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# Creating Landscapes of Practice through Sequential Learning - A New Vision for PBL

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## ABSTRACT

*In the current conceptualisations of Problem Based Learning and how we practice it, the students are expected to possess the necessary academic competencies in order to study through PBL. However, a desk research reveals that students in many cases don't have the necessary understanding or conceptual comprehension of disciplines such as problem formulation, analysis, exploration, literature review etc., which prevents them from unfolding an explorative approach to their professional practice. This article thus discusses Dewey's concepts of sequential inquiry processes to create new forms of learning designs to bolden further students ability to work problem-based. The article discusses through the development of iterative learning design how structured sequences of activities can provide a descriptive language to qualify a methodology for PBL. The study is based on Educational Design Research (EDR) as the overarching framework where the methods of Design thinking inform the design activities through iterative processes. Through a period of two years a total of 400 students at the education of ATCM, at University College of Northern Denmark has participated. The data collection included results from observation, reflective portfolios and sound recordings from*

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*the students' group work in combination with sketches, drawing and artefacts from the iterative design process.*

**Keywords:** Landscape of practice, PBL, Sequential learning, inquiry, exploration

## INTRODUCTION

A prerequisite for PBL is that the students have an autonomy that enables them to work analytically and critically concerning a professional problem. However, a PhD study (Gyldendahl-Jensen, 2020) has revealed that students in many cases don't have the necessary understanding or conceptual comprehension of disciplines such as analysis, exploration, critical thinking, reflection, process, literature review, method etc., which prevents them from unfolding an explorative approach to their professional practice. Very often, the student needs to figure out by themselves how to create a bridge between theory and practice through analytical disciplines. The students lack specific learning strategies for how, through a curious and investigative behaviour, to create an in-depth analysis of the presented content that leads toward meaningful learning experiences. It means that they often are brought into situations where they do not know what the next step is.

This perspective challenges the current conceptualisations of Problem Based Learning and how we practice it, where students are expected to possess the necessary academic competencies in order to study through PBL. Based on the danish model of PBL and from scholars originating from Aalborg University, this paper thus argues that there is a need for new theoretical and methodological frameworks that through a scaffolded approach develops the student autonomy that enables them to work and learn through a problem-based learning environment.

With an inspiration of Practice Theory's understanding and interpretation of learning, this article suggests that education instead should be designed as complex and personal learning trajectories by considering learning as a complex landscape of personal learning trajectories. To better facilitate learning trajectories it can be argued that there is an opportunity to think in terms of design strategies that more effectively facilitate students through meaningful learning processes built around an explorative approach to the traditional academic disciplines. Within the Practice theory, it is said that learning occurs as gradual, cumulative or anticipated developments that follow predictable paths (trajectories) but that it is the sudden obstructions and disturbances that trigger reflection and thereby an innovative development of knowledge (Schatski, 2016b; Dreier, 2015). For example, Theodore Schatzki (2016) describes learning as a process that follows a path that in a metaphorical sense consists of different knowledge and experience episodes that overlap and build upon each other. In practice, it would be a series of multimodal

activities that are constantly challenged by obstructions and disturbances (Schatzki, 2016). The chosen path will over time reflect possibilities for achieving specific learning based on the dependency relationship between the two concepts: ***Proceed*** and ***depends -*** how are the students going to proceed, depending on what they have already learned (Schatzki, 2016b).

This article, therefore, discusses whether a systematic approach to Dewey's concepts of sequential inquiry processes can create new forms of learning designs that strengthen the students' ability to work analytically and exploratively (Dewey 1933, 1980 and 1991). Based on Educational Design Research (EDR) as the overarching framework, The article discusses through the development of iterative learning design or design schemas how structured sequences of activities can provide a descriptive language to qualify a methodology for PBL (Stolterman, 2008; Davidsen, Konnerup, 2016).

The study is based on Educational Design Research (EDR) as the overarching framework where the methods of Design Thinking formulated by Stolterman (2008) inform the design activities through iterative processes. Based on ELYK's phase model for EDR (Christensen et al., 2012), this study addresses the first two phases; "Problem and theory identification" and "Designing the prototype" to develop conceptual designs of learning sequences based on the following three academic concepts; theory work, literature review, and conducting an analysis.

First, the following chapter presents a critical view of the current understanding of PBL. Next, the theoretical framework for how to understand PBL through the lens of practice theory is elaborated. Then the research design is described followed by an elaboration of how the iterative learning design can create structured sequences of activities to provide a descriptive language to qualify a methodology for PBL

**Challenging the current understanding of PBL**

There is a general agreement in the literature that the basic and supporting principles for PBL must be about problem identification, time and project management as well as group work based on authentic and often interdisciplinary problems. (Holgaard et al., 2014; Stentoft, 2017; Davidsen, Konnerup, 2016; Hüttel, Gnaur, 2017). Also, the student must have the freedom to influence which academic topics they choose to immerse themselves in. It means that learning through PBL is an active process that requires a high degree of commitment from the student (Holgaard et al., 2014). The theoretical learning intention behind PBL is thus that the student through an exploration of problems, among other things, achieves critical thinking and analytical competence. Also, PBL is often based on a high degree of interdisciplinarity, where the students' focus on a specific problem *"promotes an integration of ways of thinking, doing and being in different disciplines, which are isolated in the traditional approach to university teaching"* (Hernandez, Ravn,

Valeo, 2015, p. 22). It means that PBL creates a deeper understanding of the nuances that characterise a practice-related problem where it may be necessary to navigate across many different disciplines to create a link across different perspectives. Stentoft (2017), describes it in the following quote as the ability to work and investigate at a higher level of abstraction.

Having said that, it seems to be common that there is a division of the theoretical learning principles that relate to PBL, where learning outcome that deals with profession-specific competencies or general study competencies are not part of the basic pedagogical "DNA" that characterises PBL (Davidsen, Konnerup, 2016; Holgaard et al., 2014). Several texts speak about, for example, that methodical skills are only relevant as transferable skills or to achieve transferable skills and hence not something that can be characterised as a consequence of PBL (Kolmos, 1996; Holgaard et al., 2014). It reduces PBL only to include problem orientation and project management and collaboration/group work. (Davidsen, Konnerup, 2016; Holgaard et al., 2014; Kolmos, 1996). Thus, a prominent agenda is seen that PBL must adapt in a way where the epistemological, theoretical and methodological intentions and educational considerations must not be restrictions that hinder how students navigate concerning a self-directed problem (Stentoft, 2017). Here, in particular, the combination of PBL and project-based learning challenges this agenda. Kolmos (1996) points out the risk that the often teaching-centred process of project work becomes an obstacle for the student agency to explore a problem. In this regard, the concern is mainly about what significance the teachers have on the students' *choice of disciplines and methods and the problem itself arises from the problem-oriented theme"* (Hüttel, Gnaur, 2017, p. 4). It raises the question of whether the basic idea that PBL is the shift from teaching to learning is challenged by the fact that teachers support students' learning through a focus on method awareness. Several texts speak in this connection about the teacher's role as a process-oriented supervisor where the task of the teacher is altered from the transferring of knowledge into facilitating learning (Kolmos, 1996; Hüttel, Gnaur, 2017; Holgaard et al., 2014).

There is thus in PBL a basic assumption that the problem itself can constitute the learning process born out of inner motivation. And the question is whether it is an illusion that learning is constituted only from within, especially in an educational system where a specific curriculum is determined and described. It must therefore be relevant to be critical of how we understand a "problem" and for whom it is a problem? In addition, whether the student's inner motivation drives the study behind the problem, or whether it is possible to reach a higher level of abstraction and academic depth if the students are more methodically supported - that PBL is not seen as something independent of general study competencies or transferable skills.

**We comprehend with the concepts we have**

A prerequisite for PBL thus seems to be that the students have an autonomy that enables them to work analytically and critically concerning a professional problem. However, as stated in the introduction, in many cases the students don't have the necessary understanding or conceptual comprehension of disciplines such as analysis, exploration, critical thinking, reflection, process, literature review, method etc., which prevents them from unfolding an explorative approach to their professional practice. Through a systems theoretical analysis of PbL, Keiding (2008) points out that a prerequisite for the student to be able to communicate, for example, process understanding and thereby actualise their exploration of a problem, must be observed in a participant's mental system. It means that the student does not necessarily achieve learning though the project development (Keiding, 2008). That this is the case is backed up by several texts that describe how the students experience that PBL is challenging and chaotic, especially without knowledge of working methods (Holgaard et al., 2014; Hüttel, Gnaur, 2017; Stentoft, 2017). It is followed by a concern expressed by the teachers telling that the students do not get hold of challenging and ambiguous problems and that there is a lack of involvement of theory and method (Hüttel, Gnaur, 2017).

Another challenge is the extent to which students can work interdisciplinary with their problems, where they must possess the right competencies to be able to process and explore complex and situated problems at the intersections of disciplinary boundaries and conflicting epistemologies. Stentoft, 2017 points out, among other things, that″ *interdisciplinary learning cannot be taken for granted in problem-based settings, and only if issues of interdisciplinary learning are specifically addressed can problem-based learning be considered a pedagogical approach adequately scaffolding interdisciplinary learning in higher education"* (Stentoft, 2017, p. 51). The challenge for the students arises as the educational organisation around PBL does not, as described in the previous section, include a disciplinary scaffolding of the learning process. As Stentoft (2017) points out, there is a need for strengthening a general procedural scaffolding of the learning process without compromising with students' active and self-directed learning (Stentoft, 2017).

Researchers in the field of learning design, in particular, have worked to find this balance between scaffolding and self-directed learning. Here it is said that learning design can be seen as a form of descriptive language or pattern that can form the basis for being able to facilitate, among other things, reflection and discussion. Davidsen, Konnerup (2016) uses in the following quote an example of how a sheet music system provides a common language, rules and form of how music is developed, but that it is the performers who through their interpretations make the music unique and personal. Working problem-based thus involves travelling along a trajectory created by the choices the students make around method and subject based on the problem (Hernandez, Ravn, Valeo, 2015; Kolmos, 1996). When it comes to the development of a self-directed learning trajectory,

the students must be able to initiate the right activities concerning being able to explore the complexity of a given problem, which requires that the students can visualise and actualise the learning process (Keiding, 2008; Stentoft, 2017). It means that a clear scaffolding strategy to a greater extent must be created for PBL based on a strategy which does not only focus on letting students explore through problems (Stentoft, 2017). This means that the students must be supported at several levels that go beyond finding a problem, time and project managing and group work. Keiding (2008) describes, for example, how it is possible through various reflection programs to reduce the complexity within one or more dimensions of meaning-making, thereby relieving the students, without this in any way depriving the students of the responsibility to organise themselves (Keiding, 2008).

In the following section, the idea that through an explication of a specific language or pattern is possible to create greater depth and level of abstraction in problem-based learning processes is unfolded. By supporting students in developing competencies within as critical thinking, learning how to learn, integration of theory, the goal is to strengthen the students' ability to respond to changing contexts that have become central to higher education practices (Stentoft, 2017; Hernandez, Ravn, Valeo, 2015; Hüttel, Gnaur, 2017).

## THEORETICAL FRAMEWORK

There seems to be a consistent pattern for how to work with PBL pedagogically, namely a focus on formulating problems, planning and time management of project work, as well as handling the challenges that arise in connection with group work. On the other hand, a pedagogic coupling of academic and methodical skills with the PBL principles is almost absent. Several texts speak about, as described earlier, that methodical skills are only relevant as transferable skills and to achieve transferable skills and hence not something that can be characterised as a consequence of PBL or something that can promote the intended learning that arises based on PBL (Kolmos, 1996; Holgaard et al., 2014).

In the following sections, practice theory is unfolded as a suggestion and inspiration for a re-description of the theoretical foundation of PBL, where a more significant effort is made to reconcile academic and methodical skills with the PBL principles to be able to guide and facilitate the students gaining an understanding of the applied project methodology to mobilise systematic knowledge-based research approaches. A basic understanding of what characterises a methodology for exploration and experimental learning is crucial for students to achieve the learning objectives (Hüttel, Gnaur, 2017). If the students do not have the right competencies concerning being able to formulate a specific problem and afterwards unfold it through an exploration process, it isn't easy to

achieve the intended learning potential that is expected through PBL - especially in terms of depth and reflection

**Problem-based learning and practice theory**

To contribute to corroborating the existing knowledge about PBL and as a result of this challenge and provoke a new way of Thinking and Design PBL in the near future, it's meaningful to revisit some of the theoretical positions that characterise PBL. Based on the presented literature, it is found that PBL to a large extent is described within the constructivist domain with a bias towards a more socio-cultural perspective. Based on that, this article will challenge PBL through the ontology of Practice Theory's, as it argues that learning arises from designed learning spaces where a combination of different activities and social relation strengthens the theoretical learning intention that characterises PBL (Schatzki, 2016, Schatzki, 2017; Dewey, 1933; Kjær, 2010; Elkjær & Wiberg, 2013; Buch & Elkjær 2015). Within the Practice theory, it is said that when learning is considered as a complex landscape of personal learning trajectories, it creates an opportunity to think in terms of design strategies that more effectively facilitate students through meaningful learning processes built around an explorative approach to the traditional academic disciplines. Here, practice theory offers several design principles that can support the development of PBL patterns where problem-solving is supported and mediated by procedural artefacts and procedures. For example, Dewey talks about how students(re)construct meaning and actions through an experimental approach through the use of tools and artefacts were the social context acts as stimuli that elicit particular reactions (Dewey, 1933; Kjær, 2010; Elkjær & Wiberg, 2013; Buch & Elkjær 2015). By mapping these complex trajectories, it is possible to shape what Keiding (2008) calls "systems of actions" (Keiding, 2008).

Based on the theoretical position of practice theory it is especially when learning trajectories that occurs as gradual, cumulative or anticipated developments that follow predictable paths (trajectories) are exposed to obstructions, disruptions and disturbances that a reflective behaviour is created which creates new meanings and knowledge (Dreier, 2008; Schatzki, 2016; Schatzki, 2017). It means that practice theory explicitly talks about how it is possible to consciously work with the student being able to challenge specific actions and its consequences, to be able to consider alternatives and critical analysis of underlying assumptions (Hüttel, Gnaur, 2017).

**Problem-based learning as sequential learning trajectories**

A significant aspect of practice theory's understanding of learning is the idea that the learning process should be understood as sequential (episodic) and complex learning trajectory (Dreier, 2008; Schatzki, 2017). It means that the educational challenge is to create a learning design where the problem-based project is broken down into smaller iterative sequences. Schatzki (2017) describes it as learning understood as a process that

follows a "path" that is formed as a progression where different episodes of activities are overlapping and building on previous ones. Dewey's concepts of sequential inquiry can be used to elaborate how to understand the concept of sequential learning trajectories.

Dewey describes inquiry as an emotional encounter in an experience with an embedded conflict. It is a feeling that something is difficult; an uncertain situation where inquiry is the method to resolve this conflict and make sense (Dewey, 1933; Elkjær & Wiberg, 2013; Buch and Elkjaer, 2015). To do this, it is necessary to activate past similar experiences by experimenting with different possible paths to make sense of the situation (Gyldendahl Jensen, 2020).

In the learning process, these different possible paths or trajectories are constantly challenged to create processes of inquiry with a high degree of reflection and critical thinking (Schatzki, 2017). The students chosen path will reflect opportunities for learning through situations that are determined by practice-related challenges and disturbances. Inquiry can, therefore, be understood as a looping process where past experiences create the prerequisite for being able to overcome difficult situations. Experience is, therefore, a series of interconnected situations that Dewey calls organic circles. All situations are interconnected while each has its unique characteristics (Elkjær & Wiberg, 2013; Buch and Elkjaer, 2015; Gyldendahl Jensen, 2020). Working with PBL through sequential learning trajectories will thus intuitively and intentionally help the students to perform new activities in a particular practice (Dreier, 2008; Schatzki, 2017).

Understanding learning as sequential and complex learning paths opens up for an exploration process, where the student needs to find the "right" path by linking and combining the learning activities in a way that new realisations arise through reflection (Dreier, 2008). The process of inquiry thus assumes that there is an intrusion that needs to be figured out or something unclear that needs to be solved by means of thinking (Dewey, 1933; Frega, 2011) In order to operationalise this process, there must be a particular order of thought. The consequence of one thought sets in motion the next (Gyldendahl Jensen, 2020). To find these paths, the student must be able to carry out research processes by reflecting and analysing the events that affect both intentionally and unintentionally and by that disrupt the learning path and create a temporal conception (Dreier, 2008). The sequential processes of learning, therefore, has an experimental nature and Dewey argues that education and teaching are the elements that underpin and guides experience through a systematic approach to produce "intelligent actions" (Dewey, 1933, 1938a, 1938b; Tashakkori, Teddlie, 2010; Elkjær & Wiberg, 2013; Buch and Elkjaer, 2015; Gyldendahl Jensen, 2020). In such a situation, it is the ability to reflect and investigate that systematically provides the opportunity to react flexibly and well-considered to the consequences certain activities entail (Dewey, 1933; Kjær, 2010; Gyldendahl Jensen, 2020).

To do this, the students must, through a clear PBL learning design strategy, based on descriptive patterns for how to work analytical, critical and reflective, learn how to proceed depending on what they have already learned (Schatzki, 2017). Schatzki (2017) describes it as a chosen path that over time will reflect possibilities for achieving specific learning when the student faces an unclear situation, or dilemma (Dewey, 1933). Dewey thus places the initiative on the learner, pointing out that a prerequisite for creating an inquiry is that there is a curiosity to discover and investigate something (Dewey, 1933; Brinkmann and Tanggaard, 2010; Gyldendahl Jensen, 2020).

Curiosity is thus expressed as an exploration of intellectual purposes through sequences of studies and observations and ties experiences together. In order to create an inquiry process characterized by being both reflective, explorative and innovative, it is necessary that the process contains some form of coherence and continuity (Dewey, 1933; Gyldendahl Jensen, 2020). It means addressing the situation, activity, or curriculum from multiple angles, like through data- and knowledge collection, evaluation and assessment, asking questions, discussions, and arguing (Dewey, 1933). Thus, Dewey contributes to ”practice theory” ideas about the importance of thinking as he offers a conceptual apparatus that transforms intellectual thoughts into a form of practice. According to Kjær (2010), through this argumentation, it becomes apparent how thinking is an integral part of the action (Dewey, 1933; Kjær, 2010; Gyldendahl Jensen, 2020).

**Problem-based learning as Landscape of practice**

By considering learning as a complex landscape of personal learning trajectories, this article argues that there is an opportunity to think in design strategies that to a more considerable degree can help the students through complex PBL processes that point to new knowledge insights, and thereby inspiring new innovative representations of the academic (Dreier, 2016; Schatzki, 2016b; Davidsen, Konnerup, 2016). It is a way of thinking that still moves the educator's focus from the dissemination of knowledge, but at the same time offers a possibility to challenge the previous understanding of how to support the student learning process. By deliberately facilitating selections of academic activities that form an arrangement of learning trajectories it is possible to maintain the self-directed problem identification and at the same time ensuring that the student can navigate in their learning process, both analytically, critically and reflectively.

Only when the student can identify the processual and multimodal activities that are necessary to carry out a PBL project, are they given the opportunity to challenge the content through obstructions and disturbances. The teacher thus sets the framework for a learning design consisting of "landscape of practices" that reflects the student's opportunities to create trajectories full of interruptions or discontinuous. As a result of this the student's agency, capacity and ability to act in the learning process are being

brought into play (Dreier, 2016; Schatzki, 2016b; Davidsen, Konnerup, 2016). Within that framework, students have the freedom to independently and actively mix activities, and with this create learning trajectories that follow individual problem formulation or project description.

## METHODOLOGY

The study is based on Educational Design Research (EDR) as the overarching framework with a pragmatic Mixed Method approach as the primary epistemological foundation. Methods of Design Thinking formulated by Stolterman (2008) informs the design activities through iterative processes. Based on ELYK's phase model for EDR (Christensen et al., 2012), this study addresses the following phases; "Problem and theory identification", "Designing the prototype", “Intervention through the design” and “Reflection and concluding”.

It is essential to be critical of the term 'Learning Design' that are used in educational design research as one of the core elements of the research process. Another important aspects are the issue of not being able to design learning but instead, it is a matter of being able to design tasks and tools that can support the learners (Davidsen, Konnerup, 2016). A review of the relevant literature of Educational Design Research that the term design is spoken of in general terms, but no directions or methods are given for how these designs occur. Nor is there any explanation for how the theoretical perspectives, which in many ways are the basis of what is being investigated, are being translated into concrete designs.

One of the few examples related to the design process in Educational Design Research is the book “Conduction Educational Design Research” of Susan McKenny and Thomas C. Reeves (McKenney, S., & Reeves, 2018). In the section “Design and construction” they try to give several suggestions on design methods. However, there is still a tendency for the discussion to be reduced to discuss the "necessity of design", and very little about how to conduct it. Even when Mckenny and Reeves in the book of Educational Design Research (2018) become more specific about what activities a researcher can initiate, it is limited to simple brainstorming techniques and idea-generation methods. The design problem is then being boiled down to concepts such as exploring, idea-generation and mapping solution. It skips central parts like synthesis as an abductive sensemaking process that merge and manipulate different elements into a cohesive structure through sketching, drawing and making artefacts. Instead, there is a focus on solutions that must be assumed to be the end product of a design process (McKenney, S., & Reeves, 2018; Gyldendahl-Jensen, 2020; Akkerman and Bronkhorst, 2013; Amiel, and Reeves, 2008; Majgaard, Misfeldt, and Nielsen, 2011; Engeström, 2011).

The underlying problem is the methodological description of EDR with a focus on **Design requirements** that specify the criteria of the intervention tied to the long-range goal and then **Design propositions** that guide how to achieve the long-range goal. But there is no methodological insight into how these Design requirements are derived or how they are used to inform the design. When idea generation is coupled with a detailed list of requirements and wishes, there is a risk that the design process does not create new insights but more creates.

This study is, therefore, based on an iterative design process in which several design schemes have been developed based on theoretical design principles as well as practical teaching sessions (Stolterman, 2008). Design schemas can be seen as graphical abstractions that allow discussing, defining, and embracing the thoughts and reflections that the first design principles create (Kolko, 2009). Kolko (2009) describes it as a way to organise the complexity of finding clarity in chaos through; (1) translating thoughts and reflections into images, (2) creating small graphic models that combine design principles into new ones, (3) creating an overview of the ongoing knowledge acquisition by visualising abstract theories, (4) developing graphical models that describe the ongoing recognition process in a structured way, (5) visualising the exploration process driving the project forward, by linking design schemas to beginning unique new designs. The different perspectives that design schemas express causes the designers to follow and examine different trajectories that ultimately influence the final design. The graphic representations that make up the design schemas enable thus in practice that a process of"composing and connecting which pulls a variety of elements into relationships one another that are then formed into functional assemblies" can be created (Nelson and Stolterman, 2014, p 21).

Based on Davidsen, Konnerup 2019 understanding of educational design, the development of design schemes has thus aimed to create a common descriptive language that can qualify the teaching activities. It means that the development process has been focused on the following three aspects:

- Learning Design as a form of conceptual mapping that describes the overall pedagogical Landscape, regarding key components within PBL.

- Learning Design as a common language that can describe and visualise teaching and learning activities

- Testing of the specific learning design to see the consequence of the individual design schemas or concepts.

The development of design schemas is thus regarded as a form of data collection that contributes to the development of specific conceptual learning designs. The individual design schemas have been continuously qualified and reviewed through practical teaching sessions at the education of ATCM, at University College of Northern Denmark. The interaction between the development of design schemas and practical teaching sessions has taken place over two years in which a total of 324 students participated. The study is thus based on a case study that aims to develop conceptual designs of learning sequences. The study focuses on whether the development of conscious learning sequences can support PBL so that the students can develop learning strategies based on an exploration of a professional topic. In addition to the development of specific design schemes, the study also included results from observation and reflective portfolios based on the students' group work.

| | **2017** | | | **2018** | | | **2019** | | | **2020** | | | **2021** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Semesters | 3 sem | 4 sem | 5 sem | 3 sem | 4 sem | 5 sem | 3 sem | 4 sem | 5 sem | 3 sem | 4 sem | 5 sem | 3 sem | 4 sem | 5 sem |
| Number of students | 28 | - | - | 85 | 82 | 57 | 94 | 87 | 79 | 90 | 92 | 85 | 30 | 53 | 37 |
| Number of groups | 5 | - | - | 23 | 20 | 16 | 24 | 23 | 23 | 23 | 26 | 24 | 8 | 14 | 10 |

*Table 1.*

The case is based explicitly on a teaching course where the student can shape their study in a conscious academic direction through immersion and qualification of a selected profession-relevant topic. The purpose was for the student to be able to independently participate in the professional and methodological development of the profession through research and development-based knowledge within one or more profession-relevant topics.

The project's data collection focuses on the students' reflective experiences, thoughts, feelings in relation to through a sequential learning framework in a PBL setup. Thus, the primary focus will be qualitative, in which the quantitative data is processed descriptively and used as a supplement. Thus, the focal point of data collection aims to collect and analyse data through iterative processes, where theoretical assumptions are continuously modified through iterative phases. Therefore, data collection is primarily characterised as exploratory with an understanding and explanation perspective.

The purpose of the analysis is the construction of theoretical ideas based on empirical data through a continuous pragmatic coding process of puzzling pieces together (Timmermans and Tavory, 2012). The theoretical constructs of the analysis thus occur through a dialectic between theory and empirical finding (Timmermans and Tavory, 2012). The strategy for analyzing the data is based on abduction, where the coding process alone is a tool for creatively understanding and brooding the patterns of the phenomena (Timmermans and Tavory, 2012; Brinkmann, 2014).

The coding process has thus a sensitivity towards the possibilities of spontaneous categories emerging detached from the theoretical assumption. It means a focus on categories that emerged through both an explorative data-driven inductive approach to students' narratives while the design principles of the project are used as clues. The coding process is based on the number of frequencies of specific descriptions of the student experiences within their reflective reports. Based on that, representative statements have been selected where the following criteria have weighted high; (1) comparable statements from different students, (2) Overall tendency in the different project groups, and (3) statements repeated in all iterations. To ensure clarity around these three criteria the data from each iteration is assigned a colour code. Through an investigation of the found categories, new theories have emerged through an abductive resonance by a comparison with existing theories. The analytical reflection is created through sketching techniques describing interesting patterns and contradiction. The sketches act as a kind of memoir that summarises the reflections and thoughts that together create an abductive resonance. Through an axial coding of the found categories, coupled with the outlined sketches, several statements are identified. This statement provides a framework for writing up the analysis (Charmaz, 2014)

| **Sequential learning trajectory** | **176** |
|---|---|
| **Sequence of activities (overlapping episodes of experience)** - *examples where the students describe how the individual learning activities are connected* | 45 |
| **Procedural retorik, deskriptiv sprog** - *examples that describe that the students have developed a descriptive language in relation to being able to explain the content and context of the activities. Also, a description of how the activities can be related to the learning process* | 54 |
| **Proceed and Depend** - *examples of situations where students describe how one prior activity had a direct impact on the next* | 27 |
| **Learning strategie**s - *examples where students describes what strategic considerations they have had in their work* | 23 |
| **Inquiry processes** - *examples where the students describes a focus on exploration, analysis and reflection* | 15 |

| | |
|---|---|
| **Iterativ process** - *examples showing that the students have worked iteratively with the academic disciplines* | 12 |
| **Changes in normative behaviour** | **109** |
| **Changes in normative behavior** - *examples where the students unfold how they have changed, for example, their perception, workflows or their understanding of working problem-based because of the organization of the teaching activities.* | 78 |
| **Transferable skills** - *examples of students being able to describe how the learning outcome and methods can be used in other contexts and future learning processes* | 31 |
| **Problem Formulation** | **322** |
| **Practice related problems** - *examples of students describing issues related to practice* | 69 |
| **Problem identification** - *examples of students paying attention to identifying and describing issues at a general level* | 58 |
| **Depth (delimitation)** - *examples of the students having a strategy for making a demarcation in relation to an issue in order to create a greater depth* | 49 |
| **Critical thinking** - *examples of students taking a critical stance on their own work, especially in relation to sources and literature* | 125 |
| **Different perspectives** - *examples of students being aware of seeking more perspectives on their problem* | 21 |
| **Disturbances** | **113** |
| **Obstructions** - *examples in which the students describe difficulties in relation to work problem based and situations where the academic content brings them out into unfamiliar terrain.* | 60 |
| **Broken space time (trial and error)** - *examples of students describing disturbances in their process that cause them to experience a form of iterative trial and error* | 43 |
| **Innovative development of knowledge** - *examples where the students describe that their knowledge has developed on the basis of a creative process.* | 10 |
| **Collaborative learning process** | **117** |
| **Experience (inductive approach)** - *examples of students describing how they have taken their own experiences as a starting point and hence had an inductive approach to working problem based.* | 46 |
| **Dialogue** - *examples of students highlighting the group's dialogues as being the reason for progression in their process, as well as the reason for a greater academic breadth and depth.* | 71 |

| **Miscellaneous** | **123** |
|---|---|
| **Doings and saying** - *specific descriptions of how the students have carried out the individual teaching activities.* | 88 |
| **Overview of the process** - *description of how the structure of the teaching has contributed to a greater overview of the content and contexts of the learning process.* | 35 |

*Table 2.*

## DESCRIPTION OF THE SEQUENTIAL LEARNING DESIGNS

Phase 2 of Educational Design Research is called prototyping, where educational design is developed based on theoretical insight. However, no matter what kind of synthesis process used to combine and connect the theoretical concepts and keywords into a final design, the design process according to Kolko (2009) still appears to be something magical (Kolko, 2009). The challenge is how to transform design principles into design schemas in a way that both externalises and memorises that process in order to create transparency within the research process. Through sketching techniques, it is possible to translate design principles based on different perspectives into a coherent design where theoretical and practical relationships and patterns can be combined in design schemas. In this way, design schemas become graphical abstractions that allow discussing, defining, and embracing the thoughts and reflections created by the design principles (Kolko, 2009; Gyldendahl-Jensen, 2020).

In practice, it can be challenging to say precisely which steps in the development, or what design schemes lead to new specific insights. It means that there will always be iterative processes that weave in and out with each other. However, the described systematic approach supports that essential connections can be drawn between immediate unrelated elements, and thus it is key to link research to design (Stolterman, 2008; Kolko, 2009; Nelson and Stolterman, 2014; Krogh, Markussen and Bang, 2015). The different perspectives expressed by the design schemas causes the designers to follow and examine different trajectories that ultimately influence the final design. The decisions that draw these design trajectories can, according to Nelson and Stolterman (2014), be regarded as a centre between intuition and logic or imagination (Nelson and Stolterman, 2014).

The purpose of this section is to describe some of the most prominent and significant steps of the development process that has formed the framework for creating a sequential learning design. It is not an actual analysis of the individual design schemes but more a brief conceptual review of the procedure that has formed the basis of the work. The design process has been focused on the development of conceptual designs of learning sequences based on the following three academic concepts; literature review, problem formulation

and research design. The selection of these specific concepts is based on an initial review of the 118 students previous assignments at their final semester where only; (1) 28 % of the students manage to create a problem-oriented question, (2) 3% had a systematic approach to their literature studies, and (3) 40 % had a description of their study design in relation to explore their problem

**Mapping out concepts, theoretical position, activities**

A theoretical mapping of concepts, theoretical position, activities etc. that are related to PBL, where initially developed with the purpose of being able to create a landscape of practice. Here, there has been a particular focus on distinguishing between the elements in the literature that are pointing directly into a PBL pedagogy originating from Aalborg University and then the activities that are described as general study activities.

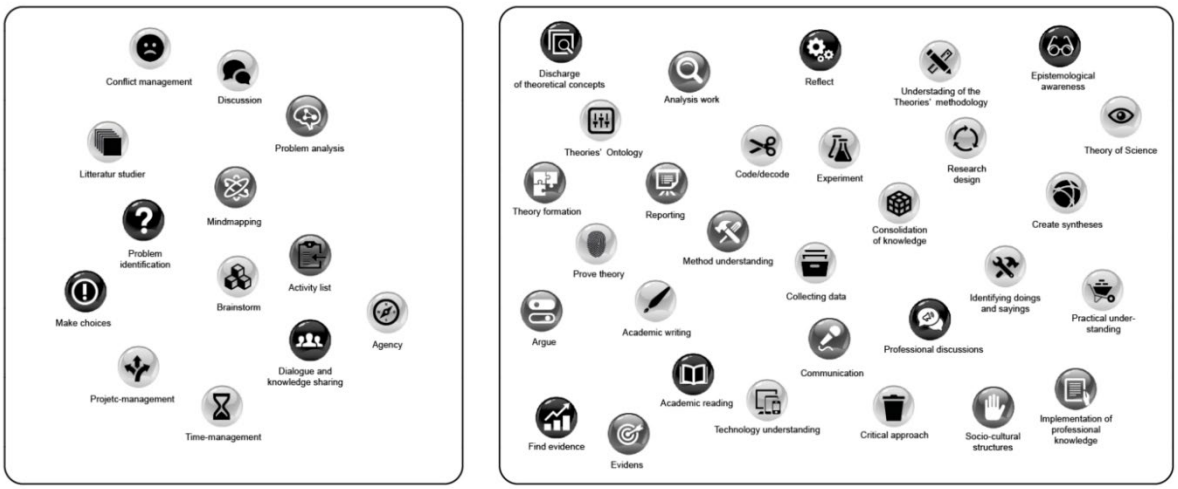


*Figure 1. The box on the left shows the activities that are pointing directly into a PBL pedagogy originating from Aalborg University, while the box on the right shows the activities that are described as general study activities.*

Through this mapping and a further division and categorization of the activities into a landscape of practices, it is clear that PBL contains far more learning activities that go beyond finding a problem, time and project management and group work. It means that a one-sided focus on these three areas in a pedagogic planning phase creates situations where the student is left blinded regarding finding the" right" combination of learning activities to create their personal learning Trajectories.

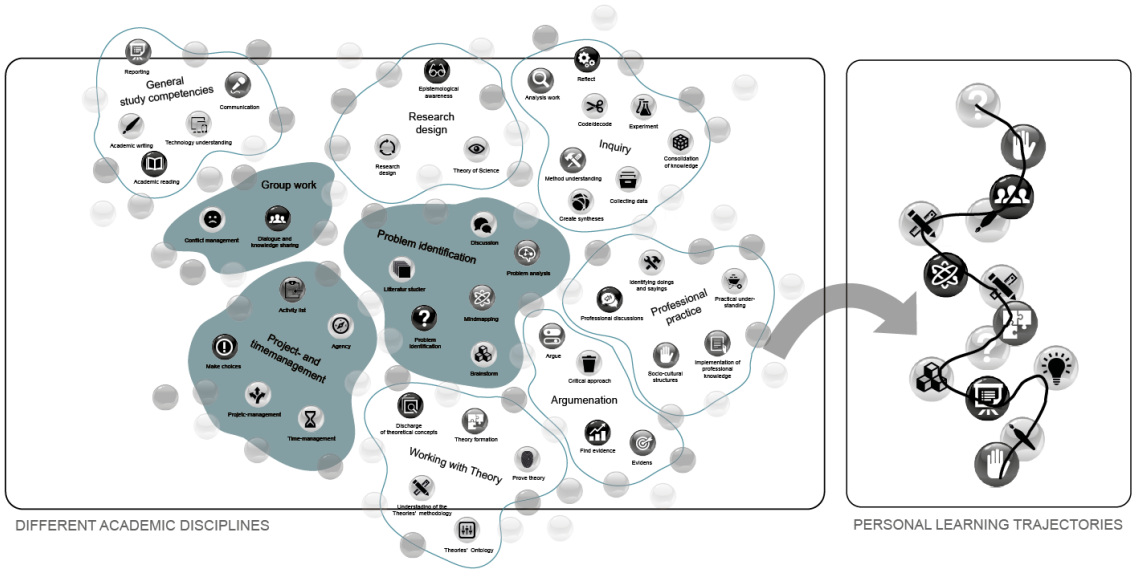


*Figure 2. The activities associated with PBL can be organized as a landscape of practices from which the students must independently develop a personal learning trajectory. However, a desk-research reveals that only a small area of the activities are explicitly formulated as being PBL.*

Based on the initial mapping and a derivation of concepts, theoretical position, activities, have been made for within the three main areas; literature studies, problem formulation and research design. Through processes of sketching, a number of design schemas have been developed for how to translate learning activities that support working problem-based into coherent learning trajectories or sequences of learning. The outline of the various design schemas includes conceptual patterns or tools with a focus on supporting the students' autonomy concerning the PBL.

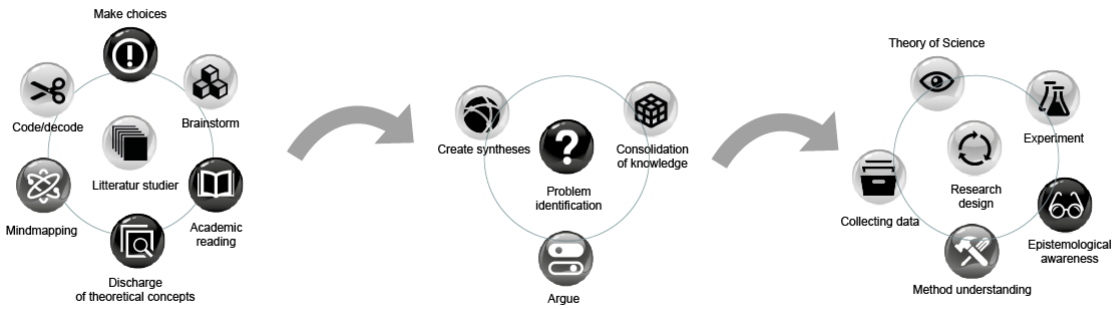


*Figure 3. Based on the initial mapping and a derivation of concepts, theoretical position, activities, design schemes have been developed for selected learning activities that support working problem-based.*

These conceptual patterns or tools can be seen as specific methods, instructions for actions, techniques that form the foundation for an exploratory PBL process. It means that the students through the tools are helped to create the necessary mental notions that, for example, are associated with formulating a problem statement. A large number of the disciplines or activities that characterise a PBL process share the same characteristics that

make them difficult to comprehend. Likewise, academic disciplines often require a level of abstraction that cannot be conveyed through the dissemination of superficial knowledge. Here it is essential to break down the process into smaller action-oriented steps of doings and sayings. For example, the following six elements are included in the concept of academic reading: Orientation, skimming, normal reading, intensive reading and selective reading. Based on practice theory, the specific steps within each learning activity can be defined as a unique and individual learning path. The combination of the different learning trajectories described though design schemas make up the pedagogical design. When the individual learning trajectories are repeated during a module, a semester, or the entire study, in parallel with new additions, a sequential learning system is formed based on a landscape of practice. In this study, work has been done to translate selected elements within each learning trajectories into specific tools to support the student in developing specific learning regarding understanding some of the abstract learning concepts that characterise PBL.

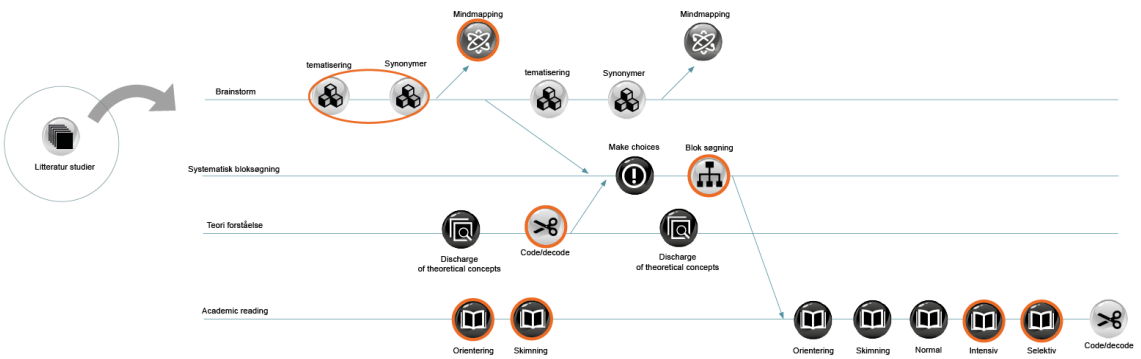


*Figure 4. Each area of literature studies has through learning sequences been formulated as action-oriented steps.*

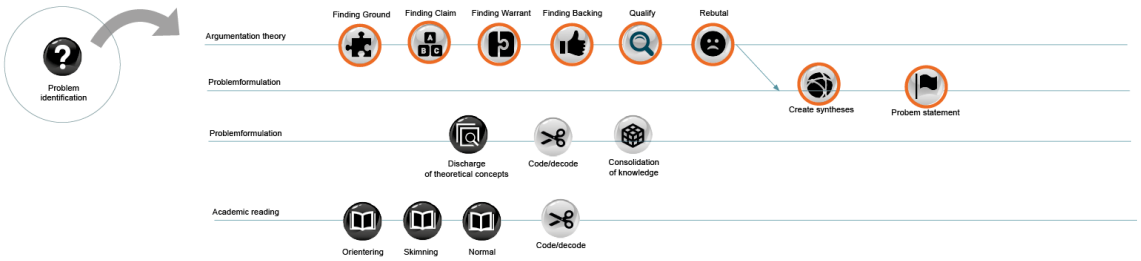


*Figure 5. Each area of problem formulation has through learning sequences been formulated as action-oriented steps.*

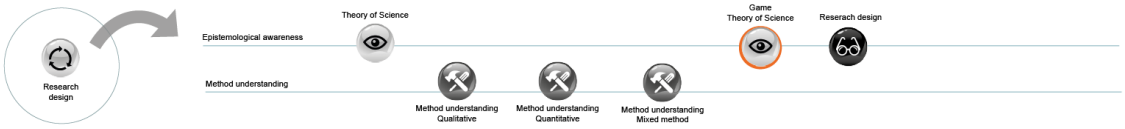


*Figure 6. Each area of research design has through learning sequences been formulated as action-oriented steps.*

The following example is a learning sequence related to literature studies Where the students through dialogue create a learning trajectory that combines initial thought and problem formulation with a systematic literature search. The final step of the trajectory loops back to the beginning of the process by using the initial headlines or problems as theoretical background for coding the found literature. The structure of breaking down the process into smaller steps of how to conduct a literature review creates a descriptive language that supports the student in qualifying a methodology for PBL.

| *Finding relevant headlines or problems within the topic through dialogue* | *Brainstorming problems related to the headlines* | *Exploring the connections and relationship between the different problems through Mindmapping* |
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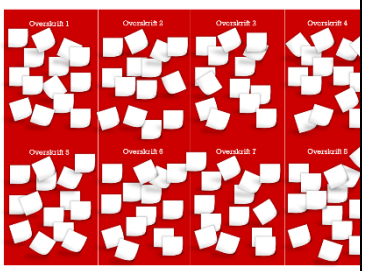
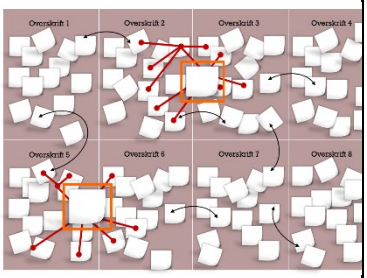
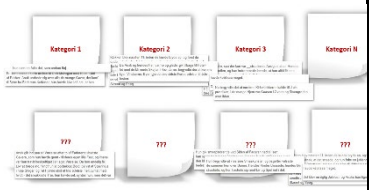
|  |  |  |
| *Turning brainstorms and mindmap into Blocks that can be used to carry out a systematic literature review* | *Search for literature within relevant databases based on the created blocks* | *Coding the text according to the initial headlines or problems* |
|  | *(Sustainability * OR "integrated Buildingsdesign" OR "Value based") **AND** (Social* OR human* OR living * OR citizen*) **AND** (Materials* OR building* OR architecture * OR integration* OR model*) **AND** (Decision * OR leadership * OR management *) **AND** (System* OR integration* OR model* OR "energy design")* |  |

*Figure 7. Examples of the process-oriented tools that have been developed continuously through the iterative design processes.*

This specific sequence of activities that draws a descriptive language for literature studies must be seen in connection with a number of other learning trajectories such as academic reading and writing. The many sequencers thus together form a landscape of practice (or learning design) that creates a coherent methodology for how to work with PBL.

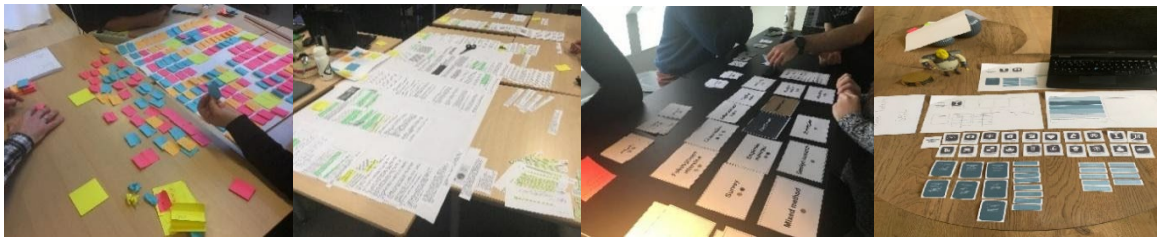


*Figure 8. Examples of the process-oriented tools that have been developed continuously through the iterative design processes.*

## ANALYSIS

The following section analyses the data collected through observation and reflective portfolios from the students' group work. The analysis will focus on to what extent the developed sequential learning trajectories have on the students' learning, including mastery of problem-based learning through the categories descriptive language and self-directed learning.

### Descriptive language

In the following two statements, the students talked about how the specific process activities contributed to an increased overview of the complexity of the task, including helping them to be able to identify learning strategies for how they could create coherence in their exploration of a professional problem:

> "Personally, I thought this VUE might be a little long-haired. But despite this, I thought this semester had made me a little positive. I've probably gotten a little more understanding of it. We have been working with games of scientific theory so we could choose the methods we would use for the analysis".

> "All of these tools and methods that we have become acquainted with in this project have helped us to form a comprehensive overview of our topic and sub-topics easily. It has helped us to quickly and efficiently find the best and most relevant literature for the project. Furthermore, it has helped us to quickly find the elements in the literature that contain the information that was relevant to us and our project. The tools have each helped to simplify the process of writing a problem statement and problem formulation".

Likewise, there was a tendency that the students in a subsequent reflection clearly could formulate and make explicit how the process tools enabled them in applying a learning strategy. Because of that, the students' reflections themselves automatically initiate the sequential learning system, as they are continuing and transferring recognisable learning paths to new contexts and situations. The following example illustrates how the students

can define the elements that created their exploration process, as well as how the individual activities were part of a larger context:

> "Just as we have used coding in relation to our literature and problem solving, we have taken coding with us in the analysis and discussion. It has provided a better overview for us to break up our studies into smaller pieces, to put it back together into a larger whole. We have done the coding digitally through Word, as we learned last semester that it could provide an equally good overview".

> "We are positive about getting to know the scientific databases. Where, in the past, we primarily used only google and books to search for information, we have now sharpened our searches more scientifically. This new knowledge enables us to seek more quality knowledge, more source-critical and better documented problems. In this way, we increase the quality of our analyzes".

The analysis thus indicates that the students, because of the designed sequential learning trajectories, have predominantly developed a descriptive language that connects to working problem-based. This is clearly seen in the collected data, where the students' in a retro-perspective view can unfold and reflect upon how to work problem based, including giving examples of situations where they experienced how one activity had a direct impact on the next. Also, adequate descriptions of how their literature studies in particular have contributed to an increased depth in the analyzes as well as a more critical stance regarding the academic problems.

**Self-directed learning**

The students' methodological and procedural reflections provide the students with experiences and insights that can be brought into future project assignments. The reflections are very much about the students' reflections on processes, results and quality, and the study as a result of this revealed how the students recognised the importance of going in-depth with their written work. Working with conscious learning strategies resulted in the students using meta-reflection to express their learning processes. The reflections were not only directed at the educational and the academic elements but were also related to the application of knowledge in practice.

> "It is worth mentioning that the whole research process has been an incredibly good eye-opener for the theoretical approach to be carried out in the practical and professional context. It is because the theory strengthens and forms a basis for how to deal with challenges".

The students' attention to the value of their efforts concerning a professionally-oriented topic suggests meta-reflections on how their acquired competencies can contribute to dealing with similar challenges in future semester projects.

> "It was such a tool that allowed us to debate things and forced ourselves to see the topic from other points of view and angles. It helped us to get the group started from the beginning, and gave us the feeling of success which is good, and helps to motivate the group to move forward with the project."
>
> "This new approach enables us to seek more quality knowledge, more source-critical and better-documented problems. In this way, we increase the quality of our analyses."

Thus, there is some indication that the step by step way of thinking through the developed learning trajectories in this project coupled with specific action-oriented tools, means that the students to a much greater extent are able to take a critical position for their learning process. Also, because of a more in-depth understanding of the learning processes associated with working problem-based, the students are then able to work more self-directed. The tools and the methods presented thus provide a core understanding of the PBL process that enables the students to have autonomy in their work.

## CONCLUSION

This article aimed to discuss Dewey's concepts of sequential inquiry processes to create new forms of learning designs to bolden further students ability to work analytically and exploratively. The study addressed two phases, "problem and theory identification" and "designing the prototype" to create conceptual designs of learning sequences. Work has been done to translate selected elements within problem-based learning into specific tools to support the student in developing specific learning strategies regarding understanding some of the abstract learning concepts that characterise PBL. The study used a specific case based on teaching sessions where data (observation, reflective portfolios and sound recordings from the students' group work) was collected over two years with the participation of a total of 324 students.

The results from the data collected showed various improvements to the student's ability to independently formulate and work with problems through exploration and analysis within selected topics relevant to their profession. The data suggested that the activities that the students participated in contributed to an increased overview of the complexity caused by a problem in their topics. It helped them to identify individual learning strategies that gave coherence in their exploration. The students were also able to reflect and formulate how the tools enable them to apply a learning strategy for how to work problem-based. When students experienced a clear, distinct and recognisable learning strategy, it leads to increased motivation and enthusiasm. The students stated that it is especially the structure and organisation of the teaching as learning trajectories that contribute to strengthen their motivation and understanding of working problem-based.

The students' reflections itself automatically initiates the sequential learning system, as they are continuing and transferring recognisable learning paths to new contexts and situations. Moreover, the students' attention to the value of their efforts concerning a professionally-oriented problem suggests meta-reflections on how their acquired competencies can contribute to dealing with similar challenges in future semester projects. The study also suggests that this approach to learning sets new requirements to the student's ability to reflect over their own learning process critically.

These sequential designs however also present a dilemma between students' self-directed learning abilities and the students' need for scaffolding. A concern could thus be that the sequential designs are inhibiting the students' self-directed learning abilities. However, the collected data indicates that a prerequisite for being able to work self-directed is an in-depth knowledge of what it means to work problem-based. The student statements clearly show that this is not the case, which is why they need to be supported methodically. In addition, the question of self-directed learning must also be seen in the light of an entire educational program. By scaffolding the student in the first semesters helps them to develop a basic understanding of PBL that enables them to develop a greater degree of autonomy.

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