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Conceptualising first-year engineering students' problem-oriented work within the context of their study programme: exemplified by studies in Denmark and Brazil

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Abstract

Problem-based learning (PBL) is a pedagogical approach that has received worldwide recognition, especially within higher education, and it can be found in a large number of diverse models. However, a common denominator among these diverse models is the principle of 'problem-orientation', which is a backbone of PBL. Problem-orientation is the basis for the students' learning process in real-world engineering problems. This paper will conceptualise first-year engineering students' problem-oriented work within the subject context, framework and curriculum of their study programme, as exemplified by the programmes at Aalborg University, Denmark and the Virtual University of Sao Paulo, Brazil.

**Keywords**: problem-based learning, problem-orientation, first-year engineering students and study programme

1   Introduction

Looking into education in general '_the banking model_', as defined by Paulo Freire (1970), is still prevalent as '_education becomes an act of depositing, in which the students are the depositories and the teacher is the depositor'_ (Freire, 2009 p. 72). This educational approach with the teacher as the narrator of a subject and students who listen to memorise the narrated content is anything but problem-based learning (PBL). As Freire argues, this teacher-centred approach must be rejected: '_they must abandon the educational goal of the deposit-making and replace it with the posing of the problems of human beings in their relations with the world'_ (Freire, 2009 p. 79). Abandoning the banking model and implementing the posing of problems is one of the backbones of PBL, which is known as the problem-orientation.

This paper will begin with a theoretical definition of problem-orientation in a PBL environment. It will then progress through a description of the individual study programmes of the selected studies, at Aalborg University, Denmark (AAU) and the Virtual University of Sao Paulo, Brazil (UNIVESP). The aim of this paper is to conceptualise the following research question: '_What kind of problems are students able to formulate within the subject context of their study programme?'_

2 Introduction to the Cases

AAU and the UNIVESP are universities with somewhat large differences: they are located on different continents, they are in terms of age 40 years in difference, and one of them is exclusively an on-line university while the other is not. However, they do have many things in common; in particular, they have the same educational model, PBL, which is fully implemented throughout both universities.

AAU was inaugurated in 1974 and right from the beginning it was founded, at that time, on a rather novel educational concept, PBL. In August of 2014, the UNIVESP was inaugurated as the first virtual Brazilian University, it was also based on the educational concept of PBL.

2.1 The Aalborg University Case

Many attempts have been made to define the PBL concept. One of the pioneers was Howard Barrows, who in the late 1960s was involved in the early stages of the development of PBL at McMaster University in Canada. Barrow defined the concept in terms of specific characteristics as being student-centred, taking place in small groups, with the teacher acting as a facilitator, and being organised around problems (Du et al., 2003, p. 657). In Denmark, the PBL model was developed based on ideas from, among others, Illeris, '*who formulated the principles of PBL as problem-oriented, project work, inter disciplinarily, participant directed learning and the exemplary principle and team work'* (Kolmos et al, 2004, p. 10).

The Aalborg PBL model is a problem-based and project organised-model, which has gradually developed at a profession-based level. However, it is important to recognise that the model and its identified principles are by no means static or contextually isolated but should always be interpreted in the light of the broader context in which the model is to be implemented and applied. The principles that are acknowledged by Aalborg University are:

- Problem-orientation: Problems/wonderings appropriate to the study program serve as the basis for the learning process.
- Project organisation: The project stands as both the means through which the students address the problem and the primary means by which students achieve the articulated educational objectives. The project is a multi-faceted and often extended sequence of tasks culminating in a final work product.
- Integration of theory and practice: The curriculum, instructional faculty members and project supervisors facilitate the process for students of connecting the specifics of project work to broader theoretical knowledge. Students are able to see how theories and empirical/practical knowledge interrelate.
- Participant direction: Students define the problem and make key decisions relevant to the successful completion of their project work.
- Team-based approach: A majority of the students' problem/project work is conducted in groups of three or more students.
- Collaboration and feedback: Students use peer and supervisor critique to improve their work; and the skills of collaboration, feedback and reflection are an important outcome of the PBL model.

(Barge, 2010)

All students and staff act out these basic principles of PBL, which is a general characteristic of all studies at AAU.

2.2 The Virtual University of Sao Paulo Case

UNIVESP was the first truly virtual Brazilian University and it offers free Bachelor's degrees in engineering. All of the public Brazilian universities offer free degree courses. It opened in 2014, enrolling 1,296 students in the freshmen year, distributed in 19 cities of the State of Sao Paulo.

Although spread out in many fields and in different perspectives throughout Brazil, a complete problem-oriented curriculum in engineering had not been implemented in any Brazilian University before the creation of the UNIVESP. Since its initial conception and opening, the principles of a project and PBL curriculum has underlaid all of the discussions as a way to form engineers who have the skills and abilities that are required by modern society and education. The case that will be presented shortly will demonstrate how PBL has been concretised in the curriculum of this two-year old Brazilian university.

The five year programme of the engineering curriculum, adopting a project-based model, requires that during every semester the students should work collaboratively to identify, prototype and solve problems in their local communities. The didactic-pedagogic model of the Bachelor's degree at UNIVESP incorporates five complementary principles that seek to ensure that students have an education that is solid, creative and focused on personal and professional innovation, as follows:

1) Knowledge transmission: this is accomplished through pre-recorded video lessons with some of the leading experts in Brazil on the issues addressed in the courses.
2) Problem resolution: this solves real problems similar to those faced in the professional labour.
3) Interdisciplinary perspective: the students have to develop solutions for non-disciplinary problems through a project-based approach.
4) *Collaborative and cooperative work:* this is anchored on the importance of social learning, group learning, as a fundamental aspect for the co-creation and preparation to work in the professional.
5) *Learning by doing:* this relies on the design thinking methodology, problem and project-based learning and the *Maker* movement, which work together as an effective approach to solve complex problems and create innovations, articulating theory and practice.

All of these principles are supported by an e-learning platform that is designed with multimedia features that can integrate the convergence of different languages and is able to foster different students' abilities to participate, to interact, and to collaborate. Many ICT tools are used to implement the didactic and pedagogical model. They are chosen to support the academic principles adopted at UNIVESP and may vary according to the needs and demands of the courses and projects.

3 Methodology: Research Approach

The research approach in this paper will begin with a literature review of PBL, with special focus on problem-orientation. A review of the study programmes that have been selected as subject context for the investigation will also be included. The literature review is supported by empirical data consisting of problem formulations (student projects), which were collected among first-year students demonstrating problem-orientation through their project work.

Beginning in a theoretical definition of problem-orientation in a PBL environment, this paper will continue through a description of the individual study programmes (syllabuses and curricula) of the selected studies in AAU and the UNIVESP. Subsequently, some examples of the student's problem-oriented project work will be exemplified through the student's problem formulation (research questions). This paper will conclude in

a discussion of the student's ability to draw up real-lift problems as a means for learning within the subject context of their study programme.

4   The Theoretical Definition of Problem-orientation

The PBL concept is based on a dialectic interaction between the subjects that are taught in a lecture and the problems that are dealt with in the project work. The project-work may be organised by using a "know-how" approach for training professional functions, or it may be organised by using a "know-why" approach for training methodological skills of problem-analysis and application (Kjærsdam et Enemark, 1994, 2008). Furthermore, Mayo et al (1993) argue that PBL is a pedagogical strategy that can be used to pose significant, contextualised, real world situations, and which can provide resources, guidance, and instruction to learners as they develop content knowledge and problem-solving skills.

But what does *'problem-orientation'* mean in the context of a problem-based and project-organised approach? It essentially means that the starting point for the students learning process is a problem (Kjærsdam & Enemark, 1974; Quist, 2004; Kolmos, Fink & Krogh, 2004; Barge, 2010; Holgaard et.al., 2015; Guerra & Bøgelund, 2014).

There have been many academic discussions about 'what is a problem'. Overall, Kolmos (2004) argues that definitions of problems are diverse in different professional areas. Quist (2004) has located a variety of understandings from a literature review of diverse problem formulations. Basically, there is consensus that a problem can be initiated by a w*ondering, a problematic situation* (Quist, 2004; Guerra & Bøgelund, 2014) or an *un-explored potential* (Guerra & Bøgelund, 2014 with reference to Borrows & Tamblyn, 1980; Quist 2004; Jonassen, 2011):

- A wondering means is an observed phenomenon creating (qualified) curiosity (Quist, 2004), which can include situations, events, persons or a thing (Guerra & Bøgelund, 2014) that happened or happens, something heard and seen (Quist, 2004), or an uncovered need or wish (Guerra & Bøgelund, 2014; Quist, 2004).
- A problematic situation can, according to Quist (2004), be 'something you find, a scandal', 'a lack of knowledge' or 'a lack of function' and it can be caused by contrasts; that is, between a wish and reality, conflicts, contradictions (Guerra & Bøgelund, 2014; Quist, 2004). In the definition of a problem, Guerra and Bøgelund (2014) explain the understanding of a problematic situation as also comprising the students' sorrow and/or indignation, frustration or stress, making them act to change this problematic situation.
- An un-explored potential or an idea is also a possible starting point for the problem formulation.

Consistent with the Aalborg PBL model, the problem can be defined as theoretical, practical, social, technical, symbolic-cultural and/or scientific (Barge, 2010, p. 7). Depending on the type of problem and its starting point (a w*ondering, a problematic situation* or an *un-explored potential*), there is also a distinction between 'retrospective' or 'prospective' problem formulations (Holgaard et.al. 2015, p. 37), which can be characterised by:

- The retrospective problem formulation wants to find justifications and explanations for something that has already happened.
- The prospective problem formulation is designed to solve practical problems and to produce concrete solutions.

Besides the three defined starting points of the problem-oriented project work (a w*ondering, a problematic situation* or an *un-explored potential*) there is also the influence of the teacher, the framework of the study

programme, the academic discipline and the topic of the semester—the 'Semester Catalogue' and so on. All of these factors influence how the students identify real-life problems and how they document this through their project work. Different types of projects have been identified by (Kolmos, 1996; Graaf & Kolmos, 2003; Kolmos et.al., 2008; Holgaard et.al., 2015):

- Task projects: These are 'teacher selected' and the problem, method (an academic discipline), and possibly subject are chosen beforehand.
- Discipline projects: These are 'teacher directed' and the method, discipline and subjects are given beforehand. The students might have the possibility to choose subjects (themes) from a Project Catalogue. The students define their own problems within one of these given subjects, which fulfil the requirements of the study programme.
- Problem-based project: This is a problem-oriented project: *"The problem will determinate the choice of disciplines and methods"* (Kolmos et.al., 2008, p. 30) and the choice of subject (Kolmos, 1996, p. 142.) The students themselves choose the problem.

In summary, problem-orientation, as one of the pillar principles of PBL, cannot be described and categorised as one and only type of problem. Problem-orientation is a concept that relates to various different types of problems with different points of departure, implementing distinctive theory and methods, which are the means for solving the problem. This is documented by the students in their project work. Problem-orientation can be derived from:

- Different types of problems: theoretical, practical, social, technical, symbolic-cultural and/or scientific (Barge, 2010, p. 7).
- Different starting points of problem identification, such as a wondering, a problematic situation or an un-explored situation or idea.
- Problem formulations, which either look for explanations (retrospective) or solutions (prospective).
- Types of projects: such as task, discipline and problem-based projects.

A discussion on problem-orientation and how it can be identified from the cases will follow the description of the cases from the two universities (see Sections 4.1 and 4.2).

4.1   Problem-orientation in the Aalborg University Case

The Bachelor's degree in computer science at AAU begins with the students getting an insight into basic computer science, mathematics and the completion of a problem-oriented project.

In the first year, the students, in project teams, analyse and solve a problem within the subject field of software. They draw up a problem-formulation and qualify a research question where software programming can be included as part of the solution. The students must create a model of the problem and include relevant concepts, theory and methods for analysis and assessment of possible solutions. As part of the solution, the students must develop a small software program of high quality, which has to be documented in the project report.

The Study Programme of Computer Science

The overall learning outcome for the computer science students of the first semester project work is to achieve experiences with PBL related to programming and program understanding in order to build both software and project competences.

To get started, the first-year the students are introduced to the Semester Catalogue, which contains formal information on the study regulation and learning outcome of the project, this has an extent of 15 ECTS (ref.). The catalogue contains seven elective real-lift problems areas, of which the students can choose one as their problem to solve within the timeframe of the semester.

The students' learning outcomes from the first semester project are as follows. The student must be able to:

Knowledge:

> • Understand and explain the theories and methodology applied for the analysis of the problem,
>
> • Especially understand and explain the concepts of programming and modelling, which has been used for the project,
>
> • Understand and explain the project's contextual circumstances.

Skills:

> • Choose, describe and apply any of the PBL-course proposed methods of organising group cooperation and in resolving group conflicts,
>
> • Apply concepts and tools for problem-based projects and reflect in writing to the problem-based learning in the context of the project,
>
> • Disseminate the project results and the work in a structured and understandable way, as well written, graphic and orally.

Competence:

> • Analyse a software problem and within this context draw up a problem formulation, where programming can be included as part of the solution.
>
> • Create a model of the problem.
>
> • Include relevant concepts and methods for analysis and assessment of project solutions in relation to the problem context. (Studieordning for Bacheloruddannelsen i Datalogi, 2013)

The seven possible areas of problems that the students can choose among are described as 'problem area, goal and examples of contextual questions and problems'. To exemplify the elective real-life problem areas 'Automating Visit Planning in Homecare' has been chosen as an example:

> Automating Visit Planning In Home Care
>
> In Denmark, many resources are spent to maintain and improve our welfare in society. Electronic systems can, in many cases, provide a more economic and timely service, therefore the services that are being offered citizens, are streamlined and modernised. Thus in recent years, the public sector has stepped up efforts to digitise public service offered in e.g. elderly care and health care.
>
> The Problem
>
> According to the Social Board the home care conducts more than 200,000 visits to the Danish citizens. Today home care staff plans most visits manually, which means a lot of work hours are spent on transport in between visits. Is it possible to automate the route planning, in order to optimise driving between visits? Here it is important to take into account knowledge of the needs of the individual citizens, the home carers work plan and transport, as well as the geographic landscape.
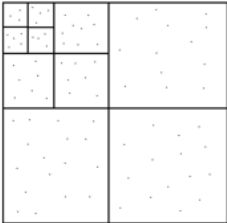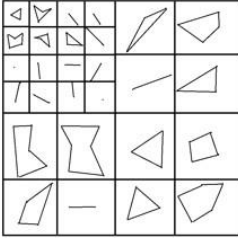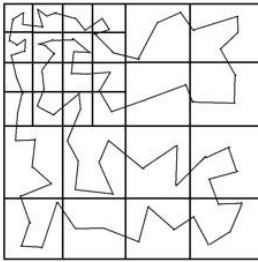
Goal

The goal is to develop and implement a model that automatically can establish an effective driving list (rout plan) for the home carer from the parameters that will be added to the system. These parameters could be employees of service of transport and skills, or the road journeys used in between visits. (Nørmark, 2013)

Based on this semester catalogue, a group of six students selected the Automating Visit Planning but they were not interested in the homecare area, instead they were interested in Post Danmark and their packages delivery system. With an increase in private persons shopping on the Internet, the amount of packages to be delivered is rapidly growing. The students wondered how Post Danmark was handling route planning and how well they were prepared for the rapid increase of packages. The students went to interview the director of the local Post Danmark and learned that what they had been wondering was a real-life problem occurrence every morning when the postmen were planning the routes of the day.

Package distribution at Post Danmark (Frandsen et al. 2014)

Initial problem	The problem in the present system at Post Danmark is that the software they have is only used to calculate routes for mail delivery. Routes for package delivery are handled manually according to the quantity of packages, which makes a route change from day to day. The postmen stubbornly make themselves accountable for the route planning because they are the ones loading the trucks in the morning. The packages are thus put into the truck in the order, which makes the most sense in terms of having to make a maximum effective route.	
	When the individual postmen are managing routes plan, this can easily lead to someone choosing a route by habit. This often results in that a route that may be unnecessarily long. It also requires experience to be able to plan a route when the postmen reasonably should know the area to be able to do it properly. This manual route planning also results in the postmen having to work more hours and thus spend more time on the sorting of packages, which can result in delay. The longer routes also result in a higher fuel consumption, resulting in poorer economy for the postal service and negative influence on the environment.	
Context (Problem analysis)	Post Danmark packages delivery department The individual postmen responsible for the rout planning Stakeholder analysis	Interview with the local director of Post Danmark: Because the amount of packages differs from day to day, Post Danmark believes that is not possible optimised routes with a software solution, it simply takes too long to calculate the optimal route. Moreover, Post Danmark assumes that in about five years, Post Danmark will mainly deal with packages delivery, since packages are increasing rapidly as their main business. From the interview it can be concluded that Post Danmark lacks a method to plan an optimal route for packages delivery, in a very short time.
Problem	Research question	How can a (software) model be used for route optimisation in Post Danmark's packages delivery be prepared? This takes into account that it only applies to 100 addresses and is also considered for the route between two points being designed and

	Requirements specification:	directed elsewhere. • A package truck holds about 100 packages and, therefore, the calculated route could contain up to 100 points. • We take into account that the addresses on the packages are scanned into the program as coordinate points, and that they do not have to manually enter the information. • The program should come with a readable list of what order packages must be delivered so that the truck can be packed from this list. • The geographical breakdown occurs from Post Danmark. • The program should not guide the driver between two addresses, but must only take into account the travel time between the two addresses. • The program does not have to provide the fastest route, but just one that is close enough to the optimal route so that it will not give significant difference. • The program must find the route in less than one minute, so that Post Danmark will not experience delays.
Solution developed	Travelling Salesman Problem Graf theory Brute-force algorithmic	The first part of the Cluster Brute Force consists of a function to be split all the items in smaller groups so that there may be the shortest route within each group. We have chosen this feature to find the individual groups, one that divides the points according to their physical location. By dividing the area into four equal parts, in which points are located, until there are groups of 6 or less. The number 6 is selected as 6! = 720 while 7! = 5040 which are the calculations required to find the shortest route within each group. This can form groups where points are almost optimally close to each other that one can get the most optimal route. Brute Force Function If the points are divided into groups, there must be the shortest route between the points of each route, as then to be put together to a greater route, the "snake" consisting of all the routes (see the figure). In this way, the calculation time for entire routing can be minimised, compared to if one would let a Brute Force be an example. 100 points, it is now only clearly 5 points 8 times, depending on the size of the groups, and the number of points.

When all the groups have found their internal shortest route, all of the groups are put together for a long route, which is based in the Post Danmark distribution centre (see the figure). This method has a 'lower driving a brute-force' but is not necessarily the most optimal route, although it is nearly optimal.

4.2 Problem-orientation in the Virtual University of Sao Paulo Case

As stated previously, the project at UNIVESP is a mandatory semester curricular activity developed by groups of six students under face-to-face guidance by a tutor who is specially trained for this function by the pedagogical coordination and supervision of the major.

UNIVESP's academic coordination defines a theme for all of the students and this general theme will orientate the problem elaboration of each group. In the first year, in 2014/2015, the theme was: climate, environment and society.

The main goal of the project development in the first year is to lead the students to comprehend the engineer's role in understanding society, and to propose actions and strategies according to the reality experienced. To do so, in a central theme like climate, environment and society, we aimed to make them understand how environmental and climate changes have gained importance in today's society, at the same time as promoting the development of skills and abilities to find solutions for real problems that they identify in their surroundings.

Following the steps of the design thinking methodology and principles of the problem and project-based learning, the project development basically involves the following three essential phases:
1) Approach to the theme, elaboration and analysis of the problem.
2) Development of actions that lead to the resolution of the problem, through the creation of prototypes.
3) Socialisation of the knowledge produced, aiming to obtain feedback before the implementation of the prototype, and the production of a written report.

The groups organise weekly action plans of the project development under the reference of the three steps of the design thinking method, which are: listening, creating, implementing.

In the first stage—listening—, during the first three weeks, the groups choose a place to conduct their fieldwork and visit it to interview individuals and groups of people about the central theme of the project, which is: climate, environment and society. At this stage, they also observe people and their routines and bring all of the information to the tutorial session at the university. To identify the local situation and possible problems, in the third week the groups have to define the problem that they will work on to find a solution for the next 12 weeks.

In the second stage—creating—, sessions of brainstorming and discussions are performed; for example, to design solutions for the problem analyzed. Groups have up to the seventh week to create the first prototype of the solution.

At UNIVESP, in the eighth week we have a session called "Fishbowl", which is a method developed by Prof. Renate Fruchter at the Stanford University PBL Lab. In this session, two experts are invited to discuss the first prototype and mentor the groups to the further development of the solution. There is an iterative process in the next weeks, where the groups have to go to the fieldwork to show and discuss with the community the prototyped solution, aiming at its improvement.

In the third stage—implementation—, the groups prepare prototypes of the best solutions created and carry out tests with the stakeholders. In this way, the solutions are fine-tuned and improved to meet the expectations and needs detected in the previous steps.

To evaluate this academic activity, at the end of the semester the groups deliver qualitative scientific reports that describe the development of the whole integrating project and the prototyping processes carried out in order to respond to the problems that have been studied. In addition, the prototypes that have been created are socialised by the group with other students and the community through videos that they have to produce and publish on YouTube (https://www.youtube.com/watch?v=r_dno3_BVOQ&feature=youtu.be).

We will next present one of the projects that the students developed to demonstrate how these students reached the goals of the project discipline, and how they could better understand the role of engineering in society and learn new skills and abilities:

A sustainable bus stop (Carvalho et al. 2014)

Problem	How to improve the conditions of a bus stop in order to bring convenience to the users of this public service?	
Context	The group identified that the biggest problem for bus users was the lack of coverage or a place to sit. Figure: Original bus stop	

Solution developed	The group created a bus stop project consisting of a rectangular profile made of iron plate and a sustainable cover prepared with thermal blanket made of TetraPak® boxes, and tiles made with pet bottles	
	Figure: Sustainable bus stop	

5 Discussion

This article presents two different perspectives on a problem-orientated curriculum that is implemented in first-year engineering Bachelor's degree programmes. As the cases demonstrate, the students from both UNIVESP and AAU are very innovative in the identification of real-life problems. Even though their culture and subject contexts are very different, the problems that they develop are real-lift problems that they have identified in a social setting.

UNIVESP's curriculum is broad and open for the students to select problems within the field of sustainability and engineering. Aligned with Kolmos et al. (2008), this type of project is a 'problem-based project' that is based on problem-orientation where the problem will determine the choice of disciplines and methods, and where the students themselves choose the problem. At AAU, PBL subject knowledge is also part of the learning outcomes along with (software) subject knowledge. However, in the case of AAU, the problems that the students come up with are much more narrow and within the subject field of their study. This calls for a type of problem defined by 'discipline projects' where the method, discipline and subjects are given beforehand and where the students have chosen the subjects from a project catalogue. Even though the project catalogue inspires the students in the AAU case, they define a problem by themselves and the problem should meet the requirements of the study programme.

The problem formulation drawn up by the engineering students at UNIVESP (*How to improve the conditions of a bus stop in order to bring convenience to the users of this public service?*) has a starting point as a '*a problematic situation*'—the students have located a lack of functions or no function at the local bus stop. This led them to act to construct a sustainable bus stop. In the AAU case, the students draw up a problem formulation (*'How can a (software) model for route optimisation in Post Danmark's packages delivery be prepared?'*) that has its starting point in between 'a wondering' and 'a problematic situation' since the students, inspired by the elective problem in homecare, are wondering how Post Danmark manages to handle their everyday route planning. Based on this initial wondering, they identify 'a problematic situation' in Post Danmark who use entirely manual route planning. With a predicted increase in the number of packages in the coming years, the problematic situation seems likely to become worse in the near future. The lack of automation in route planning made the students' act to prepare a software solution to optimise route planning in Post Danmark's package delivery.

The two cases demonstrate that the students' enrolled in both study programmes show great abilities to identify real-life problems and solve them. Both cases can be recognised as 'prospective' problem formulations (according to Holgaard et al. 2015) because they are both designed to solve practical problems and to produce concrete solutions.

6 Conclusion

In this paper, we presented first-year engineering student projects in the context of their study programmes from both AAU and UNIVESP. The aim was to answer the question: 'What kinds of problem are students able to formulate within the context of their study programme?' In conclusion, the students' projects in UNIVESP are broad and open, and can be categorised as a 'problem project'. The AAU project can be categorised as a 'discipline project'. In both study programmes, the students are able to use their problem-orientated study to focus on identifying, prototyping and solving problems in their local communities, despite notable differences in the frames of the study programmes. The students are able to act out problem-orientation through identifying problems that can be recognised as 'a problematic situation' that emphasises a lack of functions in a social setting.

References

AAU study guide for undergraduate in software (2015). Available at: 17th of August 2017

http://www.sict.aau.dk/digitalAssets/106/106274_software-bachelor.pdf (in Danish)

Barge, S. (2010). *Principles of Problem and Project Based Learning: the Aalborg PBL model*. Harvard University, prepared for Aalborg University.

Carvalho, Camila de; Dias, Rodrigo; Ferreira, Thiago; Spindola, Thiago. (2014). *A Sustainable Bus Stop*

Du, X., de Graaff, E., & Kolmos, A. (2003). *Research on PBL Practice in Engineering Education.* Rotterdam: Sense Publishers

Enemark, S., & Kjærsdam, F. (2008). El APB en la teoría y la práctica: la experiencia de Aalborg sobre la innovación del proyecto en la enseñanza universitaria. I U. F. Araújo, & G. Sastre (red.), El Aprendizaje Basado en Problemas: Una nueva perspectiva de la enseñanza en la universidad (Vol. 4, s. 67-91). Barcelona: Gedisa.

Frandsen, Thomas; Gade, Andreas; Lepka, Nikolaj; Malyutin, Arseniy; Rasmussen, Morten; Sørensen, Anders. (2014). Pakkeomdeling hos Post Danmark [Package Distribution at Post Danmark]

Freire, P. (2009). *Pedagogy of the Oppressed*. 30th Anniversary Edition.

Guerra, A., & Bøgelund, P. (2015). How to make engineering students master problem identification and problem formulation. *I E. de Graff, M. Farreras, & N. A. Arexolaleiba (red.), Active Teachers - Active Students: Proceeding of The International Joint Conference on the Learner in Engineering Education (IJCLEE' 2015) and 13th Active Learning in Engineering Education Workshop (ALE).* (s. 77-81). Aalborg Universitetsforlag.

Holgaard, J.E., Ryberg, T., Stegeager, N, Stentoft, D. & Thomassen, A.O. (2015). Problembaseret Læring ved de videregående uddannelser. Samfundslitteraturen.

Holgaard, J. E., Guerra, A., Knoche, H., Kolmos, A., & Andersen, H. J. (2013). Information technology for sustainable development: a problem based and project oriented approach. In: *Re-Thinking the Engineer* [21] Engineering Education for Sustainable Development 2013, University of Cambridge.

iDEO. 2009. Human-centered Design Toolkit. Available at: http://www.ideo.com/work/human-centered-design-toolkit.

Kjærsdam, F., & Enemark, S. (1994). The Aalborg Experiment Project Innovation in University Education. Aalborg: Aalborg Universitetsforlag.

Kolmos, A. Xiangyun, D., Holgaard, J.E. & Jensen, L.P. (2008). Facilitation in a PBL environment. Aalborg University. UNESCO Chair in Problem Based Learning in Engineering Education.

Qvist, P. (2004). Defining the problem in problem based learning. In: A. Kolmos, F.K. Fink and L. Krogh (eds.) *The Aalborg PBL Model: Progress, Diversity and Challenges*. Aalborg: Aalborg University Press, p. 77-92.

Mayo,P.; Donnelly, M. B.; Nash, P. P. & Schwartz, R. W. (1993) Student perceptions of tutor effectiveness in problem based surgery clerkship. *Teaching and Learning in Medicine*. 5(4), 227–233.

Nørmark, Kurt. (2013), Projektkatalog for P1-perioden, Datalogi og Software Første Studieår Aalborg Universitet.

Studieordning for Bacheloruddannelsen i Datalogi, 2013