The role of the teacher in a PBL teaching process

Møller Jeppesen, Mette; Routhe, Henrik Worm; Slot Kristensen , Rikke ; Prip, Jutta

Published in:
Educate for the future: PBL, Sustainability and Digitalisation 2020

Publication date:
2020

Document Version
Publisher's PDF, also known as Version of record

The role of the teacher in a PBL teaching process

Mette Møller Jeppesen
Aalborg University, Denmark, mmj@plan.aau.dk

Henrik Worm Routhe
Aalborg University, Denmark, routhe@plan.aau.dk

Rikke Slot Kristensen
Teknisk Gymnasium Aalborg, Denmark, rikr@aatg.dk

Jutta Prip
Kold College Odense, Denmark, jpr@koldcollege.dk

Abstract

The purpose of this article is to address the role of the teachers when teaching the technology subject at the Danish higher examination programme (htx). It is also the intention to address how that role is expressed in practice where use of Problem-based learning (PBL) or some PBL principles is acknowledged as a strong teaching method. Further, it is our intention to discuss the teacher role in relation to readiness of the students evolving from first to third year in the programme. This will be seen in relation to; the development of the students PBL understanding, the cognitive readiness of the students and classroom dynamics.

Researching the role of the teachers in the technology subject at htx we observed in two different classes, in two different schools during a project period and discussed our findings with the teachers. In relation to the role of the teachers, we identified a variety of tasks the teachers have to deal with on a daily basis when teaching this subject. It places the teachers in a role where a very hybrid skill set is required which is a combination of technical and non-technical skills. Further, we have also found that the teacher's role and the teacher's tasks change as the students develop their skill set during the first year until the end of the third year from a more teacher directed role to a more student-centred facilitator role.

Keywords: Teachers' role, Problem-based learning, student readiness, hybrid skill set, Danish higher technical examination programme (htx)

Type of contribution: PBL research

1 Introduction

Established in the 1980s, the purpose with the Danish higher technical examination programme (htx) was to have a high school education stream specifically directed towards science and engineering (Danish Education Ministry, 2015). The first htx was inaugurated as an experiment in 1982; seven years later in 1989 htx became a permanent addition to secondary school education in Denmark(Jans, 2007; Olsson,

2007). In 1995 it obtained its current form as a three-year high school programme with direct entry from primary school (Jans, 2007). Htx initially struggled with being an unknown educational form and with general image problems. Today, however, this educational form has existed for almost 40 years and is now generally recognised as an equal and indispensable part of Danish STEM (science, technology, engineering, mathematics) and vocational education (Olsson, 2007:7) What differentiates htx from other secondary school programmes in the Danish educational system (such as stx and hf, which offer a broad general education, and hhx, the business high school) is that project-work is central to the curriculum (Ulriksen et al., 2008) and, therefore; based upon problem-based learning (PBL) (Henriksen, 2016a). This is especially true for the central subject areas 'profile subjects'; one of these 'profile subjects' is Technology.

2 The subject of technology

The subject of technology is available to take at both A and B level. The students at the first and second year of their study (age 17 – 19 years) at htx have Technology at B level, while the students at the third year (age 19 – 20 years) can choose Technology at A level. In this subject area at both A and B level students address the relationship between technology and society (Danish Education Ministry, 2015, 2017). As Henriksen (2016a:125) puts it, the subject's goal formulations are all characterised by a 'social-technical' concept of technology (Trist & Bamforth, 1951; Müller et al., 1984). The subject area has its basis in social issues and analyses of technology and community development. Further, its starting point relates to the interplay between technology, knowledge, organisation and product. Social scientific, technical, and scientific knowledge are combined with practical work in groups (Henriksen, 2016a:125). The technology subject consists of topics such as materials and machining processes, technology and environmental assessment, product development, production and marketing. Its general aim is to develop students' understanding of broadly interdisciplinary project work as well as developing their documentation and presentation skills. Technology A also includes subjects such as quality and environmental management, strategy, marketing, logistics, costing, etc. (Htx curriculum 2017; Henriksen, 2016a:125). As project work is the htx guiding principle, teaching is regularly organised as projects with the following as the basis for such activity: projects, group work, individual work, and teacher-led classroom teaching. This approach provides students with the possibility of being active in shaping the educational content, and in suggesting how projects could be approached (Ministerial order, 2017; Henriksen, 2016a:126).

With the regular teaching organised as projects and that being mixed with teacher-led classroom teaching the roles of the teachers teaching the subject of technology at htx becomes one of a hybrid characters as they, when working with Problem-based learning, can be said to be placed in a position between being a teacher in the more classical sense and functioning as a facilitator at the same time. This hybridity presents a challenge for the teachers as they experience that it unfolds an even wider variety of roles for them to fill out within the framework of the subject.

To further understand the challenges that arise for teachers in teaching the technology subject, it is pertinent to first introduce Problem-based learning and afterwards present the realities of what is happening in the classrooms to clarify the breadth of the hybrid role of the teachers but before doing so we firstly unfold the method for collecting the empirical data used in the article.

3 Method

Our empirical data is based on observations and interviews at the Danish higher technical examination programme. The observations were conducted at htx in Aalborg and Kold College in Odense, Denmark. The observations were conducted as observation with participation as we had an interest in studying the field from the "inside". From the "inside" must be understood as we as researchers interact with the field we want to investigate, in this case the subject of technology (Krogstrup and Kristiansen, 1999:54). We observed in two different classes during a project period and discussed our findings with the teachers. At htx in Aalborg we observed at third-year level and at Kold College in first-year level. The interviews were conducted as semi- structured interviews with three different teachers from htx in Aalborg. The teachers from htx in Aalborg are selected based on two criteria: They teach technology subject and they have different professional backgrounds. The observations were subsequently used directly from the field notes and the interviews were transcribed
- both for the use in the article.

4 Problem based learning as a framework

In Graaff and Kolmos (2007) Problem-based learning (PBL) is defined as a learning philosophy and a set of learning principles. Graaff and Kolmos (2007) and Kolmos et al. (2009) summarizes the main learning principles that can cross different PBL models in three approaches; learning - contents - social. The problem is the point of departure for the learning process. The problem creates the context and is central for the motivation of the student. Often problems are solved in time limited projects, with contents considered interdisciplinary and in groups where collaboration between students is necessary. In the groups there can be different degrees of participant-directed learning (Kolmos et al, 2009:11-12).
There are many different implementations of PBL. What works at Aalborg University does not necessarily work at htx. Savin-Baden (2007) defines five PBL models or modes with six dimensions, and with inspiration from that model, Kolmos et al. (2009:15-16) develops a model based on seven elements, that all need to be aligned in a PBL curriculum (see figure 1).

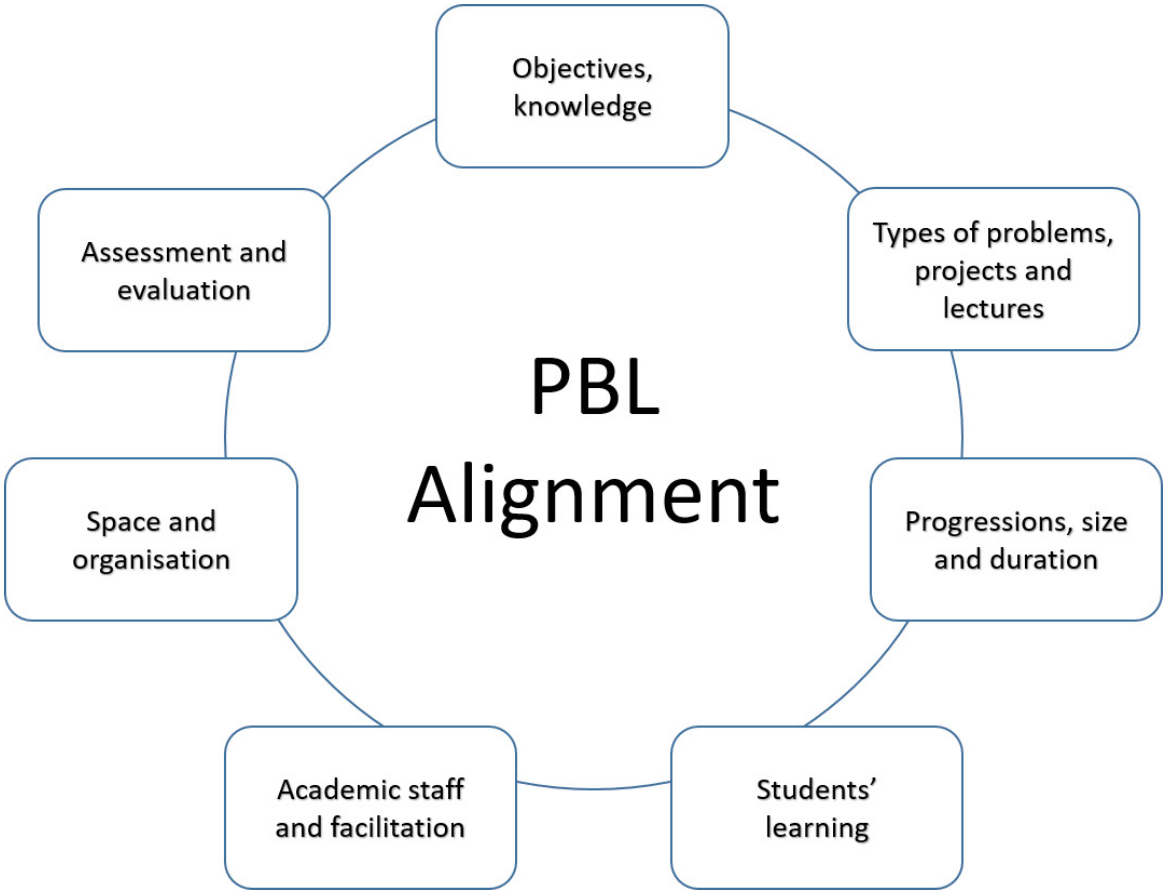

Figure 1. PBL alignment of elements in the curriculum (Kolmos et al, 2009:15)

The alignment of the elements in the curriculum means that changing one element will result in a change in the other elements. Combining the model from Savin-Baden (2007) with the model of PBL alignments result in a model with many variations of PBL in practice. The many variations in PBL practices are indicated as seen in table 1. The discipline and teacher-controlled approach and the innovative and learner centred approach (student centred approach) are the two extremes with many points in between.

Table 1. Spectra of PBL curriculum elements (taken from Kolmos etal., 2009:16)

Curriculum element	Discipline and teacher-controlled approach	Innovative and learner centred approach (student centred approach)
Objectives and knowledge	Traditional discipline objectives Disciplinary knowledge	PBL and methodological objectives Interdisciplinary knowledge

Types of problems and projects	Narrow Well defined problems Disciplined project Study projects Lectures determine the project	Open Ill defined problems Problem projects Innovation projects Lectures to support the project
Progression, size and duration	No visible progression Minor part of the curriculum	Visible and clear progression Major part of course/curriculum
Students' learning	No supporting courses Acquisition of knowledge Collaboration for individual learning	Supporting courses Construction of knowledge Collaboration for innovation
Academic staff and facilitation	No training Teacher controlled supervision	Training courses Facilitator/process guide
Space and organisation	Administration from traditional course and lecture based curriculum Traditional library structure Lecture rooms	Administration supports PBL curriculum Library to support PBL Physical space to facilitate teamwork
Assessment and evaluation	Individual assessment Summative course evaluation	Group assessment Formative evaluation

The above should be seen as a framework for PBL in higher education and the approaches that fall within this framework. Since the article's desire is to gain an understanding of the teachers' roles in relation to working with PBL in htx we in the following work with four ideal types of teaching in secondary schools (Zeuner et al. 2007) to draw parallels to the above PBL framework.

5 Methods for teaching in secondary education

Zeuner et al (2007) defines four ideal working methods for teaching in high school. The communication (mediated) orientation of work, where the teaching is centred around the teacher as a representative of the knowledge - high teacher management. The dialogically oriented way of working, where the teacher is a participant in the learning process. The task-oriented way of working, where the teacher acts as instructor. Finally, the project-oriented way of working, where the teacher acts as a consultant (see table 2).

Table 2: Part of table with four ideal types of teaching from Zeuger et al (2007:371).

	The Communication oriented High Steering Distance Representativ e Classroom	The Dialogically oriented Low Steering Proximity Participant Classroom	The task oriented High Steering Proximity Instructor Study Room	The project-oriented Low Steering Distance Consultant Practice Room
Variations	The lecture The exam (overhøringen) The exemplary experiment	The informal conversation Teacher talk with subsequent discussion Student presentation with subsequent discussion	Management degrees in relation to substance (eg questions) Management degrees in relation to communication (teacher-student conversations)	Degrees of management in relation to: - the length of the project - choice of material - problem formulation - product requirements -student-teacher-conversations during the process

Zeuner et al. (2007) mentions that the teacher types of working depend on the situation. The communication- oriented way of working seems to be most suitable when the subject is difficult - abstract, conceptual etc. (Zeuner et al., 2007:372). This way of working is what is considered as the more classical teacher role, whereas the project-oriented way of work is considered as a facilitator role (see table 2). Regarding project-oriented ways of working Zeuner et al. (2007) comments:

> "In relation to the 1st grade teaching that we have mainly followed, it becomes clear that the challenge for project work will be to establish the right balance between academic discourses and students' own learning processes" (Zeuner et al., 2007:374).

Another argument that emphasizes this point is made in Jeppesen (2020) in relation to htx where the degree of problem orientation is varying from teacher to teacher. Here the teachers do agree that the students have to do project work on their own, but they disagree of how much the teachers should control the process during project periods and introduce academic discourses or the focus should be more on students' centeredness. The question of who is actually in charge of organising the project is thereby being raised. Is it the teachers or the students? And if the students are responsible, when should the

responsibility be transferred to them? The teachers simply agree to disagree. However, what do we see in the classroom?

6 In the classroom

6.1 First-year

Working with several teachers and observing in different classrooms at htx we got insight into the various roles the teachers must take on to teach in the technology subject.
It became very clear from the beginning, visiting these two classes at htx, that the teachers as part of their role in the classroom must be able to fill the role of a classic teacher and perform classic teacher- led classroom teaching which relates to the discipline and teacher controlled approach as described in table 1- in relation to PBL in higher education and to the communication oriented approach in table 2 - related to ideal types in relation to teaching in secondary school. It is especially clear in the beginning of the first year of the study programme where the teachers make use of classicclassroom teaching more often than not in form of lecture etc. and thereby leaning towards a more teacher- controlled approach. When asked about if there is a difference in how much the teachers use different types of teaching approaches and thereby take on different roles as teacher teaching the technology subject a teacher answer:

> " Yes, less and less teacher management (...) We start with PU (Basic course in product development at the first year of the study programme) and we are actually there all the time (...) saying: "now you have to do this now you have to do that". And then when reaching the second year of the study programme the good students, especially in the technical science subject, can manage it themselves (...) As I told you earlier when the students reach the third- year of their study they should be able to control it themselves (...) Then I should dare to let them work freely (Teacher 3, 2019).

In the above quote the teacher expresses his way of teaching and thereby also showing that the roles he takes on teaching changes over time. At the beginning of the first-year of the study the teaching is very teacher- controlled (table 1) and communication oriented (table 2) and the teacher thereby takes on the role of a *classic* teacher using a more teacher centred approach. The teacher tells the students what to do and when to do it. It is also expressed in the quote how that all changes during the second- year of the students' study where the strong students figure out how to manage doing project work themselves. Further, in the students third-year of study all of them should be able to control the project work themselves and the teacher should dare to let them do so; thereby accepting the role as a *facilitator* creating a room for an innovative and learner centred approach (table 1) or a project- oriented approach (table 2) which aligns with the underlying PBL principles in the technology subject.

That fact that the teachers take on the role of *a classic* teacher teaching first-year students is further emphasized when visiting a second school. The teacher in the class we are attending is preparing to teach the students' some theory which they will need later to write their projects and develop their products and then the following happens:

> "The teacher sets out with very classical teaching-led teaching from the start of the lesson. Today's topic for the lesson is sensory theory and basic tastes, logbook, collaboration contract, groups and Adizes four leadership roles. The teacher starts out with showing the students a program about how to retrain the sense of smell. Afterwards the teacher follows up on whether or not the students have read the material for today's lesson by asking the class directly. Two students raise their hands. Subsequently, the teacher embarks on a thorough review of sensory theory including the five basic flavours; sour, sweet, salt, bitter and umami" (Field notes, 14.11.2019).

From the field notes it is clear that the teacher in this classroom accepted the role as a *classic* teacher and thereby, using a teacher centred approach as the teacher controlled the teaching communicating, in this case sensory theory, to the whole class and leaving room for the students to approach the teacher and the rest of the class and ask questions if needed. It also seems the teacher takes on this role as, when asking the students, only two of them have done their homework and read up on the theory for this specific lesson. Then it seems even more pertinent to give the students a thorough review of the theory as they cannot move forward in the process of their project work without it.

It seems that there are also other reasons as to taking on the role of a *classic* teacher and using a teacher centred approach, than having to repeat material to the student, as they did not prepare from home. One of them is teaching inexperienced first-year students. This is expressed by a teacher in the below quote:

> "(...) we also have a great challenge when we give the students a project (...) of a three months duration (...) the students cannot grasp it (...) so you have to rush them all the time (...) And that makes it more or less teacher-led and not really project work" (Teacher 1, 2019).

In the quote the teacher mentions the duration of the projects the students have to work on as a reason why he falls back on the role of the *classic* teacher when working in the technology subject. The students can't grasp or oversee projects that last for months at a time and he as a teacher then has to push the students to finish making it more teacher- led that actual project work as is the intention in the subject. It is also implied that the teacher functions as a *safety net* for the students when rushing them to finish all the elements contained in the projects to make sure they are able to hand in. Another thing that influences the role of the teacher and the teaching method being applied in the classroom is the general formation of the students. In the following quote it is emphasized just how much focus there is on that in the students first-year of study: *"There's a lot of focus on general formation at the first-year level"* (Teacher 5, 2019). When entering a technology class, at first-year level it is very clear that the teachers have the role of an *educator* e.g. in terms of keeping the level of noise in the classroom down to a minimum. A role that seems to be characterised by a more teacher-controlled approach (table 1) or communication-oriented approach (table 2). A conversation between a teacher teaching technology at first and some of the students visualises the role of an *educator* very well. In this specific example the teacher notices a group of students standing across the room talking to other students when they should be working on their own projects and the teacher initiates communication with the students:

> "What are you doing over there?" (...) We are helping with the timetable (students) (...) Okay so four is helping three? (...) Yes (students) (...) Okay I think you should go over here again" (Field notes, 14.11.2019).

In the conversation between the students and their teacher the teacher advised the students to go back to their own seats instead of hanging around some of the other students that are still working on their timetable and in doing so the teacher is trying to affect the students' behaviour in the classroom by taking on the role of an *educator*. This is done in a more direct tone when the teacher presently has assumed another role. In this case the teacher has taken on the role of a *classic* teacher, teaching the class from the blackboard, but feels the need to step out of that role because noise starts to spread across the classroom and to stop the noise the teacher says to the whole class: "*You have to look up here now*" (Field notes, 04.12.2019). Further she adds comments for specific students not paying enough attention: "*Martin sit down*" and "*Jonas you are smiling you are not listening*" (Field notes, 04.12.2019) and in doing that shifts to the role of an *educator* before returning to the role of the *classic* teacher. In the first-year of the students' study the teachers also feel they have to do a lot of scaffolding: "*There is a lot of scaffolding at the first-year level. At the second- year level it is much easier. Then you say brainstorm and then they know what to do*" (Field notes, 04.12.2019). The teacher here is indicating that there is a lot of scaffolding to do in the students first-year indicating that the teachers have a role as the students' *safety net* making sure the students acquire the set of competences they need to be able to continue their studies. After the first year it changes as the students then know many of the concepts and methods used in the subject of technology.

6.2 Summary first-year

From this first part of the analysis it is clear that a large part of being a teacher teaching the subject of technology in the first-year at htx is handling a hybrid set of teacher roles such as; the *classic* teacher, the *educator* and the *safety net*. All of which are very teacher controlled and thereby can be identified as a more teacher-controlled approach or communication-oriented approach. At the same time, it is identified that there are different reasons as why the teachers take on these roles. Some of these reasons seem to be; the students are not experienced in doing projects yet, the students need teaching in theory and methods relevant to their projects, the students do not always prepare for the lectures and the students still lack the general formation related to attending an education in secondary school

6.3 Third-year

Starting up a project in the students third-year of study takes place differently than the previous years. Below is a description of an observation from a third-year class where they are just about to start up a new project period. This project period covers the last project they will have to do while attending the Danish higher technical examination programme:

> "The teachers start out by laying out the outlines for the coming project period. Afterwards the teacher emphasises that she now longer is their teacher but only takes on the role of supervisor. Subsequently, the students withdraw to their groups and start working" (Field notes, 03.02.2020).

The teacher therefore in the beginning of the lecture expresses explicitly to the students that her role has changed from the previous project periods. In relation to this last project they have to do the teacher is no longer the teacher implicating that the students should have learned everything they need to know by now and that they now have to prove that. The teacher can therefore no longer take on the role of a *classic* teacher. Instead the teacher, for this last project, will take on the role as a *supervisor*. Thereby the control of the overall project is shifting from the teacher to the students. In the observations from the field notes it is also shown that the students accept that shift of the control willingly and are taking on the responsibility.
A similar statement is made by another teacher in a another third-year level class:

> "All the students meet in the class in the morning. Eighteen students showed up. Subsequently, the teacher states that the students themselves are masters of their own time in relation to the project. The students manage their projects themselves and ask if they need help" (Field notes, 05.02.2018).

When the students reach the third-year of their study it is very evident that the focus has changed from a more teacher-controlled approach to a more innovative and learner centred approach or a project-oriented approach with low steering from the teacher. This is both evident when looking into the classrooms but also in the questions asked by the students. In the below observation from a third- year technical science class a small detail on the black board makes it clear that what is happening in this classroom is no longer teacher- controlled: "*On the board is a list of groups that need help from the teacher*" (Field notes, 06.04.2018). The students now have to keep track of - and ask for supervision themselves when they need it. The students are now more actively defining the teacher role. The teacher in this class is taking on the role as a *facilitator* letting the students be in control of their own projects.
At the same time it is also clear that the teachers at the students third-year of study hold back and are very conscious about how much technical information they provide the students with and how much the students gather for themselves which is illustrated in the below quote:

> "Now you have asked something and I have answered a little too much (Teacher) (...) That has been seen before (Student) (...) Yes, it has been seen before. That's because I get caught up in it (Teacher)" (Field notes, 06.04.2018).

The teacher is very conscious about the fact that he/she is taking on the role as a *technical* wizz helping the students answer technical questions they themselves should find answers to and at the same time also about the fact that he/she is not taking on the role as a *facilitator* like the teacher should as the students actually can handle a lot themselves at this stage. At the same time the students are also conscious about it and seem to know that the teacher sometimes gets caught up in answering their questions and find it somewhat enjoyable as the comment; "*That has been seen before*" is said with a big smile on the students face. The fact that the teacher is very aware that he/she digs too deep and explains too much when the students ask questions also emphasizes the next quote where another teacher expresses the following; "*The attitude is that the students should have learned it by now. If not, it's too late*" (Field notes,

05.02.2018). What is expressed in this quote is that in the third-year of the study programme the students should have learned by now what they need to know to write a good project and create a good product. Even so it seems there is a paradox between knowing the students should know what they need to know to do project-work and what is expressed in the quote before about answering a little too much on the students' questions and to that a teacher adds;" we *can't just let the students crash and burn here either"* (Teacher 3). In the quote the teachers express a paradoxical situation in which it is implied that they as teachers are caught between the choice of acting as a *safety net catching the students when they fall* or letting them *crash and burn* when doing project work.

6.4 Summary third-year

From the second part of the analysis it is clear that a large part of being a teacher teaching the subject of technology in the third-year at htx is about handling another hybrid set of teacher roles than when teaching the first-year students. Some of the roles the teachers have to take on when teaching third- year students are; the *supervisor*, the *facilitator* and the *safety net*. The first two roles; *supervisor* and *facilitator* are very innovative and learner centred or project-oriented where the students are controlling the projects themselves. The difference from the first- to the third-year is that the roles seem to be taken almost automatically by the teachers and the attitude is; "*(...) that the students should have learned it by now. If not, it's too late*" (Field notes, 05.02.2018). The one role that is still taken on by the teachers in the third-year is the role as a *safety net*. So even though the attitude is that students should know the material by now and if they do not it is too late the teachers in the utmost consequence still function as safety nets for the students - they step in and help if needed.

7 Findings and discussion

What can be seen from the findings in the classroom is that the teachers' role changes very significantly during the three years from first grade to third grade. Compared to table 1 and table 2 there is a movement from left to right in the tables. A move from a classical teacher role to a role that very much is the facilitator role. At the third grade the students know what to do. They know what is expected, when the teacher says 'brainstorm' etc. Still the teachers are caught in a dilemma. Shall they catch the students when they fall or let them crash and burn? That dilemma can be related to table 1 and the alignment of the curriculum in a PBL environment. At htx the students are not responsible for their own learning, like they are in the higher educations. PBL in higher education is characterized by a student-centred approach whereas in a htx context it is generally more teacher centred. At htx it is the teacher that is responsible for the students learning. It is clear when we observe a class where the students did not prepare for the project work. Then the teacher immediately switched for the facilitator role to the classical teacher role. How about preparation for the next time? Do the students read the text or wait until the teacher gives a lecture? Moreover, the alignment of the curriculum is important compared to the different maturity levels of the students. The students inthe first year cannot grasp a project duration for three months. It is too long. Whereas for third year students it may not be a problem. The role of the teachers needs and the curriculum need to be aligned with the point of departure of the students. Besides switching between the division of the teachers working areas in table 2 covering from the classical teacher to the project-oriented teacher - facilitator, the teacher in htx has other roles. Roles that are more social related or technical oriented like the social worker, the educator, the technical wizz, the practical helper, a master role in the workshop and

not least the safety net. Roles that cannot be ignored looking at the overall teacher responsibilities in htx.

What about students in higher education using a PBL learning philosophy? Are the findings in this paper comparable to students in higher education or is it two different worlds? When students enter higher education like AAU they start working in a PBL environment. Students who have studied at htx are used to the challenge of working problem based. But what about students from other secondary school institutions like stx or hhx? They are not used to the PBL environment. When they enter the university the role for the teachers has changed totally. Now it is a facilitator role and the responsibility for learning has become student centred. The transition from secondary school to the university can be very hard for students not used to the PBL environment. Moreover, the mindset from the different students in a programme at the university cover the same range of PBL understanding as we have seen in table 1. That situation is comparable with the situation of the teachers at htx, with a very significant difference. At htx the teacher is responsible for the students learning which put them in a strong dilemma in a PBL context. They are not 'allowed' to let the students crash and burn.

8 Conclusion

The focus of the paper was to draw out empirical findings to clarify the breadth of the hybrid role of the teachers when teaching the technology subject at htx. The findings did support that the teachers at htx have a very complex and wide role. A role that changes from teaching first year students to teaching third year students and also a role that changes depending on the strength of the individual students. In relation to this it was found that the teachers not only have to shift between teacher- centred and student-centred learning (and the ones placed in between) the teachers at the technology subject also have to take on many other different roles ranging from the social worker and the safety net to the practical helper and a master in the workshop. Moreover, it became obvious that the role creates a dilemma for the teachers, trying to use PBL as a learning philosophy, however with a teacher centred responsibility for the students learning. This dilemma tends to be a restriction for the teacher in their teaching. They are not allowed to let the students crash and burn and the expectation from the students is that the teacher will be the security net in the end. Looking at figure 1 and the need of alignments of the elements in PBL calls for a clear support for teacher training to be able to work with this hybrid role. With recognition and knowledge of the hybrid role of the teachers of the technology subject at htx in more detail it is possible to identify some avenues for future pedagogical development of technology teaching at htx.
At the same time - knowledge of the role of the teachers teaching the subject of technology at htx in more detail and that being of a very hybrid character is valuable knowledge for the teachers and supervisors teaching at the first semesters at Aalborg University. With that knowledge it is possible to adjust the facilitation in the PBL environment to the different point of departures regarding first year students coming from htx, stx and hhx.

9 References

Davies, J., de Graaff, E., & Kolmos, A. (Eds.) 2011. *PBL across the disciplines: Research into best practice*. Aalborg: Aalborg Universitetsforlag.

Graaff, E. and Kolmos, A. 2007. History of problem-based and project-based learning. In Graaff, E. and Kolmos, A. (Eds.) Management of change - Implementation of problem-based and project- based learning in engineering. Netherlands: Sense Publishers.

Guerra, A et al (Eds.) 2017. PBL in Engineering Education. Netherlands: Sense Publishers.

Guerra, A & Kolmos A. 2011. PBL across the disciplines: Research into best practice. Aalborg: Aalborg Universitetsforlag, 3-16.

Henriksen, L. B. 2016a. Are they ready?: The Technical High School as a Preparation for Engineering Studies. In M. J. de Vries, L. Gumaelius & I. B. Skogh (Eds.). Pre – university Engineering Education. Rotterdam: Sense Publishers.

Holgaard, J.E., Ryberg, T., Stegeager, N., Stentoft, D. & Thomasen, A.O. 2014. PBL - Problembaseret læring og projektarbejde ved de videregående uddannelser. Frederiksberg: Samfundslitteratur.

Jans, J. 2007. Et eksperiment i modvind [An experiment in headwinds] In Kjærgård, P.M., Bendix, U., Johnsen,
V. T. & Andersen P. S. (Eds.). *HTX 25 år med teknisk gymnasium – fra eksperiment til anerkendelse* [HTX 25 years with the technical high school - from experiment to recognition]. Odense: Erhvervsskolernes Forlag, 10- 23.

Jeppesen, M.M. 2020. "Agree to disagree": technology teachers' perceptions and practices of problem-based learning (PBL) in the Danish higher technical examination programme. In review at: Journal of problem-based learning in higher education.

Kolmos, A. 2017. PBL in Engineering Education. Netherlands: Sense publishers, 1-12.

Kolmos, A., Graaff, E. and Du, X.Y. (Eds.) 2009. Research on PBL practice in engineering education. Rotterdam: Sense publisher, 9-21.

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.

Krogstrup, H.K. & Kristiansen, S. 1999. *Deltagende observation – Introduktion til en forskningsmetodik*. København; Hans Reitzels Forlag A/S.

Ministry of Children and Education (2017) The Ministerial order: HTX https://www.uvm.dk/gymnasiale- uddannelser/love-og-regler/love-og-bekendtgoerelser (accessed 18 May, 2020).

Ministry of Children and Education (2017). Curriculum, Technology subject A and B https://www.uvm.dk/gymnasiale-uddannelser/fag-og-laereplaner/laereplaner-2017/htx-laereplaner-

2017
(accessed 18 May, 2020).

Müller, J., Remmen, A., & Christensen, P. 1984. Samfundets teknologi – Teknologiens samfund. [Society's technology – Technology's society]. Herning: Systime A/S.

Olsson, F. A. 2007. En pioner blev uundværlig [A pioneer became indispensable] In Kjærgård, P.M., Bendix, U., Johnsen, V. T. & Andersen P. S. (Eds.). *HTX 25 år med teknisk gymnasium – fra eksperiment til anerkendelse* [HTX 25 years with the technical high school - from experiment to recognition]. Odense; Erhvervsskolernes Forlag, 6-7.

Savin-Baden, M. 2007. Management of change. Implementation of problem-based and project-based learning in engineering. In Graaff, E. and Kolmos, A. (Eds.) Management of change - Implementation of problem-based and project-based learning in engineering. Netherlands: Sense Publishers, 9 - 29.

Trist, E. & Bamforth, K. 1951. Some social and psychological consequences of the longwallmethod of coal-getting. *Human Relations, 4*, 3-38. doi: 10.1177/001872675100400101

Zeuner, L., Beck, S., Frederiksen, L. F., Paulsen, M. 2007. *Lærerroller i praksis*. Syddansk Universitet. Institut for Filosofi, Pædagogik og Religionsstudier. Gymnasiepædagogik, Nr. 64.