand, the task of interdisciplinary learning is full of complexity (Klein 2004), and creates challenges for learners due to the sometimes poor organisation of group work, insufficient communication from teachers and the institution, the difficulty of innovative thinking and problem solving, and so on (Marquez et al. 2011). Therefore, in PBL settings, issues encountered in group processes in interdisciplinary projects should be given attention (Marquez et al. 2011; Zhou 2012). For example, in Yueh et al. (2015) students reported that their experiences with an interdisciplinary PBL approach had multiple advantages in improving skills, such as group communication, knowledge exchange, and understanding the value of each other's disciplines. However, the study also suggests that further efforts are required, including closer attention to the features of group members, the composition of groups, and the interaction patterns of different groups. This implies the need to rethink how to facilitate learning in groups working on interdisciplinary projects, how to keep the group dynamic, and how to propose appropriate strategies for ensuring that the group makes progress and keeps moving forward.

Subsequently, this chapter aims to respond to the research needs while presenting and discussing a case study, namely the student satellite project AAUSAT3 at Aalborg University (AAU) in Denmark. We will analyse and discuss the experiences from the case and what they have taught us about how to develop successful group processes in an interdisciplinary PBL project. Furthermore, we will explain the implications for how to develop better and more successful group processes for other PBL contexts around the world.

9.2 Research Context: A Student-Built Satellite Project (AAUSAT3)

The overall research context of this case study encompasses the PBL principles and model of Aalborg University. The AAU PBL principles combine problem orientation, whereby problems or questions suited to the educational program serve as the basis for the learning process, with project work, where the project represents both the means through which the students address the problem and the main learning context for students. Figure 9.1 illustrates the elements that generally form part of

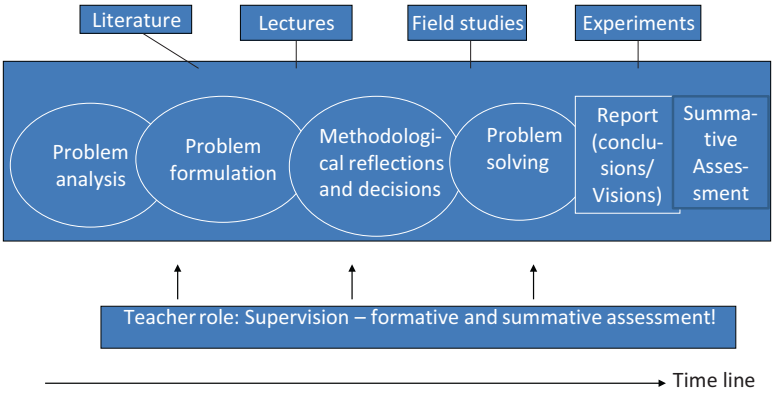

Fig. 9.1 Processes in PBL group and project work at AAU

the problem-oriented project work at AAU. The figure also shows the processes and resources available for the problem-based project work at AAU (Krogh and Jensen 2013b).

The specific research context for this study is the project to develop the third student-built satellite at AAU, AAUSAT3. The mission of this satellite is to operate the Automatic Identification System (AIS) payloads, as proposed by the Danish Maritime Safety Administration, with the aim to be used by ships to inform other ships about their position, course, speed, name, type of cargo, and so forth. It is also an important part of anti-collision systems and the supervision of near-coast traffic today. The signals used by AAUSAT3 are from ships on the open sea, especially in the Arctic regions and around Greenland (Zhou 2012). The project aims to reach the following educational objectives (Zhou 2012):

- Show that students are able to develop working satellites.
- Develop the system engineering skills of the students as a complement to their existing education while giving them experience in project management.
- Show that AIS may be able to replace the LRIT (long range identification and tracking) system as a cheaper and more effective alternative.

The AAUSAT3 is a joint venture of several institutes at AAU, including the Department of Electronic Systems, the Department of Energy, the Department of Mechanical Engineering, and the Department of Computer Science. Students at AAU in their fourth through tenth semesters have opportunities to participate in AAUSAT3, according to different levels of tasks.

9.3 Empirical Work

The empirical work of this study focuses on students' group processes in AAUSAT3. We examine the benefits students gained and the challenges they faced from their experiences working in an interdisciplinary project group. Qualitative methods

including interviews and observations were used to collect data. As suggested by Zhou (2012), the qualitative approach focuses on people's life stories and, unlike quantitative research, can often be naturalistic in terms of studying people in everyday, uncontrived settings and situations. Thus, from a qualitative view, research is a human construction, framed and presented within a particular set of discourses and ideologies, and conducted in a social context. Therefore, there will of course be limitations for generalisability.

One of the authors of this chapter followed the group development process in AAUSAT3. As it was a huge interdisciplinary project, participants from nine student groups (three from the sixth semester who are marked student A, B, and C; three from the seventh semester who are marked student D, E and F; and one from the ninth semester who are marked student G) and two supervisors (supervisor A and B) were interviewed and observed. The interviews were organised using open-ended questions that allowed for in-depth follow-up questions in order to examine participants' perceptions of the group learning experience. A total of ten interviews (including eight individual interviews and two group interviews) were carried out, with each interview lasting around 30 min. Data from the interviews were generated from transcripts, which contributed to a response to the research focuses in this study. In addition, the researcher attended a total of 18 group meetings and recorded some discussions on problem-solving processes among group members. The researcher also noted the 15-day observation diaries on the students' project work. The findings from the observations provided evidence of confirmation or contradiction of the interview results, which improved the validity and generalisability of this study.

The data analysis centred on the research focuses of this study and generalised the results from four aspects of group process, namely (1) group establishment, (2) group composition, (3) group management, and (4) supervision. Thus, the analysis encompassed how interaction between facilitation and group learning occurs in interdisciplinary contexts. In other words, through qualitative methods in this study, we connect hidden mental processes of well-known group experiences that are constructed in a setting of interdisciplinary learning and real-life problem solving, as discussed below.

9.4 Experiences Learned from Group Processes in AAUSAT3

In this section, the results of the data analysis lead us to discuss four aspects of lessons learned regarding developing successful group processes from the case of AAUSAT3: (1) peer-arranged group formation, (2) task-related group diversity, (3) shared responsibility of group management, and (4) supervisors as learning experts and facilitators.

9.4.1 Peer-Arranged Group Formation

According to the observations, all participants in group work on AAUSAT3 come from programs of study in Department of Electronic Systems. The two supervisors assigned to work with students on the project also come from the Department of Electronic Systems (one a professor and the other an associate professor). In AAUSAT3, students have opportunities to develop their groups by themselves. At the beginning of each semester, students obtain the project proposals from the AAUSAT3 website. Gathering according to common interests, they discuss the possibility of group establishment.

This method of group formation has been described as a 'peer-arranged process', according to data from interviews. Before group establishment, some of the students knew each other well, and some had experience from project work in previous semesters and felt comfortable working together. Even students in the sixth semester have already gained rich experience in how to initiate, participate in, and manage group work. The following quote comes from a student interview (Zhou 2012):

> When we started, actually, we formed the groups on Monday, before that we had already decided to do this project [AAUSAT3]. It [the group formation] also had a peer-arranged process. The other groups also said they wanted to do this so we sat down to discuss [how to collaborate and work together]. Because you also need people with different skills in different groups, it was the way it was decided (Student B).

In other words, most group members come from a community where they have had good experiences and share common interests. As Wenger (2006) suggests, a community of practice is not merely a club of friends or a network of connections. It has an identity defined by a shared domain of interests. Mutual engagement requires the ability to take part in meaningful activities and interactions in the production of sharable artefacts, in community-building conversations, and in the negotiation of new situations. Membership therefore implies a commitment to the domain, and therefore a shared competence that distinguishes members from other people. They build relationships that enable them to learn from each other (Zhou 2012). This further indicates the importance of group diversity, as discussed below.

9.4.2 Task-Related Group Diversity

Collaborators are not a homogeneous group, but rather individuals with different perspectives, expertise, conceptualisations, working methods, temperaments, resources, needs, and talents (Zhou 2012). With this perspective, a principle of task-related diversity in developing groups in AAUSAT3 becomes another lesson learned in this study. In order to complete the tasks, students require input from multiple fields of knowledge: electronics, communications, computer science, mechanics,

astronomy, physics, oceanography, industrial design, materials, energy, etc. One of the supervisors reflected on the breadth of knowledge required in an interview:

> To solve a problem or work on a project always requires a lot of knowledge, but this project is much more complex. This not only means complex knowledge, but also requires our students to be strongly confident to solve those complex problems and have good collaboration skills. We are happy to see most of us are mostly positively working on this project (Supervisor B).

Tasks are full of challenges for student groups. From observing group meetings, we found that supervisors do not assign the individual members' tasks; instead they assign the tasks agreed upon through group discussions. Normally, students have group meetings once a week to discuss milestones. In these meetings, members present their progress, share knowledge and experiences, plan the milestones for the next week, and assign tasks. If the group is experiencing challenges or difficulties, members will spend more time discussing solutions and which milestones might remain flexible for modification along the way. The principle of task-related group diversity is followed consciously when the groups are formulated and developed. This places focus on the complementarity of expertise, knowledge, and skills in the groups, which is also a consideration when introducing new group members. For example, students expressed the following view in interviews:

> We have to have a very good programmer at least […] So actually one of us started the group and tried to make the group. Though there was one guy who was also interested, but he was not really relevant to what we needed to do. So we had no ideas to introduce him as one of our members (Student E).

> We have to know each other. I am responsible for mechanical design and hardware design, but I need to have discussions with two members all the time. One works on software and one works on hardware, too. Mechanical design can't be finished without some parameters from hardware […] (Student D).

Previous studies (Amabile 1996; Choi and Thompson 2006; Zhou 2012) have indicated that group composition and choices concerning task engagement may impact group performance, and that task-related diversity in fact enhances group performance (Nijstad and Stroebe 2006). The right level of diversity seems to be essential to avoid cognitive uniformity and conformity: group members who have different approaches to the same problem are less likely to get stuck in a rut. Also, group members should perform the tasks they are good at. Meanwhile, people who are given a choice in certain aspects of task engagement will produce more creative work than people for whom the choice is made by someone else (Amabile 1996). In addition, relationships among group members, such as whether they are engaged in cooperation or competition, whether they are friendly or not, and the extent to which they have different working habits or thinking styles, etc., are also key to creative collaboration. As has been discussed regarding peer-arranged group formation, most students know each other well and have very good relationships, which also motivates collaboration.

9.4.3 Self-Managed Groups and Shared Responsibility

In order to ensure task accomplishment and stimulate group dynamics, well-organised project management is essential for learning activities. The social theory of learning indicates that project groups work as communities, needing multiple forms of leadership: leaders, networks, people who document the practice, pioneers, etc. These forms of leadership may be concentrated in one or two members of the group or widely distributed, and may change over time (Wenger 2006; Zhou 2012). This phenomenon has been found in student groups in AAUSAT3. According to the data from observations, students share the responsibility of project management. As mentioned above, students plan milestones, organise group discussions, and supervise meetings by themselves. Members make different contributions to the leadership of the group and everyone is responsible for the task's progress and success, as noted in the following quote.

> We have different kinds of responsibilities. It was easier for our supervisor, he only needs to email me, so I was appointed to contact him. And we have one guy who is responsible for contacting the company of sponsors who we have cooperated with (Student A).

> It is not like we have fixed roles, but we tried to make everyone have some specific parts… in the group meeting on Monday, if someone says 'I can't do this now', the group says 'ok, you don't have to do that' (Student F).

As discussed by Frame (2002), we can see that student groups function as self-managed teams. Team members define the approaches they will take to get the job done. This kind of self-managed team can be seen as a mechanism to empower members to do the best job they can: when people make their own decisions, they have a greater commitment to executing them effectively. Furthermore, people who are closer to the work have a better sense of what is needed to do a good job than managers far away from the day-to-day action (Frame 2002). In self-managed teams, students choose individual jobs and negotiate with each other about progress and strategies for moving projects forward. The interviews also indicate that project tasks are the core topics in both students' formal and informal discussions, and even in their social lives after study time. Through working together, students become not only professional collaborators, but often good friends, too; thus, they share their experiences and emotions with each other now and then.

Because this is a long-term project, documentation management is essential for successful work. Every Wednesday afternoon, all the participating students come together for a project meeting to foster discussion and cooperation, which allows them to move forward with the project. The agenda, points of discussion, problems, new solutions, reflections, decisions, deadlines, and task assignments are documented in Tracwiki, which is a web-based software approach to project management. Thus, groups that join the project later can easily become familiar with what has been done and how specific tasks have been handled in the past (Zhou 2012). In addition, during their daily work, students like to mark their milestones on the blackboard with a reminder of their individual roles. Usually, they update the group schedule plan each week (Fig. 9.2) based on their discussions (Fig. 9.3).

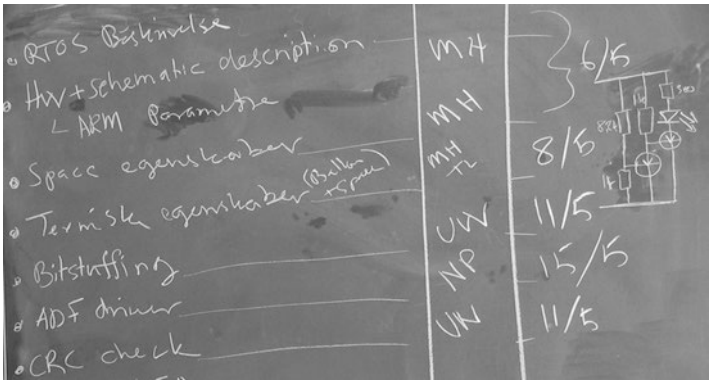

Fig. 9.2 Timetable on blackboard

Fig. 9.3 Students in discussion

> We have had milestones, which are always the plan of the whole project. So we know when we should turn in the report. OK, then we divide it into small tasks – what do we need to do this week, and what will go on to next week. Then we take out the blackboard and put the tasks and our names down on the right (Student D).

However, self-managed teams also have their limitations. In AAUSAT3 there have been some complaints, according to interviews. Students expressed that they needed more effective leadership. Although students select group coordinators who are in charge of initiating group meetings and cooperating with other groups, sometimes the lack of leadership puts students in a situation of uncertainty, as the following notes express:

> There are so many details in the project work. One person is needed to use a list to check what we have done, what we need to do, who is doing what, and when it is going to be done. This person keeps track of what someone is doing now and then to delete this or that from the list. He may also delegate assignments by saying, 'we need someone to do this now' and the other will say, 'OK, I can handle that'.

As previously mentioned, complexity is embedded in the practice of interdisciplinary projects and is often associated with difficulties (Frame 2002). These difficulties necessitate effective leadership in order to help project groups deal with task-related challenges. This also implies that there is a dilemma between intellectual freedom and the challenges of the task, which requires more help from supervisors; this will be discussed in the following section.

9.4.4 Supervisors as Expert Learners and Challenges

In AAUSAT3, both interviews and observation data indicate that there is a good relationship between supervisors and students. When student groups encounter technical problems they cannot handle or have group disagreements, they request help from their supervisors. Usually, they have supervisor meetings once every 1 or 2 weeks. The group makes an agenda and informs the supervisor before the meeting. From the interviews, we know that the supervisors tend to enjoy the students' problem-solving processes and to address some critical questions in the discussions. They tend to encourage students to explore answers instead of transferring experience and knowledge directly. The students tell us that the supervisors play an 'inspirational role' in the group work:

> He is a kind man, I think. But he didn't like to tell us answers directly. He often gave some suggestions: 'Your ideas are very good, but if you do it like this, what will happen?' or 'Can you prove your ideas in practice?' (Student C).

In other words, the supervisors act as learning experts within student groups and share learning experiences with them, using inspirational ways of addressing them instead of teaching knowledge directly. When students do not feel emotionally safe they are less likely to engage in the behavioural hallmarks of creativity: members are less likely to speak up and suggest novel ideas, criticise others' ideas, challenge the status quo, ask questions, or admit mistakes for fear of ridicule or more subtle forms of interpersonal rejection (Edmondson and Mogelof 2006). However, in AAUSAT3, with a narrow power distance between students and their supervisors, the students feel emotionally safe in a friendly learning environment. The supervisors work from the assumption that their role is to help every student to reach their inner potential in the learning processes, and they encourage and reward creative behaviour in learning that further supports successful problem-solving processes.

However, the interviews also revealed the challenges of facilitation in AAUSAT3. Supervision in interdisciplinary projects places high demands on supervisory experience and teaching skills in order to ensure that cooperative learning in and between groups breaks through disciplinary boundaries. This undoubtedly brings challenges for supervisors, i.e. when they encounter task difficulties together with students, as expressed by one supervisor in the interviews:

> Sometimes we are supposed to know much more than them [students], but we disappointed them. We are also gaining new learning experience as we are solving the new problems.

> This is exciting, but sometimes also frustrating. Our pressure comes not only from the deadline of the project, but also the quality of students' learning. Some knowledge is outside our fields, so how to motivate the groups to make progress and develop learning dynamics is really a technique that we learn, in addition to the knowledge itself (Supervisor A).

Ideally, in AAUSAT3, the supervisors and students work together, integrate several disciplines related to the central topics, identify the weaknesses and strengths of the perspectives that stem from the different disciplines and, as a result, develop critical thinking skills. Thus, they acquire high-level meta-cognitive skills, and are expected to transfer the interdisciplinary knowledge and learning experiences gained from AAUSAT3 to other projects in the future.

To summarise, students have had both good and bad experiences in the four aspects of group processes listed above. Briefly, peer-organised group formation is often based on trust and a well-known network of students that is supportive in developing a long-term learning community; task-related group diversity motivates students intrinsically for problem-solving and learning; self-managed groups with shared responsibility among group members reflect the core principle of PBL, namely 'student-centred learning', but cause management issues due to a lack of effective leadership. When the supervisors play their roles as learning experts, they may face challenges in relation to students' difficulties with interdisciplinary project tasks. All the findings contribute to implications for developing better interdisciplinary PBL models in the future.

9.5 Implications for Developing Students' Interdisciplinary Projects

This section will focus on implications stemming from the above discussions for better developing and facilitating students' interdisciplinary projects based on studies in AAUSAT3. These fall into two categories of improvements: (1) developing more effective self-managed student groups and (2) developing interdisciplinary supervision groups. The implications are also helpful for developing interdisciplinary PBL models in other contexts.

9.5.1 Developing More Effective Self-Managed Student Groups

In the overall context of the AAU PBL educational model, student project work is combined with lectures, seminars, or laboratory work on relevant subject matter. University teachers supervising student projects facilitate the students' group work. It is generally expected that students work in groups of six to eight during their first

year of study; later in their studies group sizes may shrink to just two or three students. Individual project work is accepted, but students are told that this minimises the possibility of peer learning. Each group is assigned a supervisor, who helps, challenges, supervises, advises, and discusses the work with the students throughout the process and finally assesses them (Krogh and Jensen 2013b). Supervisors play an important role in modelling the problem-solving and self-directed learning skills needed for students to self-assess their reasoning and understanding. They also support the learning and collaboration processes, which make students better at acquiring flexible and relevant knowledge within the subject area (Hmelo-Silver 2004; Zhou 2012).

In the case of AAUSAT3, while the students enjoyed self-directed learning experiences in their self-managed groups, they also needed methods for more effective group management. This also indicates that shared responsibility in the group can motivate members' mutual engagement but simultaneously cause problems of losing ways. Furthermore, supervision in AAUSAT3 lacks awareness and experience for helping student groups manage the issues that stem from the dilemma between 'equal leadership' and 'clear common goals'. According to Frame (2002), to a large extent, the potential problems of self-managed teams are hardwired due to their structure. The principal components of this structure are group decision-making, lack of a clearly defined leader and roles, and diffuse accountability. Slow decision-making, the need for compromise, and aimlessness are all potential consequences of this structure. As Gregory and his colleagues (1972) suggested, the ability of a manager will be tested to the utmost when complex technical changes demand a high level of corporate activity. A premium is placed upon fixing clear objectives, setting up high-response decision-making, and communication and control systems to enable a wide range of resources and disparate talents to be harnessed to the full.

Undoubtedly, this requires more effort from supervisors in guiding students through methods for more effective group management. As suggested by Amabile (1996), group project management requires creative ideas and other related qualities, such as freedom in deciding what to do or how to accomplish the task, a sense of control over one's own work and ideas, management enthusiasm for new ideas and ability to create an atmosphere free of threatening evaluation, sufficient resources and time, pressure, and so on (Amabile 1996). When they function properly, self-managed teams can be very impressive, as the team assumes total responsibility for the work effort with individual shared responsibility (Frame 2002). As mentioned above, the peer-arranged group formation meets requirements regarding the development of an effective project community both professionally and emotionally and fits the core philosophy of student-centred learning in PBL; however, it also requires students to develop effective methods of self-directed learning and group management, which should be integrated into daily supervision.

9.5.2 Developing Interdisciplinary Supervision Groups

In addition to the issues of facilitating more effective self-managed student groups, supervising students' interdisciplinary projects also poses challenges due to the complexity of the task. It should be noted that facilitation is the skill of knowing precisely when a question needs to be asked, when the students are going off-track, and when the PBL process is stalled. In the context of interdisciplinary projects, in particular, teaching strategies need to pay more attention to interactions between learners and their project tasks.

However, the fact is that teachers who teach and supervise interdisciplinary subjects must contend with teaching a discipline (or disciplines) that are not part of their original background (Gero 2013; Zhou 2012). In the case of AAUSAT3, an interdisciplinary supervision group needed to be developed in order to help students deal with the challenges more effectively. As AAUSAT3 was initiated by several departments, including Department of Electronic Systems, Department of Mechanical Engineering, Department of Computer Science, and Department of Energy Technology, a list of experts required by the tasks of AAUSAT3 was made. The experts came from the initiating organisations, supplemented by a broader network within and from outside AAU. The expert network can provide more knowledge resources to the student groups. In other words, the boundaries of participant groups should be broadened; as when the students formed their groups through the principle of task-related group diversity, a supervision group should be formed according to the same principles.

If an interdisciplinary supervision group is developed, this will positively influence the effective interaction between teaching and learning. When we encourage students to learn from an interdisciplinary project and to have successful group learning processes, an interdisciplinary supervision resource should be a necessary precondition. As mentioned above, in group composition, a series of fundamental factors concerning group formation are often conceptualised as representing member diversity in such dimensions as demographic characteristics, personality traits, opinions, tenure in the group, and disciplinary educational and functional background (Zhou 2012). In this sense, we argue that a group's creative potential first and foremost depends on the degree of diversity in groups. Functional, informational, and cognitive diversity are associated with higher levels of group innovation. To enjoy the task itself and the process of searching for new solutions, intrinsically motivated individuals are more likely to spend energy exploring the problem and to find creative solutions (Cooper and Jayatilaka 2006).

In addition, although task-relevant cognitive skills and personality traits are important, intrinsic motivation is a key to group processes and solving problems creatively since it reflects members' drive and determines what they will do. Thus, as when we encourage positive negotiation among student group members, it is obvious that members of interdisciplinary supervision groups must also communicate their ideas to one another and learn to support the emotional dynamics of collaboration, especially belief in a partner's capabilities (Cooper and Jayatilaka 2006).

We are calling for a broader interdisciplinary learning community helping both student groups and supervision groups reach their inner potential in learning processes.

9.6 Conclusions

In this chapter, the case of the interdisciplinary project AAUSAT3 has been discussed by focusing on group processes in a PBL environment at Aalborg University in Denmark. It argues that interdisciplinary projects can be viewed as two sides of the same coin for student groups and supervisors in PBL. On the one hand, it stimulates the dynamic of group processes in student groups and motivates learners (both students and supervisors) to engage in solving complex problems; on the other hand, it leads to difficulties for both students and supervisors due to task-related challenges. The case study and the discussion both provide a clearer understanding of PBL at Aalborg University as a learning community and of an interdisciplinary project that provides conditions calling for learner engagement in such a community of practice while exploring meaningful group processes that involve both good and bad experiences. These points underpin the previous arguments, such as interdisciplinarity being associated with complexity, which influences group processes and project supervision in PBL. However, it also leads to challenges for learning and teaching. In order to overcome some of these challenges, we suggest that AAUSAT3 first take a step towards more effective project management by strengthening group leadership, and second develop interdisciplinary supervision groups for more effective project facilitation. In a general sense, it is necessary to re-think how to deal with the issues of group processes in interdisciplinary PBL projects that are caused by the tensions in 'student-centred learning', effective learning, and effective teaching/supervision. Further re-thinking on how to improve the design of a PBL curriculum in interdisciplinary projects and how to improve interdisciplinary supervision are also needed.

References

Amabile, T. M. (1996). *Creativity in context, update to the social psychology of creativity*. Boulder: Westview Press.

Aram, J. D. (2004). Concepts of interdisciplinarity: Configurations of knowledge and action. *Human Relations, 57*(4), 379–412.

Choi, H. S., & Thompson, L. L. (2006). Membership change in groups: Implications for group creativity. In H. S. Choi & L. L. Thompson (Eds.), *Creativity and innovation in organizational teams* (pp. 87–108). London: Lawrence Erlbaum.

Cooper, R. B., & Jayatilaka, B. (2006). Group creativity: The effects of extrinsic, intrinsic and obligation motivations. *Creativity Research Journal, 18*(2), 153–172.

Edmondson, A. C., & Mogelof, J. P. (2006). Explaining psychological safety in innovation teams: Organizational culture, team dynamics, or personality? In H. S. Choi & L. L. Thompson (Eds.), *Creativity and innovation in organizational teams* (pp. 87–108). London: Lawrence Erlbaum.

Frame, J. D. (2002). *The new project management: Tools for an age of rapid change, complexity, and other business realities*. San Francisco: Jossey-Bass.

Gero, A. (2013). Interdisciplinary program on aviation weapon systems as a means of improving high school students' attitudes towards physics and engineering. *International Journal of Engineering Education, 29*(4), 1047–1054.

Gregory, S. A. (1972). *Creativity and innovation in engineering*. London: Butterworths.

Hansson, B. (1999). Interdisciplinarity: For what purpose? *Policy Sciences, 32*, 339–343.

Hmelo-Silver, C. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235–266.

Klein, J. T. (2004). Interdisciplinarity and complexity: An evolving relationship. *CO Special Double Issue, 6*(1–2), 2–10.

Krogh, L., & Jensen, A. A. (2013a). The development of PBL-methodologies in Denmark and current challenges. In L. Krogh & A. A. Jensen (Eds.), *Visions – challenges – strategies, PBL principles and methodologies in a Danish and global perspective*. Aalborg: Aalborg University Press.

Krogh, L., & Jensen, A. A. (2013b). *Visions – challenges – strategies, PBL principles and methodologies in a Danish and global perspective*. Aalborg: Aalborg University Press.

Lattuca, L. R. (2002). Learning interdisciplinarity, sociocultural perspectives on academic work. *The Journal of Higher Education, 73*(6), 711–739.

Lattuca, L. R., Knight, D., & Bergom, I. (2013). Developing a measure of interdisciplinary competence. *International Journal of Engineering Education, 29*(3), 726–739.

Marquez, J. J., Martinez, M. L., Romero, G., & Perez, J. M. (2011). New methodology for integrating teams into multidisciplinary project based learning. *International Journal of Engineering Education, 27*(4), 746–756.

Nijstad, B. A., & Stroebe, W. (2006). Four principles of group creativity. In H. S. Choi & L. L. Thompson (Eds.), *Creativity and innovation in organizational teams* (pp. 161–177). London: Lawrence Erlbaum.

Savin-Baden, M. (2000). *Problem-based learning in higher education: Untold stories*. Buckingham: Open University Press/SRHE.

Wenger, E. (2006). *Learning for a small planet: A research agenda*. Scientific Project Description. Retrieved April 6, 2009, from http://ewenger.com/research/LSPfoundingdoc.doc

Yueh, H. P., Liu, Y. L., & Lin, W. (2015). Fostering interdisciplinary learning in a smart living technology course through a PBL approach. *International Journal of Engineering Education, 31*(1, B), 220–228.

Zhou, C. (2012). *Group creativity development in engineering education in a problem and project-based learning (PBL) environment*. PhD thesis. Aalborg: ak print.

Chapter 10
Students' Positioning in Transdisciplinary Project-Based Learning

Alice Juel Jacobsen and Tom Børsen

10.1 Introduction

This chapter identifies and characterizes students' strategies to cope with challenges and possibilities related to studying an interdisciplinary Master's program in Learning and Innovational Change (LIC) at Aalborg University (AAU). The positioning concept as understood by Davies and Harré (1990), is introduced (Sect. 10.3) and used to investigate how the students negotiate discursive positioning of self and others in the process of the project-based learning program (Sect. 10.4).

In a recent publication, ACE Denmark (2013) addressed challenges facing universities and schools that offer inter- and transdisciplinary study programmes.[1] This report suggests that the philosophy of science is a central tool to ensure successful interdisciplinary higher education. The study of this chapter demonstrates that the philosophy of science deserves special attention in transdisciplinary university programs. Differences regarding students' academic bachelor background versus professional background are discussed in the chapter.

The establishment and development of the LIC programme's student intake can be related to educational reforms that occurred during the period of the study. In 2000, the medium-long higher education programmes were anchored in special institutions via an educational reform (Thomsen et al. 2013). From 2008 onward, new professional bachelor programs were offered at so-called university colleges. The aim of this reform was to give as many young people as possible the opportunity

[1] ACE is the national accreditation institution that ensures the quality of all higher educational institutions in Denmark (ACE 2010).

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to obtain higher education. The government policies were implemented and the educational system was transformed in order to create greater flexibility. Medium-long term higher education programmes – e.g., bachelor degree holders from the fields of health and nutrition, primary school teachers, and pedagogues educated at university colleges – were given the opportunity to continue their education in selected master's programmes offered by universities, including the LIC programme.

The LIC educational program was established in 2009 at AAU's campus in Copenhagen. It copied the well-established master's programme, which had been offered at the Aalborg campus for 5 years. The programme in Copenhagen started out with six students. Over the following years, the number of students enrolled grew extensively as the yearly intake almost doubled.[2] In 2014 approximately 170 students were enrolled. However, the following year the master's programme was scaled down in accordance with a change in the government's educational policy now to restrict admission to higher education.

The data for this study were generated in 2013, during a period with very broad student admissions that included a group of students from very different educational backgrounds. Compared to academic bachelor programs, professional bachelor programs incorporate much more practice-oriented approaches, and include students from a variety of backgrounds. Thus, this study offers the opportunity to present a breadth of knowledge on inter- and transdisciplinary study strategies.

10.2 Learning and Innovative Change: Transdisciplinary and Problem-Based

The term 'interdisciplinary' refers to problem-solving activities that aim at integrating at least two different disciplinary perspectives in order to manage and solve a problem at hand. Interdisciplinary activities are distinguishable from transdisciplinary activities, which refer to knowledge production wherein stakeholders from different sectors collaborate in solving pressing problems, and which therefore surpass the dichotomy between knowledge production and practical problem-solving (Apostel et al. 1972; Klein 1990, p. 36; 2010; Apostel and Vanlandshoot 1994). With Gibbons et al. (1994) we adapt this distinction when they claim that contemporary knowledge production has become transdisciplinary.

According to AAU's PR brochure, which provides information for potential students about LIC, the program combines elements from education, pedagogy, cultural studies, and organisational studies. The Master's in Learning and Innovative Change is interdisciplinary because it combines disciplinary elements from these

[2] The authors of this chapter were involved in establishing the LIC programme during its start in Copenhagen in 2009. One of them was connected to the study programme as a teacher and researcher during the period of data generation. The other author had moved on to teach another study program in 2011. Today, the authors are not affiliated with the LIC programme.

different disciplines. The same flyer states that applicants from many different backgrounds may enrol, highlighting that applicants with a professional bachelor degree, such as teachers or practical pedagogues as well as those from the fields of nutrition and health are welcome to enrol.

According to the 2012 curriculum, a number of relevant academic and professional bachelor degrees enable access to the LIC programme if the applicant has qualifications in at least two of the following above-mentioned four areas: education, pedagogy, cultural studies, and organisational studies. The curriculum from 2012 specifies that the following academic programmes fulfil the enrolment criteria: applied philosophy, psychology, communication and digital media, educational studies, pedagogy, and sociology. International business communication, language and international studies, and social science programmes might lead to enrolment if certain electives are taken and specific topics are addressed in projects. Hence, the LIC programme is transdisciplinary because it accepts academic and professional bachelor degree holders from various institutions.

The LIC programme is based on Aalborg University's principles for problem-based learning, which Harvard scholar Scott Barge (2010) identified as the principles of problem orientation, the integration of theory and practice, project organisation, and the use of team-based approaches, collaboration, and feedback.[3] These characteristics can also be used to describe the Master's in Learning and Innovative Change.

10.2.1 Problem Orientation

Student learning is oriented towards addressing problems, while successful learning is associated with identifying, formulating, and testing methods for instance problem-solving and managing problems. The problems addressed in projects can be societal problems or they can be problems that fill a knowledge gap.

A random selection of three first-semester projects at the LIC programme in the fall of 2013 are provided to give the reader an impression of the problems addressed in the project reports of that semester. Three different supervisors were assigned to the three selected project groups. The resulting problem formulations were translated from Danish into English and are reproduced below:

- What factors affect the possibilities for empowering of individuals suffering from stress in professional caring practices?
- How can Rambøll's talent development programme and the underpinning assumptions about learning and development be understood in light of John Dewey's philosophical pragmatism?

[3] A general introduction to problem based learning is also provided by Savery (2006).

- How is the role of the school leader changing due to the requirements established by the new school reform articulated and constructed by the Danish government, the Danish School Leader's Association, and the Danish Union of Teachers?

All three formulations analyse problems or events in different professional contexts, with the intention of generating better understanding. The first formulation also outlines possible options for individuals with stress, while the two other formulations do not propose solutions to practical problems. The problem formulations address one of the central themes emerging from our analysis: the tension between practical problems and the theoretical understanding thereof. To what extent can and should a theoretical understanding provide solutions to practical problems?

10.2.2 The Integration of Theory and Practice

In their project work, the students try to integrate theory and practice by analysing a relevant problem. Central theories that can be used in the project work are usually introduced and illustrated in conventional classes. Only a few theories were used in each project, and the students gained an in-depth knowledge of the theories that they linked to an academic or societal problem. The students in the LIC programme expressed two different understandings of the ways in which theory and practice could be linked. According to one position, theory is perceived as instrumental to solving practical problems (e.g., how can stress among school teachers be prevented in a specific context?). The second perception of the relationship between theory and practice views theory as a way to understand and reflect upon a given phenomenon without proposing solutions.

10.2.2.1 Project Organisation

Bachelor and master's programmes at Aalborg University are split into semesters (September to January and February to June). Each semester is organised so that it includes project work and conventional classes. The ratio between projects and lectures is approximately 50:50 in terms of student workload, but this can vary from programme to programme and semester to semester. The 2-year Master's in Learning and Innovative Change is split into four semesters as shown below (Fig. 10.1):

Each semester contains one or two modules that are evaluated independently. The first semester contains one 30 ECTS module, called Knowledge About Learning and Innovative Change. This module includes both project work (approximately 50%) and four lecture series on learning theories, curriculum design, organisational theories, and the method, evaluation, and philosophy of science. The module concludes with an oral exam based on the project report.

4TH SEMESTER	Master's Thesis (30 ECTS)	
3RD SEMESTER	Academic Internship (20 ECTS)	Portfolio (10 ECTS)
2ND SEMESTER	Learning in Multi-Cultural Contexts (10 ECTS)	Electives in Pedagogical Innovation or Organisational Learning (20 ECTS)
1ST SEMESTER	Knowledge about Learning and Innovative Change (30 ECTS)	

Fig. 10.1 Illustration of the structure of the Master's in Learning and Innovative Change

10.2.3 Team-Based Collaboration and Feedback Directed by Participants

Project work is conducted in teams, and individuals are only rarely permitted to work alone in so-called one-person groups. Teamwork is also used in conventional classes to complement lectures. Students themselves manage the project work: they form groups, choose the research question guiding their project work, formulate guidelines for such issues as internal group processes and knowledge sharing, and determine the rules concerning the collaboration with their supervisor. The students themselves distribute working tasks among the group members. They produce a collective learning output in the form of a project report and an oral project presentation. They defend the project as a group, but are evaluated individually based on how they answer questions posed during the group exam.

10.3 Research Design Based on Positioning Theory

In this study, we use positioning theory as our approach to understanding and studying the development of students' study strategies during transdisciplinary PBL work. We are interested in investigating the positions that are negotiated and constituted in the social practice among the students engaged in the PBL work from the LIC programme. Thus, using the positioning concept as our analytical point of departure, we have focused on the dynamic interactions between individuals.

Positioning theory was developed in the 1990s as an interactionist approach in which social structure is conceived as fluid patterns of positioning (Harré and Van Langenhove 1992, 1999; Van Langenhove 2010). The positioning concept was developed by Davies and Harré (1990), stating:

> […] who one is, is always an open question with a shifting answer depending upon the positions made available within one's own and other's discursive practices and within those practices, the stories through which we make sense of our own and others' lives. (Davies and Harré 1990, p. 46)

The concept seems to be broad enough to describe complexity, while also being precise enough to contribute to the articulation of meaningful fluctuating relations in social practices. In line with Davies and Harré (1990), we argue that a conversation unfolds through the joint action of all the participants as they make their own and each other's actions socially determinate.

A position is linked to the actions of a person in a certain position. An action is what the person is saying (can be heard saying) and doing (can be seen doing). Positions are socially and culturally anchored in temporal conventions and are distributed through current discourses about, for example, students' most effective ways of learning. The basis of positioning theory is the idea that the constant flow of everyday life – in which we all participate – is fragmented through discourses into distinct episodes that constitute social practice, in which we also all participate. Not only what we do but also what we *can* do are limited by the rights, duties, and obligations that we acquire or assume, or that are assigned to us in the concrete social contexts of everyday life (Harré and Van Langenhove 1999). Discursive processes are possible because we have specific skills and because rules allow us to explain our interactions. We know intuitively when it is appropriate to say what we say and we also have some insight into what will happen when we say what we say.

In this way, it is because we know the rules and expectations that meaningful communication is possible. These discursive skills are rooted in the common production of conversational episodes in everyday life (Harré and Secord 1972, p. 10). Yet, an episode is more than just visible behaviour; for everyone who participates, it includes thoughts, feelings, intentions, plans, and so on. As such, episodes are determined in the conversational process by their participants and, at the same time, they also shape what the participants do and say.

The aim of positioning theory is to understand the dynamics in social episodes. An investigation into these episodes demands an appropriate conceptual and methodological framework that allows the investigators to take into consideration the characteristics of interaction in conversations, as well as the more general aspects of the episodes constituted by these conversational exchanges. Positioning theory can be seen as such a conceptual and methodological framework, and it draws on the analogy that all social life is manifested in conversations.

Positioning and actions are both linked to a storyline that reflects past episodes. According to Davies and Harré, a way to grasp the concept of positioning is to think of someone listening to or reading a story (1990, p. 49). Storylines are understood to have a basis in various discourses, some of which their participants are in the process of living out (Harré and Moghaddam 2003, pp. 7–9). In this case, the storyline could be that of becoming and being an academic at a PBL university.

Positioning theory is summarized in the positioning triangle, which presents an image of dynamic stability between the actors' positions, the social force related to what the participants say and do, and the storylines that emerge from what the actors have said and done. Subject positions are seen as constantly being negotiated between the narrator and the listeners (Davies and Harré 1991). The positions reflect the degree to which the initiator of the conversational exchange is able to impose positions on others or the degree to which the assigned positions are rejected.

Positioning theory thus accentuates and brings the constitutive process of discursive practices to the fore. Hence, positioning theory is useful for our analysis of PBL students positioning themselves and others in interdisciplinary project work.

10.3.1 Empirical Material

This study is based on empirical data produced through a focus group interview with five students. The interview was conducted in 2013 with students in the Master's program in Learning and Innovative Change. The students participating in the focus group interview were invited on the basis of their capability as spokespeople for the semester's students. They were at the beginning of their studies, and at the time of the interview they had just handed in their first large project to conclude the first semester; thus, the process was fresh in their minds. Three PBL groups were represented in the focus group. The focus group interview lasted approximately 2 h. It was transcribed verbatim and analysed on the basis of the transcription, whereby it was read through and coded in its full length. During the interview, we facilitated a dialogue about the evaluation of the semester and asked open-ended questions, such as about learning outcomes and procedures involved in group work.

The focus group interview comprised a broad evaluation of the learning outcome of the programme's first semester. Hence, questions were asked in order to gain insights into the students' experiences and strategies connected to learning using the project-based approach, while we also asked several questions on the practice of *participation and learning in the group's project work*. These questions should be seen in connection with the fact that the first semester focuses on developing competences in collaboration as part of the students' introduction to working with PBL.

This study is part of a bigger longitudinal project consisting of five focus group interviews with LIC students over a period of 5 years. We conducted one focus group interview per year in 2010, 2011, 2012, 2013 and 2014. In this chapter we have thoroughly analyzed the focus group interview carried out in 2013, and identified positioning strategies expressed in the interview. We have made parallels to the remaining four interviews conducted in 2010, 2011, 2012 and 2014 at the end of the chapter.

10.3.2 Analytical Strategy

In order to process the empirical material, we constructed a list of themes and arranged these using visual displays in order to identify and differentiate patterns. Thus, it became possible to identify both different and identical themes throughout

the interview with a focus on the students' positioning in the PBL processes. The overview of themes formed the basis for the explanation, illustration, and exposing of nuances through quotations from the interviews that described the students' positioning in relation to the PBL work. During this process, we investigated the language used as expressed directly in the focus group interview. The statements were coded according to the following themes:

- informant experiences with PBL,
- informant experiences with philosophy of science, and
- informant attitudes toward the relationship between practical experiences and theoretical knowledge.

We have thus investigated how these issues are used by the informants to position themselves and others.

The themes chosen for this chapter are a result of the interaction between theoretical ideas and empirical data. In the following analysis, we begin by briefly introducing the focus group participants' academic backgrounds and their connections to their PBL project groups. Hereby, it is possible to discern study strategies connected to positioning dynamics as well as study backgrounds.

10.4 Results: Positioning in Transdisciplinary PBL Practice

In 2013, five students participated in the focus group interview: Frede, Kennet, Anni, Marianne, and Tina. Three of these students, Frede, Kennet, and Anni, worked together on their first and latest semester project, and their group also included three additional students who did not participate in the focus group. The two other students in the focus group, Marianne and Tina, finished their project work in different groups. Marianne left her group during the process and continued working alone, while Tina wrote her project with five other group members. Thus, three PBL groups out of 12 were represented in the focus group. Frede and Kennet both had academic bachelor degrees in social science from Roskilde University (RUC) and AAU, respectively. Anni holds a primary school teaching degree. Marianne holds a professional bachelor degree in practical pedagogical work, and Tina holds a professional bachelor degree in health and nutrition.

10.4.1 PBL Experiences and Positioning

At the beginning of the interview, Frede expressed strong opinions about the introductory programme to the project work at the AAU master's programme. He already had experience with project work from his bachelor studies at RUC, and he stated that this was extremely useful skills for him. It had taken him several years to collect

these skills. According to him, AAU's master's programme allotted merely 1 week to learn about project work before the students were required to work in groups of six and collectively produce a 120-page project report. Frede said that even with a university background, there could be great differences in existing knowledge of the project-oriented work format. According to both Frede and Kennet, it was a major challenge to their work and learning process that their fellow students did not share an understanding of what it means to do a PBL project.

> I was annoyed and felt that I was (being) slowed down, not allowed to gain any new insights on the master's level; it was a bit like being back in undergrad again. All the same mistakes. (Kennet)
>
> I felt exactly the same way. I felt it was the same again, i.e., like the first semester at RUC […] One thing is the study plan, but another thing is the people who are in the classroom, you know. Many of them were just from Suhrs school of home economics, and that sets an agenda.[4] If I hadn't been at that phase of my life where I had to complete my studies, I would have dropped out. […] That's for sure. I also wondered why there were so many students with a Suhr background. Also, it [professional bachelor background] affects the study environment and things like that. (Frede)

The two students who had completed university-level bachelor degrees expressed an explicitly negative distinction between university bachelor graduates and professional bachelor graduates. They positioned themselves as possessing the appropriate academic qualifications to do the PBL work and characterised their fellow students, professional bachelor graduates, with the degrading idea that they were *just from Suhr's* and many of them *with that background*, implying that they did not meet the same academic standards as themselves.

It turns out that Frede and Kennet, due to their experience with project work, came to play a dominant role in planning and managing their project group's work, according to themselves and the other group members (Anni). Their group members had many different ideas and perceptions of how a project is defined. According to Frede, there is no easy way to learn PBL and group work. Therefore, having experience with both group work and project design is crucial, and he expressed that it must have been very difficult for those who lacked that experience, implying that he knew what was needed:

> If I didn't, […] I mean it would have been really frustrating—if I had never completed a project of more than 120 pages before. I thought all along, "Oh yes, that's okay." It would have been very frustrating if I hadn't had this background […] It must have been a challenge not to have had it […] (Frede)

The third group member, Anni, confirmed that she really learned a lot from the two who had experience with project work:

> Yes, of course I really learned a—a lot, it made it all much easier for us that they said: 'I have done this kind of project before, and we used to do it like this, so we can just design it like this and put in these new headings', and that made everything much easier. (Anni)

[4] Suhrs' school of home economics was a university college in Copenhagen that offered professional bachelor degrees in nutrition and public health. Suhrs' school of home economics is today a part of the Metropolitan University College.

Thus, Anni supports the similar positioning of the others. Her learning strategy seems to be to accept both her own and the position of the other's by mirroring and imitating their way of conducting the project work.

Frede told us how he had previously had the opportunity to be more creative with his project work; but this, he continued, was only possible if the group had some experience with the writing and understanding of each part of the project. Therefore, in this project, it was necessary to use a schematic setup because the group was comprised of people from many different backgrounds as well as gaps in knowledge and experience regarding project work.

Another student (Marianne) dropped out of her group work during the project process. According to her, the group had not responded well to her asking so many questions. From the beginning, however, Marianne had high expectations for the group work. She described her ideal expectations of PBL collaboration that had been left unfulfilled:

> I was looking forward to the group work, where asking questions and challenging each other can create productive dynamics. To me, the group process is a question of using the differences in a group positively; it is also crucial that the power to make decisions is nested in the group and not in an individual or a certain group member who takes the leadership and tells us which way to go. To me, it is important that we share responsibility. We make stops and find a common direction. And it wasn't like that […]. So, for the first time in my life, I worked alone, and that was really a major learning process. (Marianne)

The major learning process Marianne referred to is learning by doing on your own. She pointed out that this was a very hard way to conduct a project and she experienced it as a frustrating learning process. According to her, the great learning potential, which is an important part of group dynamics, gets lost when things go wrong in a group, because possibilities for feedback becomes restricted.

In Tina's group, meta-reflection was used as a tool to ensure joint decision-making. After each meeting, half an hour was set aside to discuss the process and ensure that the decisions made had joint support. For this group, meta-reflection became very productive from the point of view of learning. It created confidence in the group, as everybody felt that they were being listened to and that they had an opportunity to discuss frustrations and disagreements. Marianne stated that in her group, it was the individual's responsibility to bring up challenges when things did not function properly; however, this did not always happen.

Both Marianne and Tina seem to have chosen strategies that were different from Anni's. Marianne chose the challenging learning strategy of working alone, thus rejecting the collaborative PBL way she was expected to follow. From this position, she kept working in order to fulfil her study requirements but she definitely felt let down by the lack of support from her PBL study programme. In contrast, Tina and her group members succeeded in creating and formulating their own tools to complete the PBL group project.

In this focus group, it seems that from the outset the two university bachelor graduates strongly positioned themselves and were positioned by their group member (Anni) in a way that was asymmetrical to that of the professional bachelor graduates. This position was guided by their PBL experiences gained from their former

education. Their positioning seems to have had a defining impact on the rest of the focus group members, who all related to this received view – which the academic bachelor graduates represent – recognising that PBL primarily deals with producing a project report that fulfils academic requirements rather than establishing well-functioning working groups.

10.4.2 Attitudes to Practical Problems and Theoretical Knowledge

In the focus group discussion, a theme emerged concerning the different approaches of the students and their reasons for joining the LIC programme. This discussion concerned the use, value, and applicability of academic analysis in practice.

The group members Frede, Kennet, and Anni were aligned in their viewpoints. They believed that the students from the professional bachelor degree programmes were often driven by the desire to improve specific practices which, in their experience, does not work. In other words, they were motivated by a drive to solve problems. In contrast, they describe their own motivation and the experience gained from their academic bachelor degrees as spurring their work within a disciplinary field. More succinctly, Frede formulated this as the distinction between an issue-focused approach to studies versus a discipline-focused approach. Anni's description is a caricature of the issue-focused approach, partly formulated in a distorted tone of voice:

> Yes, if you think you have a discipline, you can—it's hard to explain—but then it's connected to this broad disciplinary understanding, you work within a discipline and not 'I shall go out to save the world and solve problems in a nursing home' or something like that [to improve something]. (Anni)

Marianne, a student with a professional bachelor's degree, actually had a desire to improve conditions in nursing homes when she joined the LIC programme. She explained that this was the case and that she continued to want a toolbox to solve problems. She also agreed, however, that she was now aware of a broader academic and theoretical interdisciplinary background, which gave her the opportunity to analyse what was at stake from a more nuanced perspective. She described the approach that she had started with as being 'maybe naïve and crusader-like'. Thus, she recognised and accepted the position; however, she also signalled that she had advanced and gained academic qualifications. Although she partly distanced herself from the issue-focused position she had when she started, she also challenged the position of the university bachelor graduate by calling for a more open view, e.g., on the part of her fellow students and the study programme:

> It seems that some groups of fellow students interpret what others say, and suddenly either you are issue-focused or discipline-focused! I'd hate to stand here after graduation and hear someone say, 'Marianne, she is just issue-focused, problem solving with a naïve approach to analysing and saving the world', because I feel that would be wrong. You are limited or

> inhibited in this way. I think there should be dialectical dynamics in the study of learning and change processes—that is, in what you investigate in practice and what you create at a university. (Marianne)

Marianne opposed the either/or positioning described here, and thus she raised the question of whether there is room for a reflective and nuanced concept of the issue-specific approach within the academic disciplinary study of the processes of learning and change. At first, she resisted the position of the professional bachelor graduate that was offered. Frede explained that to him it was okay that the issue-specific approach was part of the project work, but he also wanted to state that this was not to say that he 'aimed randomly at different practical goals'. He argued that the academic dimension of project work was connected to the demand that students should be able to argue for what they do. The practical dimension of the academic work must thus also be linked to a scientifically and theoretically justified position.

> So, it's just as important to say that that's what I mean when I talk about practice, that is, that it may well be included, but in an academic form. (Frede)

Tina added to the description of the academic position, stating that to her, the starting point for academic work is curiosity regarding an academic field, and that theory is used to illuminate the questions asked. In spite of her background coming from a professional bachelor programme, she identified with a classic academic understanding. She stressed that there are not necessarily correct or incorrect answers, but that it is possible to shed light on your questions from different theoretical angles.

Tina, a professional bachelor degree holder, said that an academic investigation could just as well start out as a question raised during practice. According to Tina, academic analysis can inspire and be eye-opening or illuminating without necessarily recommending a specific practice. With this understanding, Tina distanced herself from the either/or positioning of the issue-specific or discipline-focused approach.

Marianne's goal was also to understand practice much better, and she required theoretical approaches as a result. By employing a theoretical perspective, Marianne believed that she could gain new insights into practice. However, she did not believe that this would make any difference unless such insights could be brought back to the field of practice. Marianne's approach could be phrased as 'why do it if it is not used in practice?'. As she stated:

> It makes me a bit sad if it means that there is a divide, so that it can only be one way or the other way; it has to be a combination. (Marianne)

Academia and having a bachelor's degree from a university are associated with understanding social practice and theoretical knowledge. This position is connected with working within an established academic discipline. The position of the professional bachelor graduates, however, was seen as being connected to taking action and 'saving the world'. The position of the university bachelor graduates was seen as superior to the position of the professional bachelor graduates, that is, the academic approach can stand alone, whereas the position of 'saving the world' and

solving practical problems cannot. It must either be complemented by an academic approach or not be present at all.

10.4.3 The Philosophy of Science: A Positioning Device

An especially important element in the disciplinary positions among the students was expressed in the continuing dialogue, whereby participants provided more detail regarding their experiences of the division between professional bachelor graduates and academic bachelor graduates. They generally agreed that the distinctive divide is related to differences in the knowledge and skills they possess regarding the philosophy of science. This distinction pervades the broad differences in their understandings of what it means to conduct a project. Knowledge and skills in the philosophy of science were seen and accepted by all focus group students as *the* primary skill necessary in order to become an academic. Anni explained that during her teacher training she was not in any way introduced to the philosophy of science. She knew a little because she had previously, very briefly, studied theology. In addition, Tina related that when she began her education in health and nutrition, the programme had not been approved as a professional bachelor degree. When it was finally approved, a course related to the philosophy of science was added. Tina described her recognition of the difference between the professional approach and the academic university approach as being anchored in a philosophy of science background to guide project activities:

> It becomes very clear to me what the difference was because the course we received was precisely philosophy of science, and I came to understand that this was the difference that lies in being profession-oriented and having the opportunity to understand things differently. We learned it at the very end, and it made a huge difference in relation to the work we had done earlier in our bachelor project, because we suddenly had to use it. […] But yes […] That's maybe where the difference lies. (Tina)

From the group work with the two students with academic bachelor degrees, Anni reported that it was those who had the best arguments who won the acceptance of the group. Celerity and good arguments were the deciding competences based on experience with project work (PBL) and the philosophy of science. As such, students from academic bachelor programmes made more decisions and, thus, led the progress of the project work. As Anni stated:

> It was they who were allowed to decide. […] We really didn't discuss which scientific theoretical view we should use because the two very quickly could say 'that fits really well'. And it did, too, and I don't regret it, but it was just quickly those who had the best arguments and were fastest. And I think it's often that way. (Anni)

Marianne also recounted how there was no expectation that students integrate philosophy of science when writing a paper at a university college. In this regard, she experienced a great gap in her own knowledge and thereby signalled that she also accepted this part of the positioning, which was offered from this point of view:

> I wish I had the background you guys have; then, I would have had skills [*in philosophy of science*], because it also means that you begin to talk a different language. As I see it, the philosophy of science actually becomes a language at the university. (Marianne)

Tina agreed and thereby confirmed that she saw the inadequacies regarding the philosophy of science as a great burden for fellow students with this background. In short, the two professional bachelor graduates felt that they were not academic enough.

> […] because it is also too bad for Kennet and Frede that they had to spend so much time to going back to a different level. (Tina)

With these remarks, Marianne and Tina confirmed the asymmetrical positions between the two types of bachelor degree graduates. They both regretted their inadequacies and felt pity for the academic bachelor degree graduates due to their own insufficient competences in the philosophy of science, and they fully accepted the asymmetric positioning.

10.5 Conclusion: Student Positioning and Project-Based Learning

This study has identified a storyline found in the analysis of a focus group interview where the academic bachelor graduates were positioned and positioned themselves as being able to meet the perceived academic standards of the Master's in Learning and Innovative Change. The academic bachelor graduates perceived their position as being superior to the positions of the professional bachelor graduates. The academic position was perceived to be superior in three aspects:

- The academic bachelor graduates had experience with PBL.
- They had greater qualifications within philosophy of science.
- They had theoretical and academic knowledge and did not naïvely intend to 'save the world'.

From this position, the academic bachelor graduates took on a leadership role during the project work. Thereby, they assumed a dominant position and set the agenda for the project work.

It thus became an important study strategy for the professional bachelor graduates to position themselves in relation to the received view of the academic bachelor graduates. Regarding the three professional bachelor graduates, it became clear that they were positioned as *a burden* by the two academic bachelor graduates, Kennet and Frede; they accepted this by expressing a desire that they had had the same background as the academic bachelor graduates. This applied more to Anni and Marianne, as Tina added that their insufficient abilities affected Kennet and Frede.

The professional bachelor graduates generally spoke of themselves, and were also referred to, as lacking important PBL qualifications.

At the same time, the three professional bachelor graduates positioned themselves in divergent positions in relation to the received view. As a member of the group that included Kennet and Frede, Anni adopted a fully accepting, aligning, and assimilating strategy in the group. Tina partly accepted the received view, but also co-constructed academic virtues from her own independent position. We term this a strategy of paralogy. We adapt the term of 'paralogy' from Lyotard (1984). It means going against or redefining an established way of reasoning. As a third strategy, Marianne rejected the received view as she felt unfairly limited due to a non-recognised and disrespectful view of the knowledge of practice that professional bachelor graduates can add to PBL work.

The academic bachelor graduates seemed to have an advantage over the professional bachelor graduates at the Master's in Learning and Innovative Change. This was due to their experiences with PBL projects and especially their skills in the philosophy of science.

We would like to put the storyline, which so forcefully manifested itself in the analysis of the focus group interview, into perspective by questioning some of its underlying assumptions. The PBL perceptions of the academic bachelor graduates was quite instrumental and focused primarily on producing an academic report. This is a narrow understanding of PBL that conflicts with the AAU's PBL model, which emphasises inclusive and symmetrical group dynamics. The perception of the philosophy of science on behalf of the graduates from academic bachelor programmes seemed to be associated with scaffolding different theoretical and academic perspectives and positions, facilitating interdisciplinary work, and understanding conflicts between different paradigms. Maybe this understanding of the philosophy of science cannot stand alone in a transdisciplinary study program. An alternative perspective on the philosophy of science departs from conflicts between academia and other professional practices – between the conflicting desires of trying to understand and transforming social realities.

As mentioned previously in the chapter an additional four focus interviews were carried out. In this paper we have not analyzed these interviews in depth. A read through of the transcribed interviews show that they also thematize the backgrounds of the students (academic versus professional bachelor degree), and that the interviewed students refer to both PBL, philosophy of science and the relationship between practical experiences and theoretical backgrounds in their positioning strategies. How they encompass these elements in positioning strategies are very different and context dependent, and that will be the topic of a later publication. In other words, additional research is needed before it can be determined to which extend the strategies portrayed in this chapter are specific to the particular interviewees or whether they also are expressed by other students at the LIC program or at other interdisciplinary study programs.

References

ACE Denmark. (2010). *Vejledning til ansøgninger om akkreditering og godkendelse af nye universitetsuddannelser* 1. udgave. Available at http://www.acedenmark.dk/fileadmin/user_upload/dokumenter/Akkreditering_dokumenter/Vejledninger/Vejledning_om_nye_universitetsuddannelser_1_marts_2010.pdf. Accessed 29 Apr 2013.

ACE Denmark. (2013). *Tværfaglighed på dagsordenen – Udfordringer og potentialer*. Copenhagen: ACE Denmark. https://akkr.dk/wp-content/filer/akkr/Tvaerfaglighed.pdf

Apostel, L., & Vanlandshoot, J. (1994). Interdisciplinarity: The construction of worldviews and the dissemination of scientific results. *Issues in Integrative Studies, 12*, 9–22.

Apostel, L., Berger, G., Briggs, A., & Michaud, G. (Eds.). (1972). *Interdisciplinarity: Problems of teaching and research in universities*. Paris: Organisation for Economic Co-operation, and Development.

Barge, S. (2010). *Principles of problem and project based learning: The Aalborg PBL Model*. Aalborg: Aalborg University.

Davies, B., & Harré, R. (1990). Positioning: The discursive production of selves. *Journal for the Theory of Social Behavior, 20*(1), 43–63.

Davies, B., & Harré, R. (1991). Contradiction in lived and told narratives. *Research on Language and Social Interaction., 25*, 1–36.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge. The dynamics of science and research in contemporary societies*. London: Sage.

Harré, R., & Moghaddam, F. M. (2003) The self and others: Positioning individuals and groups in personal, political, and cultural contexts (R. Harré & L. Van Langenhove, Eds.). London: Praeger.

Harré, R., & Secord, P. F. (1972). *The explanation of social behaviour*. Oxford: Blackwell.

Harré, R., & Van Langenhove, L. (1992). Varieties of positioning. *Journal of the Theory of Social Behavior, 20*, 393–407.

Harré, R., & Van Langenhove, L. (1999) *Positioning Theory: Moral Contexts of Intentional Action* (R. Harré & L. Van Langenhove, Eds.). Malden: Blackwell Publishers Inc. ISBN: 0-631-21138-1.

Klein, J. T. (1990). *Interdisciplinarity: History, Theory, and Practice*. Detroit: Wayne State University Press.

Klein, J. T. (2010). A taxonomy of interdisciplinarity. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity*. Oxford: Oxford University Press.

Lyotard, J. F. (1984). *The postmodern condition: A report on knowledge*. Minneapolis: University of Minnesota Press.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdiciplinary Journal of Problem-Based Learning, 1*(1), 9–20.

Thomsen, J., Munk, M., Eiberg-Madsen, M., & Hansen, G. (2013). The educational strategies of Danish university students from professional and working-class backgrounds. *Comparative Education Review, 57*(3), 457–480.

Van Langenhove, L. (Ed.). (2010). *People and societies. Rom Harré and designing the social sciences*. Routledge. ISBN:978-0-415-56724-4.

Chapter 11
Student Interdisciplinary Practices in a PBL Study Environment

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11.1 Background

Since the Second World War, the number of students in higher education worldwide has dramatically risen. Education appears to play an important economic role, serving as a commodity in the competition in the global market (Lyotard 1979; Jeffrey and Troman 2011). Nations are investing in education, and in general, the number of students has risen. At the same time, the Bologna Process has encouraged more comparable, compatible, and coherent systems of higher education in Europe. This phenomenon has been conceptualised as *mass education* and has been problematised as a decline in quality (Scott 1997). In Denmark, over the last 60 years, the number of students attending Danish higher education has increased tenfold, and the number of available university places has doubled since 1979 (Thomsen et al. 2013). This increase has been based on efforts toward democratisation and the levelling of class differences. Economic resources should not be a condition of access to education (Thomsen et al. 2013). Accordingly, in Denmark, more students in master's programmes come from different fields of study, thus bringing different disciplines into master-level study programmes.

As a new trend, a large number of profession bachelor graduates (PBs), such as bachelor degrees in nutrition and health,[1] pedagogues,[2] and teachers educated at university colleges, are gaining access to a (limited) number of master programmes.

[1] Nutrition and health is a 3.5-year bachelor's degree programme. In this degree programme, students work with nutrition and health from various perspectives.

[2] The concept *Pedagogue* is specific to Denmark. The Danish *pedagogues* are comparable to "preschool teachers" in other countries.

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Much research demonstrates that parental socioeconomic status, education, cultural assets and social networks are associated with educational outcomes (Bourdieu and Passeron 1990), and that the differences in resources shape an individual's school performance and educational aspirations. Thus, the probability of success is strongly associated with social origin at early, rather than late, transition points (Breen and Jonsson 2005). Danish and EU citizens are not required to pay tuition fees to enrol in degree programmes, as this is covered by the Danish state. In addition, students receive government stipends while they study. When considering processes of social differentiation in access to university, the economic hindrances in accessing higher education in Denmark seem significantly less compared to other countries (Jaeger 2011). Other scholars find that university students in general can be divided into two large groups: (1) a classic non-vocational university group of students from homes where the transmission of academic skills is the primary mechanism of reproduction, and (2) a vocational group of students who are from homes where education is highly valued as it leads to well-paid and well-respected jobs (Thomsen et al. 2013). Whereas students from the first group usually attend liberal arts universities and are more likely to study law or medicine, in the other group students are more likely to study pharmacy or business. Some programmes require medium-high to high grade point averages in order to gain admission, meaning that the relative prestige of university programmes is reflected in the admission criteria.

11.1.1 Theoretical Background: Praxeology

Bourdieu's theory of cultural reproduction (Bourdieu and Passeron 1990) is concerned with the link between original class membership and ultimate class membership, and the ways in which inequalities are mediated by the education system. To understand how individual students act in social practices and the way that they orient their practices, the notion of *strategy* is important. This term is usually used to imply the conscious and rational calculation of risks and/or deployment of resources. Bourdieu (1990a) uses strategy as a term to refer to something that rests on a practical 'feel for the game'. Strategies are the result of combining practical good sense with commonly accepted practices. This is most often done in a semi-automatic manner. The field of education can be viewed as a market where agents competing for their products rule social activity. The structures of the field arise from differentiation, which is grounded in a defining principle of what is of value. Thus, value is assigned by the dominant positions in the field and at a rate determined by the proximity and distance from the present orthodoxy. According to Bourdieu (1977), the primary vehicle for the transmission of the dominant class culture is the education system. Thus, teachers have the authority and the means to assess students, and do so based on a certain set of assumptions, expectations, and values that are not always explicit. The notion of cultural capital is therefore crucial to understanding the experiences of student strategies in higher education. In turn,

cultural capital has been defined as high cultural knowledge that ultimately fortifies the owner's financial and social advantages (Bourdieu 1986). As Bourdieu claims,

> [...] different schools attract pupils of different social classes very unequally, in accordance with their previous academic success and the class-differentiated social definitions of the types of courses and types of schools—it can be seen why the different types of syllabus give very unequal chances of entering higher education. (Bourdieu and Passeron 1990, p. 158)

Hence, understanding the role of a student coming from a different disciplinary background has to do with the student's ability to think what is possible for him or herself as well as in which particular form it is thought (Bourdieu 1971). In other words, an ability to understand the tacit requirements of university staff members and appropriately perform a PBL university student's role impacts interdisciplinarity as well as students' performance, success, and achievements in the specific context of a PBL university.

In this study, our research question analyses what interdisciplinary practices emerge from students' bachelor degree backgrounds and what institutional habitus is formed by their entering a PBL study environment. Hereby, we draw on the work of Reay (1998) and colleagues, who define institutional habitus as 'the impact of a cultural group or social class on an individual's behaviour as it is mediated through an organisation'. Thus, educational institutions may be able to determine what values, language, and knowledge are regarded as legitimate and therefore award qualification and ascribe success on the basis of mastering these skills (Thomas 2002). We question whether in this interdisciplinary environment some students are better than others at understanding the unwritten requirements and are thus more likely to perform in ways that meet them. The university, thus, is the locus of a particular habitus that 'produces patterns of thought which organize reality by directing and organizing thinking about reality and makes what he thinks thinkable for him as such and in the particular form in which it is thought' (Bourdieu 1971, pp. 194–95). Whereas Bourdieu sees habitus as potentially generating a variety of possibilities for action and states that 'the habitus goes hand in hand with vagueness and indeterminacy' (Bourdieu 1990b, p. 77), his emphasis is on how individual agency predisposes people towards certain ways of behaving. This indeterminacy about the concept of habitus is explained by Bourdieu when stating that his concepts are 'open concepts designed to guide empirical work' (Bourdieu (1990b, p. 107).

11.1.2 Student Exposure to Problem-Based Learning: In What Way?

The idea of learning through solving or managing problems is not new. Savin-Baden (2000) argues that disciplines that are less bounded by a distinct pedagogy of their own tend to more easily adopt problem-based learning, whereas other disciplines may be affected by the traditional ways of teaching and the values and distinct views of knowledge held therein. In the syllabus of a specific course, students follow

learning goals that in many ways are aligned with what Savery (2006) calls the generic essentials of PBL in that they are set to promote students' self-directed learning abilities, develop students' reasoning skills, develop skills to work and learn with others in teams, develop presentation skills, learn negotiation and problem-solving abilities, develop research skills, and reflect on what they have learned and on the effectiveness of the strategies employed. An underlying premise of the syllabus is that learning is attuned to the world of work. The syllabus sets a learning goal whereby students can engage with the complexity and diversity of everyday problems. They learn in classes, groups, and workshops where they are confronted with understandings from different professional perspectives. Hereby, the goal is to understand the similarities and differences between a range of perspectives and how professions utilise the same knowledge in different ways (Savin-Baden 2000). In PBL learning environments the students are requested to document their own learning process, identify their own strengths and weaknesses, and undertake appropriate remediation—a way of practicing self-directed learning.

11.1.3 Interdisciplinarity as an Empirical Concept and an Analytical Construction

In this chapter, we approach interdisciplinarity at two levels. At an empirical level, we have selected an interdisciplinary programme at a PBL university. Here, interdisciplinarity is understood as having a group of students from different bachelor degree fields work on a project together. This heterogeneous composition of students represents interdisciplinarity at the empirical level.

At the second level, we approach and perceive interdisciplinarity as a practice and an approach that is inspired by our theoretical foundation; namely Pierre Bourdieu's praxeology. Because of the interdisciplinary group of students whose practices we are studying, our analytical perspective on interdisciplinarity occurs through the practices of different students. From this perspective, interdisciplinarity is not seen as something we can go out and register in the world, but instead as something that receives its character through the way that it is practiced—in our case, by students being part of an interdisciplinary programme. In this way, interdisciplinary practices can have a large scale and various ways of being practiced. We are not interested in how interdisciplinarity can be understood in different theoretical ways, but rather in how the empirical phenomenon of interdisciplinarity is practiced.

To grasp these interdisciplinary practices, we construct them analytically by using the concepts of institutional habitus and strategies. Thus, interdisciplinarity is analysed and analytically constructed through student experiences and objective structures—meaning the academic culture in the interdisciplinary and PBL-orientated programme—that make these experiences possible.

11.1.4 Contours of Bachelors' Institutional Habitus as a Starting Point for Interdisciplinary Practices

Before considering the transformative traits of habitus, we must briefly describe the dispositions of the main groups of our students, drawing mainly on the institutional habitus they bring to the PBL university environment. In a typical cohort, one third of the students have a UB degree, while two thirds of them have a PB degree. UB degree holders come from a range of bachelor programmes, such as physical education, communication, sociology, and educational science. Since we lack sufficient data to divide them into subgroups, we divide them in half namely coming from bachelor programmes with or without PBL experience.

The PB degree holders can be divided into three main groups, namely pedagogues, teachers, and nutrition and health studies. In Denmark, the professional history of teachers is longer than that of pedagogues. Teachers have gradually gained almost an occupational monopoly within schools, while unskilled workers do a relatively large part of pedagogues' work. Both teachers and pedagogues are often considered to have extensive practical knowledge, but scarce dispositions for scientific knowledge (Bayer and Brinkkjær 2003). Teachers' forms of knowledge are assumed to be highly context-bound and are often considered almost mosaic-like, sporadic, and private. Neither group can be said to have a professional language, but rather a professional consciousness in the form of a kind of 'culture', which gives both professions status both internally and externally (Bayer and Brinkkjær 2003). Professional consciousness is for teachers, and is to some extent tied to the school's syllabus, while for pedagogues, it is built around the concepts of care, compensation, and development.

As for the third group, the holders of nutrition and health degrees, they also draw upon a practical approach to knowledge. Derived from a housekeeping school established at the turn of the twentieth century to secure high standards of young women's housewifery skills, the education has continuously fought for recognition. Although its professors have been educated at universities from a very early stage and attached to programmes affiliated with the most prestigious sciences (i.e. biomedicine and economics), people from outside the field have considered the core syllabus of nutrition and health degreed to be merely basic knowledge about cooking skills (Overgaard 2005).

11.2 Methods

We draw on mixed methods of social inquiry to answer our research question. Our approach is to engage dialogically with the differences between quantitative and qualitative data in order to place the two in conversation with each other throughout the study, as this will allow for a deeper understanding based on the convergence and dissonance found in the approaches (Greene and Hall 2010).

We used an administrative dataset of students in a specific master's programme who were enrolled at a university that is committed to a PBL pedagogy. This allows us to use individual information related to the pre-enrolment period and also to take into account changes in university attendance decisions year by year. The data were collected over a two-year period and, ultimately, we observed three outcomes: (1) students obtained their master's degrees, (2) they dropped out, or (3) they are still enrolled. The analysis was carried out on 138 incoming students and information about the students' characteristics (gender, age, and pre-enrolment characteristics (type of bachelor degree)) and information about their university careers and performances was collected. The aim of the quantitative analysis is to gain insight into the determinants that affect student strategy in the PBL programme. In an attempt to underline the potential transition between the first and second years in the programme, we follow the evolvement of student grades. A student was considered as having dropped out if she/he had not received any credit or passed an exam for 1 year.

In dialogue with the quantitative data on grades and dropout rates, we draw on qualitative interviews with eight students who were enrolled between 2012 and 2014. The interviews were conducted by two of the authors. These eight students were all in their mid-twenties and were selected to achieve variance in terms of the UBs and PBs degree. We selected UB graduates coming from bachelor programmes with a PBL tradition so that we know that these students have a habit of working in groups.

Verbatim transcripts of interviews were analysed primarily in terms of students' relations to the presented syllabus. We focused on how the dynamics in an interdisciplinary context of students from various bachelor degree backgrounds can be seen as a strategy to meet PBL requirements.

In the interviews, we focused on the students' perception of how they are expected to work with the presented theories and their strategies of doing so. We questioned them about their experiences of working in project groups, about their teachers' responses to their work, and on the extent to which they felt that this university helped them achieve their objectives.

This project was approved by the Danish Data Protection Agency. No formal ethical clearance was required. In all cases, informed consent was gained prior to the interviews, anonymity was guaranteed, and the participants were informed that they could withdraw from the study at any time. Individual names and other identifying details have been omitted from the data presentation in order to ensure confidentiality.

11.3 Findings

The quantitative data consisted of 121 students who had completed the master's programme; there were 95 female and 26 male students, who had an average age of 29 years (see Table 11.1). Regarding their background, 61% of students had PB degrees and 39% had UB degrees. Among the professional bachelor degree holders,

Table 11.1 Background information on students in relation to gender, age, and educational background

	Professional Bachelor Degree holders	PBL University Bachelor Degree holders	Other University Bachelor Degree holders	Total
Number of students	74	24	23	121
Average age	29.84	26.24	31.52	29.45
Men	17	6	3	26
Women	57	18	20	95

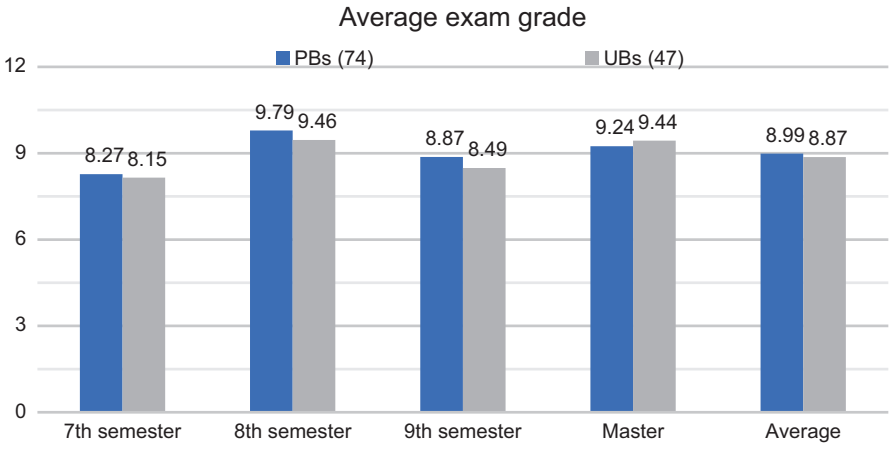

Fig. 11.1 Average exam grades by PB graduates and UB graduates (Total number of observations = 101)

the three main groups came from the field of nutrition and health (24%), while 31% were pedagogues and 27% were teachers.

When considering average exam grades, there was no significant difference between the average grades earned and educational background of the students (see Fig. 11.1). In the 7th semester, PB graduates on average achieved grades that were 0.12 points higher than UB graduates (8.15). This pattern was observed during the 8th and 9th semesters. Only in relation to the thesis did UB graduates achieve grades that were marginally higher than PB graduates. Data were tested for both gender and age (which is considered to play an insignificant role in this model).

When considering the distribution of grades based on the degree programme PB graduates came from (nutrition and health, teachers, and pedagogues), they had uniform average exam grades in the first two semesters. Starting in the 9th semester, however, the data showed that pedagogues performed worse than teachers or nutrition and health graduates. As a result, it can be concluded that teachers or nutrition and health PB graduates bring with them dispositions that seem to contribute to a better match with the institutional habitus (Fig. 11.2).

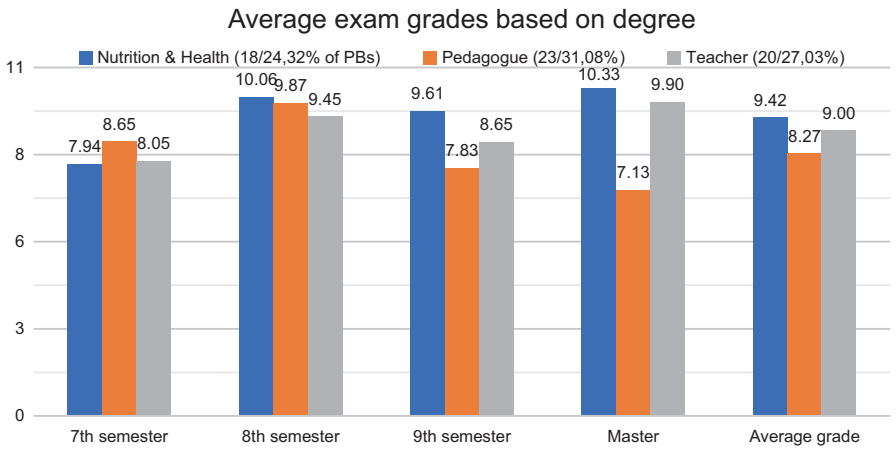

Fig. 11.2 Average exam grades based on type of degree (Total number of observations = 61)

Although both the socioeconomic and academic backgrounds of students are known to influence their overall chances of graduating, the ways in which these factors influence the graduation from a particular institution are less well documented. We considered that completion and dropout rates could best be explained by focusing on the interaction between the individual student and his/her particular university environment in which his/her attributes (dispositions, interests, strategies, skills, etc.) could be exposed to the demands and mutual expectations from the university.

The dropout analysis shows that fewer UB graduates (4) compared to PB graduates (18) dropped out of the programme after one or more years of the programme (see Fig. 11.3).

On the other hand, no significant differences were found regarding finishing the programme in the allotted amount of time (see Fig. 11.4). This finding indicates that the institutional habitus of a PBL university seems to provide an environment that equally values a diverse range study programme backgrounds.

In order to seek broader and deeper portraits of the selected constructs from the quantitative data we will now turn to the qualitative data and the different types of student experience within a PBL-based university environment.

11.3.1 Interdisciplinarity Practice as Segregation

From the qualitative interview material, it became clear that the students related to each other as students either with or without a UB degree. This distinction was reflected in the way that students assessed themselves and other students, and also upheld a certain segregation between the students in their everyday lives at the university. It stereotyped UB graduates as academically strong, as 'appropriate', and as

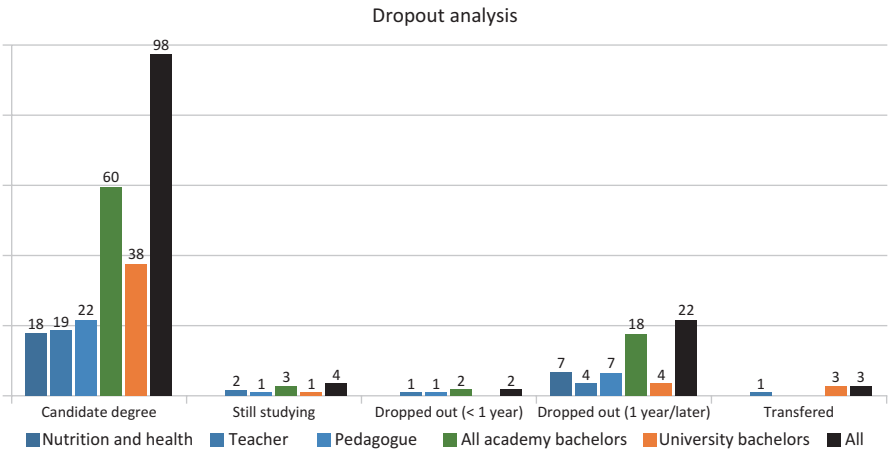

Fig. 11.3 Completion and drop-outs (Total number of observations = 129)

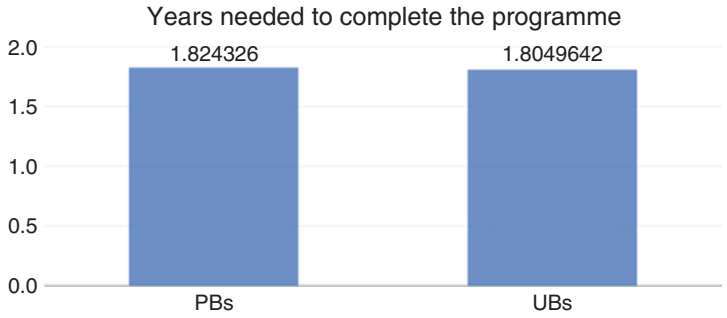

Fig. 11.4 Time needed to complete the programme (Total number of observations = 121 (students who dropped out during the 7th semester were removed))

the resourceful members in group work for their semester projects. In contrast, the PB graduates were seen as academically weak, the 'dead weight', and as disadvantaged in project work. Sarah, a PB graduate, expressed it this way:

> It was really a brutal start when you are not used to […] I had not been to lectures […] I've almost never been to lectures when I was trained as a teacher. To sit on a chair for 18 hours a week for 6 weeks when starting up at the university, and afterwards to go home and reading […] it felt as if there was a big hole, some knowledge, some skills, and some overview missing […]. (Sarah, PB graduate)

Interestingly, the quantitative data did not match the students' own experience of UB graduates performing better when it comes to academic success. Nonetheless, all PB graduates had experienced problems when participating in academic discussions and in thinking 'right' when using theories. They felt like they had to 'unlearn' their more practical perspective as well as their 'evaluating' ways of, for example, analysing empirical data. They came to the PBL university with practical

knowledge, which guided them to evaluate and to find solutions rather than to—academically—describe the empirical situations and analyse them from a certain theoretical point of view. However, during their group work and interdisciplinary contexts, they learned to crack the academic code and ultimately performed well in terms of grades. The following quotation provides good insight into how a student (Abraham, PB graduate) explained this learning process:

> It's been difficult to find your feet, to start with […] there has been a huge difference between how you think and work at the university and the way you think and work at the teacher training programme […] on several occasions in class I was thinking 'That was weird'. Then I just said nothing. I tried to figure out […] how the other students were thinking […] we were talking about something, I think it was Ziehe—then at some point I said that I had read a report from XX and related the theme of the discussion to the report. Then the teacher reacted: 'Yes, that is so true. YES!' […] I really felt that I was recognised and accepted […] since then when I argue or state a point—I always refer to something I read. (Abraham, PB graduate)

Apparently, Abraham was clearly conscious of his strategy. He knew that he lacked skills in terms of acting like a 'proper academic'. However, he observed the institutional habitus carefully and found a way to be successful.

11.3.2 Interdisciplinarity in Organising Project Work

When it came to interdisciplinarity and the division of labour, there was a mutual understanding among students from both groups that the UB graduates had some advantages in academic writing. This point of view was expressed below by Rune (UB graduate):

> I am often the one who writes the introduction and the theory […] the most 'theoretical' group member […] taking responsibility for writing up the theory and the more complex parts […] also shaping the project […]. It comes pretty natural, I think […] but I guess, I also take on these tasks without thinking about it. (Rune, UB graduate)

Rune did not fight for these tasks when the group, consisting of both UBs and PBs, was organising the project work, nor was he 'forced' to take up these specific tasks. Both student groups seem to have incorporated the knowledge of who has the 'necessary' capital and who could contribute the most to getting the best result, which is part of the specific institutional habitus.

Whereas UB graduates who came from a PBL university had a rather ambiguous attitude toward project work (a cornerstone of PBL), PB graduates had a more positive attitude. The ambiguous attitude can be attributed to the UB graduates' experiencing both learning a lot from project work, but at the same time finding it very difficult and hard work, academically, when working in groups. The following quote illuminates the difficulties that a student with a PBL-university background can experience when practicing project work with fellow students with PB backgrounds. His experiences expressed the theme of having different approaches when conducting academic inquiry:

> […] it is difficult in project work to agree upon anything […] I often read a lot in the beginning of a project, and then start writing while I have an idea of what to do. Some of my fellow students do it the opposite way. They […] just start interviewing people, and then afterwards they read about how to conduct an interview. It has probably something to do with the academic practice […] It is difficult (for) one man [referring to himself as a UB graduate] cooperating with three other PB graduate students […] trying to pull the work in a direction that you think is the typical academic way, that is recognised at the university […] and convincing fellow students… without putting people down. (Rune, UB graduate)

Jane, who came from a PBL university background, benefited from her background and her habits of working in groups, which is reflected in her PBL institutional habitus. She stated:

> I've always studied at a PBL university, and I'm really pleased […] [that] you can share ideas and discuss these with your fellow students. You always have someone to discuss things with, and to reach new insights with. It's this sparring [that] I think is cool, and when it goes up to a higher level and you hit a joint point and you start to understand things. That's what I really like about the project work. I cannot imagine being on my own anymore, I'm so used to sparring. (Jane, UB graduate)

However, organising project work could also be quite autocratic. For example, Jane talked about a piece of the project that took a wrong turn due to time pressures and a specific situation with a PB graduate co-student who, according to Jane's perception, lacked academic skills, and the co-student, in some way, was left behind during the project work.

> The third person [fellow PB student] was there too, but drove the project off track. At last, he did not even know what the project was about. He could not write anything because what could he write when he did not know anything about the content or the problem that was to be answered. Moreover, we [Jane and her other fellow UB graduate student] did not have time […] we did not have the capability to sit down and constantly explain everything to him. It was uncomfortable. (Jane, UB graduate)

This experience led Jane to prefer to do projects alone or at least with other UB graduates like herself in the future, whereas none of the PB graduates considered doing project work alone as a future possibility. Rather, they seemed to experience that they learned a lot from project work. An exception is Sarah, a PB graduate, who saw both advantages and disadvantages in being in an interdisciplinary project group. Nevertheless, she ended up saying that in the future she would choose to work only with other PB graduates because then, as she said, they could 'discover things together'.

> There are advantages and disadvantages of both [doing project work with fellow students who have a university background]. I have learned a lot from being in project groups; I have experienced working with people [students with a university background] from whom I have learned a lot. They could really teach me something because they were academically savy, and had a whole different insight and overview of the different theories and the philosophy of science […] It was more fun to be in the other kind of group [project work with PB students] […] you discovered things together […]. (Sarah, PB graduate)

Based on her experience, Sarah—like Jane—preferred to be in project groups consisting of students 'of her own kind'. Thus, interdisciplinarity was practiced in

such a way that a greater segregation between UB graduates and PB graduates was produced not only in distributing tasks during project organising, but also in future group formation. Their habitus seemed to orient them towards 'their own'. Interestingly, these distribution patterns did not support the joint responsibility of the work, which is an important part of PBL.

11.3.2.1 Collaborating with the Outside World

Part of project work is comprised of collaborating with the outside world, where more disciplines are needed. Whereas PB graduates and UB graduates did equally well in terms of grades, the PB graduates expressed the most enthusiasm about this part of the PBL approach to learning. As professional bachelor graduates, both Sarah and Abraham had experienced project work based on collaboration with an external partner—in this case an organisation. In the interview, Sarah showed a great deal of enthusiasm for this kind of project work. The same was true for Abraham. Both believed that this kind of real-world collaboration was more real and authentic since they worked with 'real people'.

In the interview, Abraham described how both the project work and the collaboration with co-students as well as external organisations were difficult, but also very exciting and challenging. When collaborating with an organisation, he learned to think of knowledge as more than only one entity. Instead he began to think of knowledge as something that can be divided into different kinds of types of knowledge. This insight helped him handling the cooperation in a less frustrating and more insightful manner. This is a classic Aristotle-inspired way of thinking (a theory from the syllabus), as stated in the interview;

A: It is difficult […] But we split it up: In the initial cooperation, we tried to build up a problem with the company, a problem relevant for them—as well as for us […] It was very exciting and it was a great way of learning.
I: So you actually collaborated with the company…?
A: Yes, exactly. The preparation and construction of the problem—it was actually participatory. But the […] the study was more descriptive.
I: And you succeeded in doing it?
A: Yes, I succeeded. And I think that I can vouch for it […] Well, this researcher role, or whatever you call it […] where our knowledge is better than the practitioner's […] I think it was really cool that we could say: 'So, we have come to this, but it is not necessarily true. Our knowledge is not more correct than your knowledge, but your knowledge is not more correct than ours […]'
I: You think there are various forms of knowledge?
A: Yes, exactly. And maybe we can bring it together, and then make something more out of it. It was so exciting.

Abraham understands the asymmetrical social relationship between a researcher and a practitioner, and he finds it attractive to be in a position where he can compensate for ones 'lack' of knowledge by judging the other person's knowledge as being equally valuable. This position is new to him now that he is on the other side, so to speak.

Sarah also described the project work in positive terms. She emphasised that they have worked on an authentic problem and with 'real people';

S: Yes, it's been really exciting […] when the project work is based on a real problem in a real company […] I think it's been really cool. It gives much more sense to me to work that way.
I: How did you do it?
S: Well, we had a contact at a company through our supervisor. The company had a problem that they wanted us to deal with: spaces for innovation. It was really motivating that we worked with real people who had something at stake—and had a real problem to be solved […] So, I thought it was really cool.

Both Sarah's and Abraham's habitual dispositions with the practical approach completely meet the PBL requirements from the university. They were at ease with 'real life' people and their problems and they furthermore gained knowledge from their new position as 'researchers', where they now had the upper hand.

11.4 Conclusion and Discussion

When considering the transformative potential of being part of a PBL environment, where the integration of different disciplines is emphasised, our study showed that the habitual dispositions that PB graduates tend to bring with them to the university seem to embrace the idea of collaborating with the outside world. However, we also saw reproduction traits in the practices of interdisciplinarity, since the different bachelor backgrounds, and thus the presence of various disciplines, seemed to contribute to a desire to segregate rather than unite the different disciplines when working in groups during project work. In this way, some students seemed to be more successful and dominant in the academic activities than others. An asymmetric relationship between students from different academic dispositions is not new, as shown by Bourdieu above. Nevertheless, there was no significant differences in performance based on grades. One could argue that differences in disciplinary approaches are not the same as bringing different disciplines of knowledge into play in the students' project work. However, like Bourdieu we argue that when both dispositions meet the field—here the university setting and all the implicit requirements—the strategies for interdisciplinarity are formed.

Thomas (2002, p. 439) investigated the ways in which institutions can support so-called 'non-traditional' students to succeed, and found that students are more likely to persist within an educational institution that does not expect them to deviate radically from their habitus. She argues that 'the willingness of institutions to embrace and value diversity, and thus respond positively to the differing needs of student groups who are traditionally underrepresented' reflects the particular institutional habitus necessary when aiming for student persistence and success.

A gap in our study is the phenomenon most precisely explained by Bourdieu, that the legitimate is never made fully explicit. Thus, many of the rules and principles of what it means to be a competent student and how to bring your discipline and

dispositions into play may be valued differently from teacher to teacher. Likewise, teachers also have different disciplinary backgrounds, which can increase the complexity of the implicit codes of conduct. Within the academic system, grades represent the most conspicuous form of reward. Some students might consider the rewards available within the PBL university to be insufficient and may decide to withdraw. However, it may be more important for those who attended university as a part of their personal development, where 'success' is measured by having attitudes, interests, and personality dispositions that are compatible with the attributes and influences of the university (Spady 1970).

In our mixed methods approach, we incorporated quantitative and qualitative data in dialogue with one another, as the different methods are intended to measure different facets of the same construct. Apparently, there are no clear winners and losers since students from different educational backgrounds had the same grades. However, in terms of project work, the PB graduates profited from their dispositions in relation to cooperation with practitioners, whereas UB graduates were stronger in theory. The two UB graduates interviewed in this study were both from a PBL university. They seem to have dispositions that are loyal to PBL, and thereby protect the PBL idea from external scepticism. Nonetheless, whereas they found the interdisciplinary project work useful for a learning outcome, they nevertheless ended up preferring mono-disciplinarity and carried out project work with fellow students of their 'own kind'—or went solo. The primary reason for this—among both UB graduates and PB graduates—is that it is the easiest and least troublesome, as well as the least unpleasant, way to proceed. What the students refer to as 'unpleasant' is primarily the fact that students from different educational backgrounds speak and write different languages and argue differently, thus creating difficulties in meeting the academic standards or the institutional habitus.

The PB graduates expressed enthusiasm towards PBL educational practices, especially when they cooperated with practitioners. Thus, we see a difference between the two groups of students in their perception and experiences of sources of learning.

This study has shown that interdisciplinarity is not simply a matter of mastering different disciplines when studying and solving problems. Instead, interdisciplinarity is practiced and must be understood and explained as an ongoing, institutional habitus that has both transformative and reproductive traits.

References

Bayer, M., & Brinkkjær, U. (2003). *Professionslæring i praksis. nyuddannede læreres og pædagogers møde med praksis*. København: Danmarks Pædagogiske Universitets Forlag.

Bourdieu, P. (1971). Systems of education and systems of thought. In M. F. D. Young (Ed.), *Knowledge and control: New directions in the sociology of education* (pp. 189–207). London: Collier-Macmillan.

Bourdieu, P. (1977). Cultural reproduction and social reproduction. In J. Karabel & A. Hasley (Eds.), *Power and ideology in education* (pp. 487–551). New York: Oxford University Press.

Bourdieu, P. (1986). The forms of capital. In J. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241–258). New York: Greenwood Press.

Bourdieu, P. (1990a). *The logic of practice*. Stanford: Stanford University Press.

Bourdieu, P. (1990b). *In other words: Essays towards a reflexive sociology*. Stanford: Stanford University Press.

Bourdieu, P., & Passeron, J. C. (1990). *Reproduction in education, society and culture*. London: Sage.

Breen, R., & Jonsson, J. O. (2005). Inequality of opportunity in comparative perspective: Recent research on educational attainment and social mobility. *Annual Review of Sociology, 31*, 223–243.

Greene, J., & Hall, J. (2010). Dialectics and pragmatism: Being of consequence. In A. Tashakkori & C. Teddlie (Eds.), *Sage handbook of mixed methods in social & behavioral research* (pp. 119–143). California: Sage.

Jaeger, M. M. (2011). Does cultural capital really affect academic achievement? New evidence from combined sibling and panel data. *Sociology of Education, 84*(4), 281–298.

Jeffrey, B., & Troman, G. (2011). The construction of performative identities. *European Educational Research Journal, 10*(4), 484–501.

Lyotard, J.-F. (1979). *The postmodern condition: A report on knowledge*. Manchester: Manchester University Press.

Overgaard, S. S. (2005). *Fra mangel til overflod – ernæring og sundhed 1905–2005*. København: Suhrs Seminarium.

Reay, D. (1998). 'Always knowing' and 'never being sure': familial and institutional habituses and higher education choice. *Journal of Education Policy, 13*(4), 519–529.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning, 1*(1), 9–20.

Savin-Baden, M. (2000). *Problem-based learning in higher education: Untold stories*. Buckingham: McGraw-Hill Education.

Scott, P. (1997). The meanings of mass higher education. *The Canadian Journal of Higher Education, 27*(1), 121–126.

Spady, W. G. (1970). Dropouts from higher education: An interdisciplinary review and synthesis. *Interchange, 1*(1), 64–85.

Thomas, L. (2002). Student retention in higher education: The role of institutional habitus. *Journal of Education Policy, 17*(4), 423–442.

Thomsen, J., Munk, M., Eiberg-Madsen, M., & Hansen, G. (2013). The educational strategies of Danish university students from professional and working-class backgrounds. *Comparative Education Review, 57*(3), 457–480.

Chapter 12
The Problem, the Group Meeting/Tutorial, the PBL Process and Learning

Terry Barrett

12.1 Introduction

Barrows defined problem-based learning as:

> the learning that results from the *process* of working towards the understanding of a resolution of a problem. The problem is encountered first in the learning process. (Barrows and Tamblyn 1980, p. 1)

Different models of problem-based learning are used in different universities and programmes across the globe. However, following the definition above and reviewing PBL practice in different contexts, the four key characteristics of problem-based learning generally are:

1. The *problem*, i.e. the problem defined by the students from the theme of the unit, at Aalborg University, or from a trigger or starting point given to the students, at some other universities.
2. The *group meeting/tutorial* of a small group of students. The supervisor or tutor facilitates students in developing their group project work.
3. The *PBL process*, i.e. the overall learning process that includes PBL group meetings/tutorials, independent study, presentations and other curriculum inputs.
4. Learning, i.e. the new knowledge, skills and attitudes gained from the PBL process.

My starting point is my current understanding of these four characteristics, which was recently published in a book entitled *A New Model of Problem-based Learning: Inspiring Concepts, Practice Strategies and Case Studies from Higher*

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Education (Barrett 2017). I respond to the chapters in this section of the book by discussing the following questions:

1. What is my conceptualisation of each of the four characteristics of PBL?
2. What significant new contributions do the chapters in this section of the book make to understanding each of these four characteristics of PBL?
3. What PBL practice strategies do these educational insights suggest?
4. What are the emerging questions?

I argue that the practice and research of interdisciplinary problem-based learning discussed in this section of the book gives us new insights into understanding the nature and practice of the four key characteristics of PBL.

12.2 The Problem as a Provoker of a Liminal and Interdisciplinary Multicultural Space

The first characteristic of PBL is the problem. In problem-based learning the students must define the problem themselves; the supervisor or tutor does not define the problem. In Aalborg, students define the problem within the thematic framework for the semester, and problem definition is a key part of interdisciplinary professional work. In other models of PBL, students are given a trigger—this could be something authentic from professional life, e.g. a scenario, dialogue, photo or video clip—and then must define the problem on which they will work from this initial trigger. The trigger is the starting point from which they define the problem that they have chosen to investigate.

I have conceptualised the problem as a provoker of a liminal space. The concept of liminal space is from the Latin word *limen*, meaning threshold or boundary (Meyer and Land 2005). Liminal spaces are in-between, betwixt and between spaces (Meyer and Land 2006), and as such have special functions. Sometimes we cannot go directly from an old state to a new state; rather, we first need to enter an intermediary state that is neither the old nor the new. Liminal spaces can provide opportunities for people to learn, grow, explore identities, work on problems and develop their critical and creative thinking. Liminal spaces can become places of transition, transformation, stagnation or attempted regression. High-quality PBL problems can create liminal spaces that challenge students to know more, learn new skills, develop creativities and move forward, in the words of the Irish playwright Dunsany (1972), to move ‘beyond the fields we know’. I captured a rural metaphor for this in the following photograph. A liminal space is like a threshold by the hinge of a rustic gate that marks the space between familiar fields and the start of the fields beyond, a space of possibilities (Fig. 12.1).

A well-designed set of PBL problems can provoke liminal spaces between (1) current levels of knowing and new levels of knowing, (2) habitual forms of professional action and forms of professional action new to the learner and (3) satisfaction

Fig. 12.1 A liminal space; a threshold at the hinge of a rustic gate that marks the space between familiar fields and the fields we do not know (Barrett 2017, p. 19)

with current identities and a desire to explore other possible identities. The illuminative concept of *the problem as a provoker of a liminal space* is a three-dimensional concept; the three dimensions are a knowledge dimension, a professional action dimension and an identity dimension (Fig. 12.2).

The major contribution of this section of the book is the conceptual and practical 'exploration of the combination of multiculturalism and interdisciplinarity in PBL project groups' (Jæger and Jensen, Chap. 8, in this volume). They fill a very important gap in researching interdisciplinary knowledge production through students' work on PBL problems. These chapters help us understand more about this liminal problem space by highlighting *the interdisciplinary multicultural space* created by the problem. Students move from old levels of understanding interdisciplinarity and multiculturalism to new levels of thinking about and understanding both. By working on the problem, they increase their repertoire of ways of working in interdisciplinary and multicultural teams. Well-designed PBL problems also have the potential to help students develop new identities, e.g. as empathetic and confident workers in multicultural teams.

The major insight from this section of the book is that a large part of the liminality of the problem space is the space where students define the problem themselves in interdisciplinary ways. What this means, in terms of practice strategies, is that this stage of defining the problem should not be rushed, but rather that students should stay in this liminal, confusing and sometimes uncomfortable space for a significant amount of time, and that their problem definition will be better for this. One team talked about spending a very significant length of time formulating a problem (Jæger and Jensen, Chap. 8, in this volume):

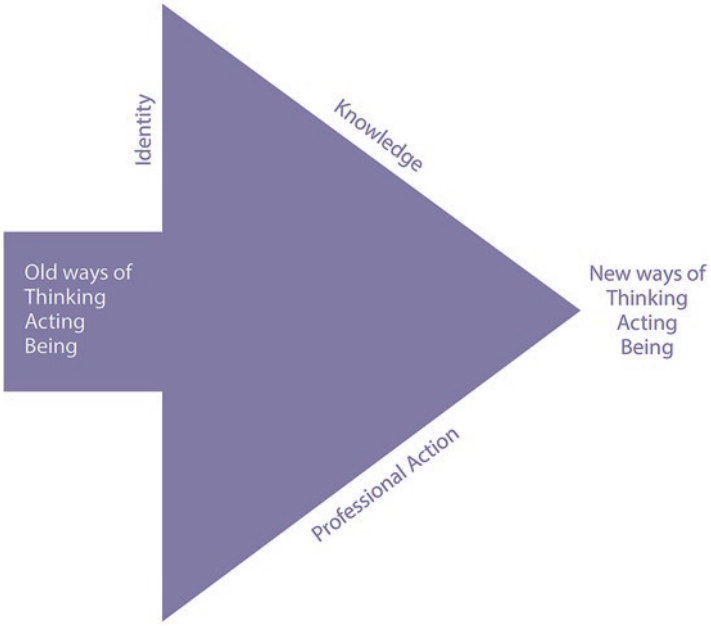

Fig. 12.2 The problem as a provoker of a liminal space: a three-dimensional concept (Barrett 2017, p. 65)

> I believe a good problem formulation is the beginning of success. Actually, our group spent almost half of our project time on trying to formulate a proper problem last semester. Seeking a problem itself is a learning process, and following the problem to conduct further study is a more focused, more critical, and deeper learning. (Chinese master's degree student, Aalborg University)

These authors show us how, at the start of the problem formulation stage, the disciplinary difference can be an inhibitor to defining a critical, deep problem; however, they also show that by providing sufficient time, attention and discussion to problem formulation, a wider interdisciplinary lens can be used to define the problem (Jæger and Jensen, Chap. 8, in this volume):

> One member, who used to learn economy, wanted very much to write the whole paper in economy direction, so he tried to convince us to only write about the economic relations between China and African countries. But as everyone knows, that of course when we talk about the relationship between countries, we cannot only touch the economic field. (Chinese master's degree student)

Formulating a problem effectively is key to research processes and professional practice processes. Einstein (Einstein and Leopold 1938) put it very well: 'The formulation of the problem is often more essential than its solution'. It is an important attribute for graduates to be able to define and see problems from different disciplinary perspectives and to combine different disciplinary angles to see fresh possibilities and raise new questions. Graduates will be faced with new situations that will

demand high-level capabilities in the area of problem formulation. Given that graduates will be working in interdisciplinary multicultural teams, the question arises: What about designing a trigger around the threshold concept of interdisciplinary multicultural teamwork?

12.2.1 What About Supporting Students in Designing Problems Around Working in Interdisciplinary Multicultural Teams?

If students are working on problems that require an interdisciplinary approach, and they themselves are from different disciplines and cultures, they can learn much about interdisciplinarity and multiculturalism. It is vital to learn to work on problems and in teams that both have interdisciplinary and multicultural dimensions. Why not push the boat out on this in the thematic framework for a semester at Aalborg by selecting a theme that supports and encourages students to formulate problems around working in interdisciplinary multicultural teams? This would lead them to research and find evidence about interdisciplinary multicultural teamwork through reviewing the literature and perhaps interviewing people in different work contexts. In other models of PBL, students could be given a trigger in the form of a real-life scenario in professional life that would encourage them to define a problem in the area of issues common to working in interdisciplinary and multicultural teams.

Why not instruct the supervisor to deliberately structure the groups to include a rich variety of cultures and disciplines, with students coming from a wide spectrum of programmes? If this problem were featured early on in their programme, students could refer again to the learning they gained from it when working on further problems. The combination of these two new elements, namely, working on a problem about interdisciplinary multicultural teams in a group that has been deliberately structured for its diversity in terms of disciplines and cultures, would open up new dynamic learning spaces for students.

12.3 The Group Meeting/Tutorial as a Potential Site for Dialogic Knowing and Epistemic Fluency

The second characteristic of PBL is the group meeting or PBL tutorial. Dialogic knowing is the knowledge that comes from dialogue with others. I have conceptualised the group meeting/PBL tutorial as a potential site for dialogic knowing. One of the ways of learning and growing in a liminal space is using the group meeting for its potential for dialogic knowing.

The problem-based learning group meeting is the pivotal learning site for PBL students. In PBL it is important to encourage all students in the group to talk to one another on the basis of their prior learning, disciplinary and cultural understandings, research carried out and developing ideas. Paulo Freire provides us with a strong philosophical understanding of dialogic knowing:

> What is dialogue in this way of knowing? Precisely this connection, this epistemological relationship, the object to be known in one place links the cognitive subjects, leading them to reflect together on the object. […] Then instead of transferring the knowledge *statically,* as a *fixed* possession of the teacher, dialogue demands a dynamic proximation towards the object. (Shor and Freire 1987, p. 10)

I make two crucial interrelated arguments about dialogic knowing in group meetings. Firstly, dialogic knowing has to be *constructed* discursively in the language of the conversations of the group meetings; it does not happen *automatically* in these meetings. Merely co-ordinating a PBL initiative, designing thematic frameworks or triggers and having students work in small groups on problems with a supervisor or tutor does not mean *per se* that dialogic knowing will take place. Rather, dialogic knowing can be constructed through three interrelated processes, namely,

1. A movement towards more democratic social relations
2. The co-construction of knowledge through co-elaboration and
3. The relinquishment of individual control and the embracement of shared control of PBL tutorials and the results produced.

The second argument is that understanding the *three dimensions of the group meeting/tutorial as a potential site for dialogic knowing* will encourage us as supervisors or tutors to use this discursive site for realising dialogic knowing. Dialogic knowing is one way for PBL students to move within and beyond the liminal space provoked by the problem. Dialogic knowing is a method by which students can develop new ways of thinking, acting and being (Fig. 12.3).

My understanding of all three dimensions of dialogic knowing has deepened significantly from reading the chapters in this section of the book and from discussions with the authors. The first dimension, democratic social relations, is a basis for effective learning in groups. We are provoked by Jæger and Jensen in Chap. 8 not only to think of democratic relations in terms of traditional ideas about all people being equal and all voices being heard, but also in terms of consciously developing ‘anti-authoritarian learners’. This is a crucial contribution in terms of students not only questioning what they read and what their teachers and fellow students say, but also relating critically to current and future economic, social and political situations, a key skill in an era of ‘fake news’.

In the PBL literature there is much discussion about the development of critical thinking through the second dimension of the co-construction of knowledge (Abrami et al. 2015; Downing et al. 2009; Yuan et al. 2008; Williams 2001). However, Jæger and Jensen, in Chap. 8, provide fresh insights that challenge us to define how we both understand and practice criticality in PBL. They challenge us to find effective ways of facilitating *all* students to ‘celebrate the critical exchange of

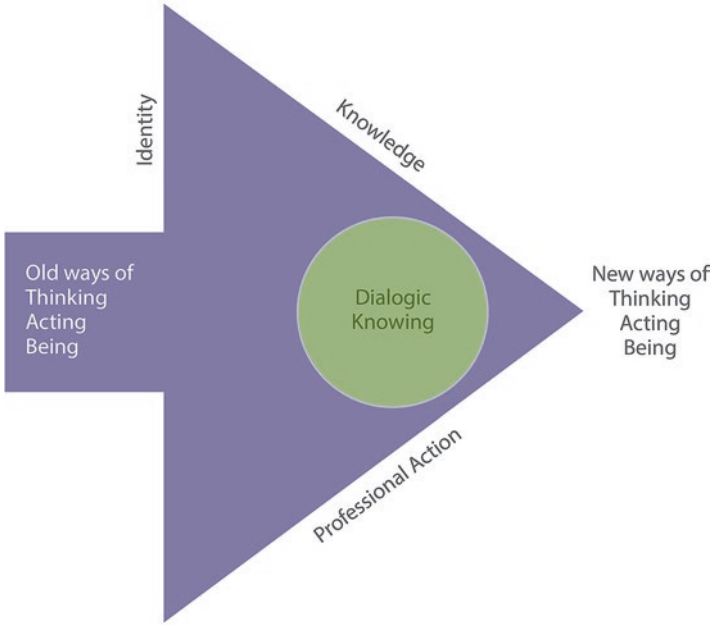

Fig. 12.3 Learning in a liminal space through dialogic knowing in group meetings/PBL tutorials

ideas', but also to progress to both 'critical deconstructive inquiry into established discourses and practices' and 'calls for radical change' (Jæger and Jensen, Chap. 8, in this volume).

The major contribution of these authors is their conceptualisation of *the group meeting as a potential site for developing epistemic fluency*. Epistemic fluency is the ability to really understand the meaning of everyday language, theoretical concepts, and values from the perspective of the other (i.e. someone from a different discipline and/or culture) and to respond with empathetic and effective language. This is the high ideal we should be explicitly asking all our PBL students and tutors to aim for. Jæger and Jensen very forcefully make this point regarding the importance of epistemic fluency in Chap. 8:

> Such skills are becoming increasingly recognized, in professional life as in the university [….]
>
> [The ability to] adapt one's use of language to the needs of one's interlocutor…is a capability that many companies are now looking for in new recruits. Developing this competence requires practice over time, and mixed-national group work at university offers an ideal opportunity to hone such capability (Spencer-Oatey and Dauber 2016, p. 13).
>
> Working in interdisciplinary and multicultural project groups both requires and contributes to intercultural understanding and epistemic fluency.

A key dimension of dialogic knowing is the relinquishment of individual control and the embrace of shared control of the group meetings and the resultant

products. This dimension is important for two reasons. Firstly, unless there is some degree of shared control, the potential for group meetings to become a site of dialogic knowing will not be fully realised. A key question is, what is the dialogue for? The second reason shared control is important is that the dialogue in the group meeting is not just for discussion but must also result in effective group products that meet quality criteria being produced. Jacobsen and Børsen (Chap. 10) quote a student's view on this: 'To me, it is important that we share responsibility. We make stops and find a common direction'. A student from my own research echoed this: 'I enjoyed the whole process of discussion and sharing of ideas, workload and presentation. I feel a form of shared ownership in the solution of the problem' (Barrett 2017, p. 122).

As the group meeting is the crucial pivotal learning site in problem-based learning, the question of the best way to form the groups is an important one.

12.3.1 How to Form the Groups?

From reading this section of the book, particularly Chap. 11, about students from different educational backgrounds, and Chap. 8, about epistemic fluency, the emerging question is, *'How to form the groups?'*.

In Aalborg, groups are formed by the students themselves, who decide which group to join on the basis of the shared problem formulation they want to work on. There are some advantages to peer-formed groups, as they give students a choice in the topic of the problem they want to work on and whom they want to work with. In some ways, this offers a high level of self-directed learning and student autonomy.

However, there are also advantages to supervisor- or tutor-formed groups. Firstly, the supervisor can ensure some level of diversity in relation to discipline, culture and educational backgrounds, together with some gender balance. Zhou and Krogh, in Chap. 9, highlight the importance of diversity, as they advocate, 'The right level of diversity seems to be essential to avoid cognitive uniformity and conformity'. Supervisor intervention in terms of group composition is recommended by Jæger and Jensen to 'enhance multicultural collaboration'.

Secondly, we rarely get to choose the group we work with in employment, so working with people students would not necessarily choose to work with is good preparation for this reality. Thirdly and most importantly, if we want to develop the epistemic fluency advocated by Jæger and Jensen in Chap. 8, students need opportunities to understand how different people make meaning, work and communicate. Supervisors can facilitate this by choosing diverse groups. Programme teams should consider what mixture of supervisor/tutor-formed groups and peer-formed groups best suits their context.

12.4 The PBL Process as One of Finding and Being in Flow as Well as of Embedded Values

The third characteristic of problem-based learning is the PBL process. This is the overall learning process that includes group meetings/tutorials, independent study, presentations and other curriculum inputs. I have conceptualised the PBL process as a process of finding and being in flow (Barrett 2017). This concept has two parts: the first part is the non-flow state involved in finding flow, and the second part is the flow state of being in flow (Csikszentmihalyi 1997). Flow is a state of optimal performance. It occurs when there is a match between a high degree of challenge and a high level of skill required (including knowledge and creativities) (Csikszentmihalyi 1997). We have all experienced this state when we are performing at our best and one action or thought flows naturally into the next (Fig. 12.4).

In the PBL context this means that the high level of challenge inherent in the problem, together with students challenging one another to understand better, means there is real potential for the group to experience flow. One of the ways of learning and growing in a liminal space is for students to find and be in flow in the PBL process. This is illustrated in the following figure (Fig. 12.5).

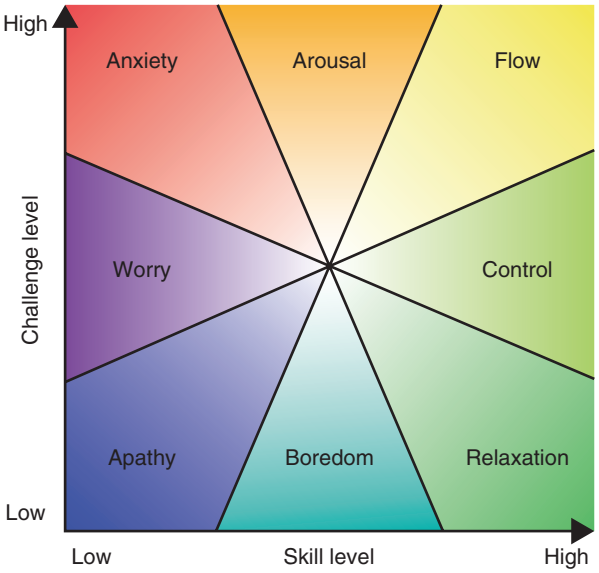

Fig. 12.4 Mental state in terms of challenge level and skill level, according to Csikszentmihalyi's flow model. (Wikipedia, Flow – psychology)

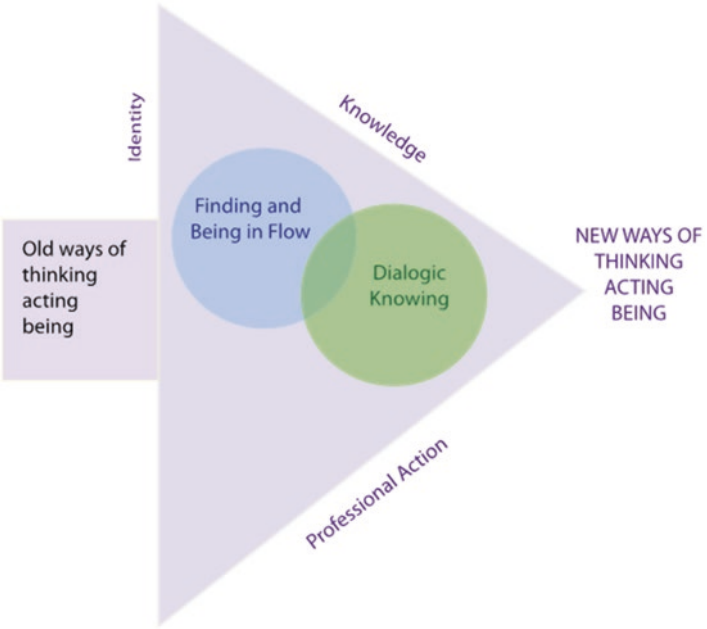

Fig. 12.5 Student learning in a liminal space through finding and being in flow (Barrett 2017, p. 139)

A student with considerable experience of PBL elaborates on this in Chap. 11 (Hindhede, Martinussen and Højbjerg):

> You always have someone to discuss things with, and to reach new insights with. It's this pairing [that] I think is cool, and when it goes to a higher level and you hit a joint point and you start to understand things.

Often on the way towards flow people experience non-flow states where there is a mismatch between the degree of challenge experienced and the level of skill possessed. Flow occurs in the delicate zone between the anxiety of confusion and the uninterest of boredom (Csikszentmihalyi 1997).

The authors in this section of the book help us understand better what the anxiety of confusion and being lost means for interdisciplinary and multicultural group work in general, and for non-Western students in particular. Jæger and Jensen in Chap. 8 share insights from their research into problem construction in interdisciplinary and multicultural PBL groups. They discuss the differences between traditional Confucian Chinese education and the approach used for PBL at Aalborg, highlighting the specific implications for the participation of Chinese students and the potential for them to excel. They quote a Chinese student expressing an understanding of being lost at the start of the process:

> Yeah, in the beginning it's quite difficult, but when we decide which one to choose then it's gonna be really good. Yeah, it's quite fine that only at the beginning we don't know… We are totally lost. We don't know which way to go.

The authors' major contribution to understanding the PBL process is not only reminding us that PBL is infused with *the embedded values of individualism, autonomy, authenticity and criticality,* but also challenging us not to take these values and practices for granted. Rather, we should explain and discuss what these mean with students in multicultural groups to maximise the possibilities for flow, innovation and creativity in the PBL process. These values in action are the preconditions for experiencing flow. The first component of flow is setting clear personal goals (Csikszentmihalyi 1999). The values of individualism and autonomy in action facilitate groups naming their own learning goals for working on the problem. The second component of flow is clear and immediate feedback (Csikszentmihalyi 1999). The values of authenticity and criticality in action facilitate individuals in the group, and the group as a whole, receiving and acting on regular feedback and confirming or criticising emerging ideas. The values of authenticity and criticality should also underpin the process of reviewing work in progress in terms of discussing both strengths and areas for improvement. These values will also help in evaluating the progress of a project in terms of purpose, meaningfulness and audience. The third component of flow is the perceived match between challenge and skill (Csikszentmihalyi 1999). The value of autonomy in action facilitates a group formulating its problem statement at a level of challenge that is conducive to flow.

Problem-based learning can facilitate students finding flow and developing their creativity. In problem-based learning, the problem motivates and focuses learning. However, for all students, including PBL students, assessment is a major driver of student learning. A key question that emerges is whether to use pass/fail assessments to promote student creativity.

12.4.1 Consider More Pass/Fail Assessments to Encourage Creativity

Discussions with authors highlighted that many student groups are creative. However, others play it safe because they are worried about grades, while some engage in ritualistic PBL behaviours in groups, leading to boredom for students and staff. I argue that if students know they will do enough to pass, they feel free to take more risks and be innovative. This gives them greater freedom to express *the embedded values of individualism, autonomy, authenticity and criticality* to a higher degree. Research suggests that pass/fail assignments can enhance students' psychological well-being, promote self-directed learning and encourage more adventurous and creative assignments (Bloodgood et al. 2009; Leske and Ripa 1985; Robins et al. 1995; White and Fantone 2010). For some students, aiming for high grades can be a driver for learning. Thus, it is worthwhile for programme teams to ask themselves what mix of pass/fail and graded assessments would best encourage student creativity.

12.5 Learning in PBL as Hard Fun, and the Integration of Practice-Based and Research-Based Approaches

The fourth characteristic of PBL is learning. Learning is the new knowledge, skills and attitudes gained from the problem-based learning process. I have conceptualised learning in PBL as hard fun. What is hard fun? For Papert (1996), the meaning of this concept is that learning is fun *because* it is hard. I use the concept in a more limited sense, that learning is simultaneously fun *and* hard. In a research study, while PBL was fun, enjoyable and creative for the PBL students, it was simultaneously hard, challenging and stretching for them (Barrett 2008). PBL students move within and beyond the liminal spaces, prompted by the problem in different ways. One of the ways of learning and growing in a liminal space is for students to experience learning as hard fun (Fig. 12.6).

One of the dimensions of the hardness of hard fun is the level of difficulty of the problem. One reason for the hard level of difficulty for the students in Chap. 10 was 'the tension between practical problems and the theoretical understanding thereof' (Jacobsen and Børsen, Chap. 10). This chapter discusses differences and similarities among master's students, some of whom have completed a university bachelor degree, while others have completed a professional degree: 'Tina, a professional bachelor degree holder, said that an academic investigation could just as well start out as a question raised during practice' (Jacobsen and Børsen, Chap. 10). The authors have highlighted this crucial inherent tension in learning in problem-based learning, namely the tension between practice-based and research-based approaches and the challenges PBL students face in integrating both into their learning.

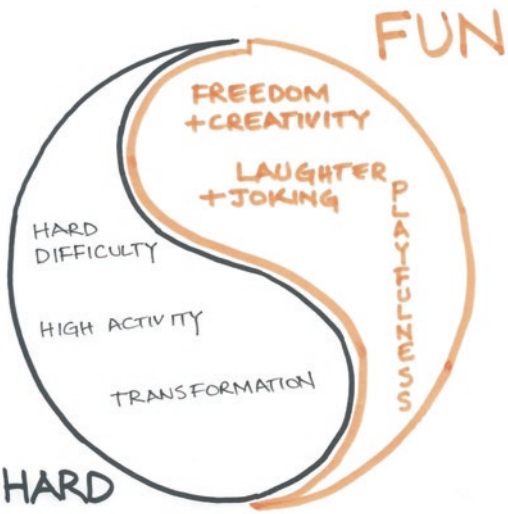

Fig. 12.6 The map of the concept of hard fun: The dimensions of fun and hardness (Barrett 2017, p. 188)

A key resource in *integrating practice-based and research-based approaches* is the philosophy of science. A major contribution from these authors is their research into how having an understanding of the philosophy of science helped PBL students to more quickly decide 'which scientific theoretical view we should use' (Annie, master's student, Chap. 10) and what arguments and decisions the group should choose. The authors highlight how the philosophy of science is a meta-language required for engaging in the critical thinking inherent in problem-based learning. This points to the practical importance of ensuring that all students have an initial grounding in this, and that they are able to develop it further as they work on problems.

The transformation that can be part of learning and PBL is hard because it is at the level of changing attitudes and values. The research in Chap. 10 shows how students on a master's course with a bachelor degree from a university considered their learning superior to that of students who had completed a professional degree and 'were just from Suhr's school of home economics' (student with a university bachelor background, Chap. 10). The research in Chap. 11 also shows that those with a university bachelor background had a superior and sceptical attitude towards their classmates with a professional bachelor background. Interestingly, this chapter shows that there was no significant difference between the final levels of learning of the two groups as measured by grades. As there is no objective difference between the grades of students from these two types of backgrounds, even though there is a perceived difference regarding learning in the two different groups, it may be useful to address this underlying tension as an educational opportunity.

12.5.1 Consider Discussing the Learning from Different Educational Backgrounds

The question that arises for me is, 'Why not discuss the learning from different educational backgrounds?'. Why not present and discuss a trigger based on qualitative and quantitative data about the similarities and perceived differences between students with an undergraduate university bachelor programme background and those with a professional bachelor background? What scope would this offer for changing attitudes? These questions are particularly relevant to students studying education and management, as they themselves may face similar issues in their own work. One approach might be to have a discussion on the integration of practice-based and research-based approaches in university studies based on case studies of previous student projects and on the research literature in this area. Alternatively, a panel of recent graduates from different educational backgrounds could share their difficulties and breakthroughs in integrating practice-based and research-based approaches in their study and employment contexts.

12.6 Conclusion

The chapters of this section of the book have taught us much about the practice of problem-based learning generally and the four characteristics of PBL in particular. My conceptualisation of the interrelationship of these four characteristics is illustrated in the following figure. The PBL problem can provoke a liminal or threshold space between (1) current levels of knowing and new levels of knowing, (2) habitual forms of professional action and forms of professional action new to the learner and (3) satisfaction with current identities and a desire to explore other possible identities. This liminal space is represented by a triangle with these three dimensions. PBL students move within and beyond the liminal spaces as prompted by the problem and learn and grow in three ways: (1) using the group meeting/tutorial as a site for dialogic knowing, (2) developing flow and creativity in the PBL process and (3) experiencing learning as both hard and fun at the same time.

The following figure is a visual representation of the model. These illuminative concepts are represented as interrelated and overlapping (Fig. 12.7).

The authors of the chapters in this section of the book help us understand more about this liminal space provoked by the problem by highlighting *the interdisciplinary multicultural space* created by the problem. What this liminality means for interdisciplinary problem-based learning is that the stage of defining the problem should be given sufficient time. Regarding the problem, these chapters teach

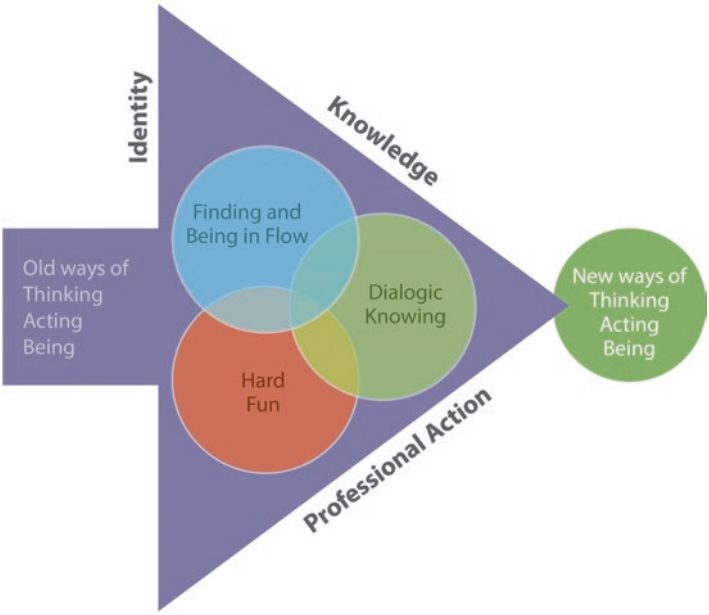

Fig. 12.7 Barrett's model of four interrelated illuminative concepts for understanding students' talk about problem-based learning (Barrett 2017, p. 232)

us that students should stay in this liminal, confusing and sometimes uncomfortable space for a significant period of time in order to integrate understandings from different disciplinary perspectives into their problem definition. A question that arises for me is, 'Why not support students in designing problems around working in interdisciplinary multicultural teams?'. This would prompt students to explore the research evidence for working effectively in interdisciplinary multicultural teams.

In terms of learning more about the group meeting, the major contribution of these authors is their conceptualisation of *the group meeting as a potential site for developing epistemic fluency*. The group meeting/tutorial has the potential to develop students' capabilities in understanding the language, meanings, culture and values of others and to respond to others in ways that demonstrate that they have a deep empathetic understanding of their perspectives. A question that emerges for me is, 'What is the best way to form the groups?'. It is good to debate the advantages and disadvantages of peer-formed versus tutor-formed groups.

This section of the book teaches us much about the PBL process. Its key contribution to understanding this process is not only reminding us that this process is infused with *the embedded values of individualism, autonomy, authenticity and criticality*; it is also prompting us to explicitly discuss and debate these values with staff and students. A key question that arises for me is, 'Why not use more pass/fail assessments to encourage student creativity in the PBL process?'. I have been impressed with how this pass/fail approach to assessments in my own PBL practice has promoted impressive innovation, risk-taking, courage, flow and enjoyment.

The fourth characteristic of PBL is learning. The authors have highlighted a crucial inherent tension in learning in problem-based learning, namely the tension between practised-based and research-based approaches and the challenge PBL students face in integrating both into their learning. The emerging question for me is, 'Why not discuss learning from different educational backgrounds (especially in contexts where there are groups of students from significantly different educational backgrounds)?'. This discussion, combined with insights from the philosophy of science, could help students understand the tensions they are experiencing between practice-based and research-based approaches and help them to move forward in their learning.

The chapters about interdisciplinary PBL have taught us much about the practice of problem-based learning generally and about each of the four characteristics of problem-based learning specifically. Moreover, they have highlighted that all well-designed problem-based learning is interdisciplinary in nature. They have pointed us towards research insights and practice strategies that can help us to maximise the interdisciplinary dimensions of our PBL initiatives. This will expand both the depth and breadth of our students' learning.

References

Abrami, P. C., Bernard, R. B., Borokhovski, E., Waddington, D., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. *Review of Educational Research, 85*(2), 275–314.

Barrett, T. (2008). *Students' talk about problem-based learning in liminal spaces.* Unpublished PhD thesis, Coventry University.

Barrett, T. (2017). *A new model of problem-based learning: Inspiring concepts, practice strategies and case studies from higher education*. Maynooth: AISHE. Downloadable as a full book or individual chapters on a free creative commons license http://bit.ly/2qHv5gB.

Barrows, H., & Tamblyn, R. (1980). *Problem-based learning: An approach to medical education*. New York: Springer.

Bloodgood, R. A., Short, J. G., Jackson, J. M., & Martindale, J. R. (2009). A change to pass/fail grading in the first two years at one medical school results in improved psychological well-being. *Academic Medicine, 84*, 655–662.

Csikszentmihalyi, M. (1997). *Finding flow: Psychology of engagement with everyday life*. New York: Basic Books.

Csikszentmihalyi, M. (1999). A systems perspective on creativity. In Edited extract from R. Sternberg (Ed.), *Handbook of creativity* (pp. 313–335). Cambridge: Cambridge University Press.

Downing, K., Kwong, T., & Chan, S. (2009). Problem-based learning and the development of metacognition. *Higher Education, 57*(5), 609–621.

Dunsany, E. (1972). *Beyond the fields we know*. London: Pan Books.

Einstein, A., & Leopold, I. (1938). *Evolution of physics*. Cambridge: Cambridge University Press.

Leske, G. S., & Ripa, L. (1985). Comparison of dental students' academic performance using honors/pass/fail and letter grades. *Journal of Dental Education, 49*, 176–177. Available at http://www.ncbi.nlm.nih.gov/pubmed/3156166.

Meyer, J., & Land, R. (2005). Threshold concepts and troublesome knowledge (2): Epistemological and ontological considerations and a conceptual framework for teaching and learning. *Higher Education, 49*(3), 373–388.

Meyer, J., & Land, R. (2006). *Overcoming barriers to student understanding: Threshold concepts and troublesome knowledge*. London: Routledge.

Papert, S. (1996). *The connected family: Bridging the digital generation gap*. Atlanta: Longstreet Press.

Robins, L. S., Fantone, J. C., Oh, M. S., Alexander, G. L., Shlafer, M., & Davis, W. K. (1995). The effect of pass/fail grading and weekly quizzes on first-year students' performances and satisfaction. *Academic Medicine, 70*, 327–329. Available at http://www.ncbi.nlm.nih.gov/pubmed/7718068.

Shor, I., & Freire, P. (1987). *A pedagogy for liberation*. London: Bergin and Garvey.

White, C. B., & Fantone, J. C. (2010). Pass–fail grading: Laying the foundation for self-regulated learning. *Advances in Health Sciences Education, 10*(15), 469–477.

Wikipedia. *Conditions, flow (psychology)*. https://en.wikipedia.org/wiki/Flow_(psychology)#Components.

Williams, B. (2001). Developing critical reflection for professional practice through problem-based learning. *Journal of Advanced Nursing, 34*(1), 27–34.

Yuan, H., Kunaviktikul, W., Klunklin, A., & Williams, B. A. (2008). Improvement of nursing students' critical thinking skills through problem-based learning in the People's Republic of China: A quasi-experimental study. *Nursing & Health Sciences, 10*(1), 70–76.

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