Chapter 6
Supervising the Interdisciplinary PBL Project

Scaffolding an Open-Ended Space of Scientific Possibilities

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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.

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