Problem-Based Learning and Deep Learning Approach in relation to Self-Directed Learning

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A Master thesis by

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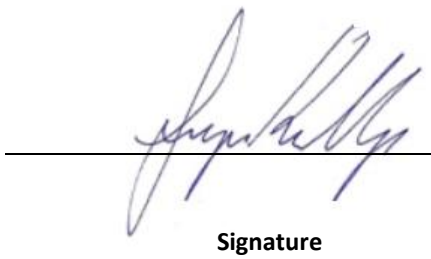

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Abstract

It is widely accepted that a deep learning approach and enhanced Self-Directed Learning skills are benefits of a Problem-Based Learning environment. The aim of this study was to investigate the relationship between a deep learning approach and Self-Directed Learning skills in general and in relation to a Problem-Based Learning environment. To analyse students' perception of their SDL skills and deep learning approach, quantitative measurements were conducted in three consecutive semesters as well as before and after a single PBL course. To support the quantitative data, interviews were conducted. It was found that a single PBL course does not foster significant differences in deep learning approach nor SDL skills. This Research suggests general PBL experience implies greater SDL skills. Finally, this research shows a relation between a high level of deep learning approach and a high level of SDL skills.

Keywords

- Self-directed learning
- Deep learning approach
- Problem-based learning

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Chapter one - Introduction and problem statement

1.1 Introduction

A major stimulus for recent transformation of the Bachelor of Technology Management and Marine Engineering education is a profound wish to prepare graduates for lifelong learning in a constantly expanding and changing world of knowledge (SIMAC 2015). Knowledge and creativity together with continuous personal development of skills are main components of the requirements of globalization and technology development.

Lifelong learning has been recognised as an important skill of modern education for many years. From a political point of view, lifelong learning has been an important focus point, which is reflected in the European Community guidelines on higher education (High Level Group on the Modernisation of Higher Education 2014). Lecturers are encouraged to introduce learning environments where they change the approach from a teacher centred to a more student centred approach.

According to Collins Dictionary (2015), lifelong learning can be defined as:

"The provision or use of both formal and informal learning opportunities throughout people's lives in order to foster the continuous development and improvement of the knowledge and skills needed for employment and personal fulfilment."

Lifelong learning can broadly be defined as learning that is pursued throughout life for either personal or professional reasons. The basis of lifelong learning is learning to master learning tools instead of acquisition of structured knowledge. This includes the ability to analyse problems, define what needs to be learnt, gather and evaluate information and awareness of own limitations. The rationale is then, that the students, who develop such skills, will be ready for any requirements of the future and will continue to learn and develop their entire life, even when they are not part of a formal learning programme. Self-directed learning (SDL) can be associated with lifelong learning. Self-directed learning requires learners to be aware of cognition, metacognition and self-regulation. This includes the ability to reflect about what the learner do and do not understand. The learner must be able to set learning goals and plan their learning and select appropriate learning strategies. The learner must also be able to evaluate the learning process.

Self-directed learning skills can be fostered in formal education by the use of collaborative learning principles. Curriculums based on Problem-based learning (PBL) is an example hereof. One of the advantages of education based on Problem-based learning (PBL) is the ability to promote retention and application of knowledge and its encouragement of self-directed lifelong learning. Problem-based learning develop self-directed learning skills, as the learner is aware of own cognition, metacognition and self-regulation as part of the learning process. The students can thereby develop self-directed learning (SDL) skills when applying problem-based learning. (Hmelo-Silver 2004)

Problem-based learning is said to direct students into a more deep learning approach (Biggs 1999). PBL is situated around real-world problems and helps students to become active learners and take responsibility for their learning (Hmelo-Silver 2004), thus engaging students in a deep learning approach.

1.2 Problem statement

As described above lifelong learning can be associated with self-directed learning. Self-directed learning can furthermore be associated with Problem-based learning, which again can be linked to a deep learning approach of the learner.

Enhanced lifelong learning skills are a desirable goal for learners to achieve, but the direct measurement of the development of Lifelong learning skills over a lifetime is restrained by time limitations. Instead of direct research of Lifelong learning skills, research of learners' ability of Self-directed learning, and deep learning approach can give an indication of learners anticipated ability of Lifelong learning. Even though, Self-directed learning, Problem-based learning and deep learning approach can all be associated with Lifelong learning, the direct relation and influence in between them is uncertain.

The purpose of this research is therefor to investigate relationship between students' use of a deep learning approach and their perception of their Self-directed learning skills. Also to be researched is if the level of deep learning approach and perception of SDL skills is influenced by a single PBL course or PBL experience in general.

1.3 Research question

- What is the relationship between students' perception of their self-directed learning skills and deep learning approach in relation to a specific PBL course?
- What is the relationship between students' perception of their self-directed learning skills and deep learning approach in relation to PBL experience in general?
- What is the relationship between students' perception of their self-directed learning skills and deep learning approach?

1.4 Purpose of study

The purpose of this paper is to explore students' deep learning approach and perception of SDL skills, developed through a PBL environment and general PBL experience. It is hypothesized that:

- Students level of deep learning approach and perception of SDL skills will increase when working in a PBL course
- Students' level of deep learning approach and perception of SDL skills will increase with PBL experience in general.
- Students perception of their level of SDL skills is related to their level of deep learning approach

1.5 Significance of study

This paper seeks to contribute to the existing research by conducting a study involving students at a maritime academy, by assessing their perception of their SDL skills as well as their learning approach. This research intends to contribute with a scientific study of students' development of their perception of SDL skills in a Marine Engineering education in general and in relation to PBL. The research also aims to elucidate if a deep learning approach promotes students perception of SDL skills among maritime engineering students.

1.6 Definition of terms and abbreviations

Self-directed learning [SDL]: A process where learners take initiative in deciding their learning needs, decide learning goals, identify resources needed, decide and manage learning strategies and evaluate learning outcome.

Problem Based learning [PBL]: An educational approach that centres around the students' work and real-world problems. The learning results from the process of solving the problem.

Deep learning approach: An approach where learners actively engage in the learning process that includes critical analysis, understanding and application of knowledge.

Bachelor of Technology Management and Marine Engineering [Marine Engineering]: Education in Denmark designed to qualify students to be responsible of operation and maintenance of technical equipment and installations, operated to optimum safety, economic and environmental consideration on a management level on ships and in shore based companies. (SIMAC 2015)

1.7 Outline

The project will be structured the following way.

- I**ntroduction:** Description of the background of this research, research questions and significance of this study
- **Theoretical and conceptual background:** Description of the theoretical background of this research and reference to similar researches
- **Context of research:** Description of the educational institute, education and course where the research takes place
- **Research methodology:** Description of research variables and the tools used for data collection
- **Collection of data:** Presentation of the collected data
- **Analysis and discussion of data:** Discussion of the collected quantitative and qualitative data
- **Conclusion:** The conclusion of this research and reference to other relevant studies
- **Recommendation for further studies**

Chapter two – Theoretical and conceptual background

In this chapter the theoretical background of this research will be presented. First an overall presentation of theory behind Problem-based learning, Self-directed learning and students learning approach will be done. Following this, examples of previous relevant studies of the topics will be made.

2.1 Introduction

PBL has many possible uses in the educational field and has also shown to sustain the principles of lifelong learning. From a political point of view student centred education is emphasized. In the European Community guidelines on Higher Education, lecturers are encouraged to introduce learning environments where they change the approach from a teacher centred approach to a more student centred approach as stressed below in the citation from a report made by the High Level Group on the modernisation of higher education.

"*… From the mere transmission of information to a co-partnership in learning, can have a worthwhile, meaningful impact on both the learning and the teaching experience…. Its recommendations called for a change in attitudes towards the teaching mission, by introducing greater professionalism in teaching, more student engagement in the learning process and better recognition of good teaching."* (High Level Group on the Modernisation of Higher Education 2014, 19)

PBL and the effects here of have been thoroughly researched the last decades in various aspects of student learning. These aspects include students' problem solving skills (Hmelo-Silver 2004), self-directed learning (Lee, Mann and Frank 2010) and students' learning approach (Papinczak 2009).

2.2 Problem-based learning

Problem based learning (PBL) has received much attention in the recent decades due to its student centred teaching/learning approach, which increases students' development of important process skills. PBL started as an educational strategy and was later systematically introduced at the McMaster University in Canada in the 1960s. According to Barrows and Tamblyn problem-based learning can be defined as the following:

"Problem-based learning can be defined best as the learning that results from the process of working towards the understanding or resolution of a problem." (Barrows and Tamblyn 1980, 18)

Barrows and Tamblyn (Barrows and Tamblyn 1980, 1-19) stipulate that the problem is encountered first as part of the learning process and acts as a motivation factor in the application of problem-solving as well as in the process of searching for information needed to understand the mechanisms behind the problem and how it might be resolved.

Hmelo-Silver defines PBL as:

"*An instructional method in which students learn through facilitated problem solving*." (Hmelo-Silver 2004, 1)

PBL requires the student to actively participate and to form their own goals of learning as well as to take responsibility for their own learning. Students have to plan and learn by themselves, which is necessary to solve the problem. In a profession, the ability to direct one's own learning is important for continuous competence development.

Developing a group of individuals into highly motivated and effective PBL students is a challenge. All students and classes are different. Students' prior experience of working in a PBL environment is vastly different, which requires competencies

that they may not develop in a traditional individual based learning environment. The students are the centre of the teaching, and together they create their learning as well as their identity, which is of great importance as stressed by Wenger:

"*Participation here refers not just to local events of engagement in certain activities with certain people, but to a more encompassing process of being active participants in the practices of social communities and constructing identities in relation to these communities"* (Wenger 2000, 4)

A main part of PBL education is the problem. The problem is the initial part of the students' learning, their motivation to be part of the process and therefore result in the students' acquisition of new knowledge and skills. The requirement of solving problems in groups as part of PBL, gives the students the opportunity to develop their problems solving skills, their group process skills and their self-directed learning skills. (Dolmanns, et al. 2005)

The designs of effective PBL problems have also been widely discussed by researchers. Research, guidelines and suggestions for creating effective PBL problems have been provided (Hung, Mehl and Holen 2013). Effective PBL problems should consider students' prior knowledge and use weakly-structured and real-life problems, which enhance collaboration between group members and promote self-directed learning. (Dolmanns, et al. 2005).

Research of PBL has given evidence of the effectiveness of PBL on students' learning. John Biggs and Catherine Tang (Biggs and Tang 2011) have found that PBL promotes student to use a deep learning approach instead of a surface learning approach. Maggi Savin-Baden (Savin-Baden 2003) has found that the use of PBL helps students develop criticality. Hmelo and Evensen (Evensen and Hmelo 2008, 1-18) have found that the use of PBL improves students' self-directed learning capabilities. However, Abrandt Dahlgren and Dahlgren (2002) made a qualitative analysis with the aim to describe and analyse how students at three different study disciplines conceive of the meaning of problem-based learning. The findings showed that students in two out of three disciplines found uncertainty about what to study.

Downing et al. (Downing, Shin and Kwong 2007) have conducted a research at City University of Hong Kong to investigate if PBL enhance metacognition. They studied 66 first year undergraduate students from two programmes at the university. One with a PBL approach and one with a traditional learning approach. The students attending the programme with a PBL approach had a substantial lower academic entry level. After 15 months, the students' developments were measured and the students attending the programme with a PBL approach showed a large improvement in relation to metacognition, compared to the non-PBL programme. The non-PBL programme displayed a stagnant level of metacognition.

2.3 Self-directed learning

The principles behind Self-directed learning (SDL) skills, which can be associated with lifelong learning (Hmelo-Silver 2004), presents an attractive solution to the ceaseless growth of engineering knowledge for developing graduate engineers, who can sustain the educational demands of continuing professional development. According to Knowles (1975);

"self-directed learning describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes". (Knowles 1975, 18)

Self-directed learning is the process where group members identify the knowledge and skill demands of their problem, assess their own competencies with respect to these, identify learning issues in relation to what more must be learned as well as locate and use effective resources to address their identified deficiencies. (Kelson and Distlehorst 2008)

The students' ability of SDL can hereby be divided up into their ability to design, organize and monitor their own learning process. SDL is therefore a process that happens all the time, when the students are learning, and not just during the formal education. This requires the students to have much control and responsibility of the organization of their learning. Students that actively use SDL are often found to be proactive and able to motivate themselves.

Knowles (Knowles 1975) states that learning is not a process that takes place in isolation, but in association with others. This could for instance be in association with teacher, tutors and peers. Learning can therefore be placed on a scale, going from teacher oriented at one extremity to self-directed at the other extremity. When shifting from one extremity to the other, the control of the learning changes as well, together with the freedom to identify learning needs and strategy to overcome the learning issues.

Self-directed learning implies that the students have an active role in the management and monitoring of their own learning process. That the students are active in relation to management implies that the students explore alternatives and make sound decisions in relation to their learning and that they are able to formulate their own questions and generate own inquiries. A high ability of self-directed learning implies that the student manages their own workload and time effectively, as well as reflects on their own learning and use feedback to improve their learning process.

Self-directed learning is a main characteristic of the challenges students are faced with, when engaged in PBL (Yew, Chng and Schmidt 2011). The students have to self-direct their own process when solving their problem. PBL has the advantage of suggesting a method to promote active and reflective knowledge building.

Students with a high ability of self-directed learning are able to extend the reach of their learning. The students are able to apply learning in a new context and learn beyond the curriculum. To embrace this the students are required to be able to take ownership of their own learning as well as identify potential learning gaps and set new learning goals together with identification of learning tasks to achieve these learning goals.

Self-directed learning involves not only management and insight in own learning, but also motivational self-direction. Motivation is an essential part of sustaining and promotion of self-directed learning (Dolmanns, et al. 2005). To maintain a high level of motivation, students' self-efficacy is an important aspect of SDL. As students' independent work is a major part of the students' learning, a high level of self-efficacy is desirable. Enhancement of students' perception of their self-efficacy is a variable that can be improve by using active learning principles, i.e. Problem based learning. According to Dale Schunk, self-efficacy is a person's perception of its capabilities to produce actions. Self-efficacy is strongly connected to effort and task persistence. Individuals with a high level of self-efficacy are more prone to exert effort when faced with difficulties they have the necessary skills to solve. (Schunk 2012)

According to Schunk (Schunk 2012) higher self-efficacy leads to sustained motivation when students believe that continuous work will allow them to fulfil their goals. Students who fulfil their goals are also more likely to apply new goals. Connecting the students learning environment with PBL is done with a goal of increasing the students learning outcome. Self-efficacy for a specific task may be influenced by many internal factors, i.e. preparation, physical condition and general mood. External factors that influence self-efficacy could be the specific task, as well as both the surrounding physical and social environment. (Schunk 2012)

When working in a PBL environment students' motivation and frustration is of major importance. If students lack SDL skills, they can be frustrated and not be able to set proper learning goals to achieve, however, Hmelo-Silver (2004) states that the use of PBL can help students develop SDL skills as well as intrinsic motivation.

SDL skills are something that can be learned and developed over time. Li, Favreau and West (2009) suggest that self-assessment and self-directed learning skills are not innately present. These skills are instead developed over the course of training and by the gathering of experience. They recommend the implementation of curricular activities to support the development of self-assessment and self-directed learning skills. The research they have done is based on a mixed-method combining a quantitative survey with qualitative comments. As students' years of study experience increases, their SDL skills also evolve. This was also found by Evensen and Hmelo (Evensen and Hmelo 2008) in a qualitative analysis of six medical students.

It is suggested by several researches that there is a relation between PBL and development of SDL skills. SDL skills in a hybrid PBL environment were examined by Lee, Mann and Frank (2010) and their findings show that students and faculty focus groups support the perceived positive influence the hybrid PBL curriculum has on SDL. They found that the students' perceived SDL skills are influenced positively by several components of the hybrid PBL curriculum, though they recommend further investigations are to be conducted. Moshe Barak (2010) have proposed a compensative model for self-regulated learning in technology education that suggests that teaching students problem-solving strategies help them improve their individual thinking and reflection about their learning. The students' beliefs about their self-efficacy in relation to problem-solving and creativity is also enhanced. He found that people's self-efficacy is highly correlated with people's ability to regulate their own learning. With self-efficacy, he means people's beliefs about their ability to accomplish a task successfully, which can be determined by previous positive experiences in dealing with similar tasks, as well as by a supportive social and emotional environment.

2.3.1 Measuring self-directed learning

To make students' ability of Self-directed learning measureable, SDL can be divided up into three components:

- Ownership of learning
- Extension of learning
- Self-management and monitoring

These three components are based on the above-mentioned theories about SDL and each component is further described below here.

The learners personal attributes are important to SDL, especially possessing personal responsibility in learning. Brockett and Hiemstra (1991) argue that personal responsibility is a cornerstone of SDL. Students who take personal responsibility in learning have ownership of their own learning and their learning goals. Developing ownership of learning is also closely related to the motivation to learn. When students are taking ownership of their learning, they can identify, determine and articulate their own learning goals. They can identify necessary learning tasks to achieve the goals and they challenge themselves and set the standards for the achievement of their learning goal.

Students control of their extension of learning refers to how much control students have about the choice of what to learn, how to learn and how to evaluate the learning. Indicators that students have control of their extension of learning are that, student applies what they have learned into new contexts and that the students use the skills they have learned to learn beyond the curriculum.

Self-management and monitoring is also a cornerstone of SDL according to Brockett and Hiemstra (1991). Self-management and monitoring focuses on both cognitive and metacognitive aspects of learning, where cognition refers to making meaning of information and integrating new knowledge into existing knowledge. Metacognition refers to thinking about thinking which again refers to students' ability to reflect on their own learning. Indicators that students manage and

monitor their own learning could be that students explore a range of possibilities and make sound decisions. The students plan and manage their time independently and that students critically reflect on their learning.

These three components of SDL correspond to activities the student has done before, during and after a process with self-directed learning. According to Zimmerman and Lebeau (2008) the three aspects can also be directly compared to the major components of self-regulated learning, namely forethought, performance and self-reflection.

Forethought includes goal setting, task analysis strategies and self-motivational beliefs, such as self-efficacy. Performance includes the use of strategy and self-observational processes. The self-reflection component relates to self-judgement and self-reactions. (Zimmerman and Lebeau 2008)

According to Zimmerman and Lebeau (2008) a number of instruments were developed during the 1980s that can measure SRL abilities. Among these are the Learning and Study Strategies Inventory (LASSI). The LASSI test is designed to be a screening measure to help students develop greater awareness of their learning and studying strengths and weaknesses. This questionnaire measures the components Will, Skill and Self-regulation in relation to study strategies. (Weinstein and Palmer 2002)

The Will component of the LASSI test measures students' receptivity to learning new knowledge together with their diligence and self-discipline. The Will component is used to measure the forethought component of SRL and the Ownership of own learning in relation to SDL. (Zimmerman and Lebeau 2008) (Weinstein and Palmer 2002)

The Skill component of the LASSI test measures students' skills and thought processes related to identifying, acquiring and constructing meaning of new knowledge. The Skill component can measure the performance component of SRL and the Extension of own learning component of SDL. (Zimmerman and Lebeau 2008) (Weinstein and Palmer 2002)

The Self-reflection component of the LASSI test measures how students self-regulate and control the whole learning process through management and monitoring of their learning. The Self-reflection component is used to measure the Self-reflection component of SRL and the Self-management and monitoring component of SDL. (Zimmerman and Lebeau 2008) (Weinstein and Palmer 2002)

2.4 Students learning approach

One of the benefits of PBL, is said to be a higher degree of deep learning approach, as the students are activated and part of the learning environment. Social constructivism stresses the collaborative nature of learning and suggests that meaningful learning is the result of active social and cultural interaction as suggested by Vygotsky and his theory of zone of proximal development (Illeris 2004). Biggs and Tang (2011) suggest that PBL creates a higher level of student activation and also a higher level of student engagement. According to Biggs and Tang (2011), active collaborating students will increase learning outcomes, compared to a passive learning environment.

Tracey Papinczak (2009) has made a preliminary study investigating if deep strategic learners are better suited to PBL. The purpose of this study was to investigate if deep strategic learners found PBL more enjoyable and supportive of their learning. A combination of qualitative and quantitative data were collected and based on that it was found that students could be categorized into learning approach. The students categorized as deep strategic learners were found to be more efficacious and scored higher scores on written examinations. Deep strategic learners were also found to be less vulnerable to stress during their study.

2.4.1 Surface learning approach

The principles behind a surface approach to learning, is to get the task done with a minimum effort, with no regard to the intended learning outcomes of the curriculums.

Behind a surface learning approach are low cognitive-level activities such as rote learning selected content, instead of a deeper understanding of the content. Rote learning in itself is not necessarily a surface learning approach. It depends on the context in which rote learning is used. If the academic task is to achieve an understanding of a topic, and rote learning is used to give the impression that deeper understanding has occurred, it can be defined as a surface learning approach. The assessment method can be an important tool to limit students' use of a surface learning approach. If a surface learning approach is to be avoided, the assessment method should not allow the students to get a good grade by memorizing facts, but encourage the student to demonstrate a deeper understanding (Biggs and Tang 2011), According to Biggs and Tang there are limitations though;

"Even under the best teaching some students will still maintain a surface approach." (Biggs and Tang 2011, 26)

Students approach to learning can often be found to be a response to the teaching and assessment method, if the curriculum, teaching and assessment are not all aligned.

2.4.2 Deep learning approach

A deep learning approach comes from a motivated need to engage in a learning task, in order to create a deeper understanding of a topic. To do so, students use learning activities that promote deep learning to understand the underlying meaning of the topic. According to Biggs and Tang (2011) the following can be said about a student with a deep learning approach:

"When using a deep approach in handling a task, students have positive feelings: interest, a sense of importance, challenge, exhilaration. Learning is a pleasure. Students come with questions they want answered, and when the answers are unexpected, that is even better." (Biggs and Tang 2011, 26)

To enhance this kind of learning requires a lot from both the student and the teacher. The teaching method must encourage a positive working environment, allowing students to make mistakes and learn from them. The teacher must ensure that the curriculum, teaching method and assessment tool is properly aligned. This is known as constructive alignment as suggested by John Biggs (Biggs 1999, 95-110). The idea is that the intended learning outcomes are used to decide student learning activities. The teacher's role is then to facilitate a learning environment encouraging students to participate in the learning activities. Focus is on what the student does and learns. In a good constructive aligned course, the intended learning outcomes, the teaching/learning activities and the method of assessment are properly aligned to support each other.

2.4.3 Measuring surface and deep learning approach

Students' learning approach can be influenced by the teacher as well as by the teaching method and model of assessment. Measurement of students learning approach as feedback to teaching methods is therefore important for future improvements. Students' learning approach can be measured by questionnaires made for the same purpose. Biggs has developed a questionnaire that measures two factors of students learning approach, i.e. deep and surface approach, and translates the two factors into a measureable score. Respondents' results illustrate the quality of the teaching environment, because students adapt to the expected requirements of the teaching environment. The scales of both deep learning approach and surface learning approach in Biggs two factor questionnaire can be divided up into two subscales, Strategic and Motive. In relation to deep learning, the subscale Motive indicates an intrinsic interest and wish for

achievement while the subscale Strategy indicates a wish for effective use of space and time to maximise meaning. (Biggs, Kember and Leung 2001)

Chapter three - Case study

3.1 General description of case study

In the following section a presentation of the academy where the research is conducted is made, a presentation of the education and the students as well as a presentation of the pedagogical principles of the academy.

3.1.1 The academy

The data collection of this research takes place at Svendborg International Maritime Academy (SIMAC) in the fall semester of 2014. SIMAC is a maritime academy offering educations as master mariner, ship's officer and marine engineer. The academy has approximately 750 full time students and employs approximately 40 full time lecturers. The academy was established in 2001, as a fusion of Kogtved Søfartsskole, A.P. Møller Maersk Værkstedsskole, Svendborg Navigationsskole and Svendborg Maskinmesterskole. SIMAC is an institution placed under the Ministry of Higher Education and Science.

3.1.2 The education

The research is conducted in relation to students attending three consecutive semesters of the Bachelor of Technology, Management and Marine Engineering education (Marine Engineering education).

The marine engineer education is a broad technical education in Denmark, including topics such as mechanical, electrical and automation engineering as well as law, administration and management. SIMAC educates marine engineers aiming for both maritime and land-based operations. Common for both is a focus on technical operation and general management. A marine engineer at sea is in charge of the ship's machinery, i.e. operation and maintenance as well as management of engine crew. The type of ships varies, ranging from merchant cargo ships, passenger ships or specialised ships, such as inspection, safety support or environmental surveillance ships. (SIMAC 2014)

The education is built around 9 semesters, i.e. BM1 to BM9. BM1 and first part of BM2 takes place at a workshop school training students with practical competences to make them ready for their subsequent periods of seagoing service/apprenticeship. The latter part of BM2 and BM3 takes places either on board a ship or in a relevant shore-based company. The semesters BM4 to BM8 are theory semesters. The last semester, BM9, is divided up into the final period with either seagoing service or an apprenticeship ashore followed by the final bachelor project (SIMAC 2014). An illustration of the semester structure from the course catalogue can be seen in appendix D.

3.1.3 The students

The students involved in this research have in general one of two kinds of backgrounds, typically either a high school background or a craftsmanship background. The students' age varies, ranging from start twenties to more than thirty years of age. The students with a craftsmanship background are often seen to be a bit older when beginning the education than the students with a high school background, and they often have more practical work experience. Students with a high School background (Gymnasium, HTX, and HF etc.), is often seen to have more study experience and often more experience with PBL. No exact measurement of this has been made though, and prior statements about students' background, age and experience, are based solely on researcher's own experience.

3.1.4 The pedagogical principles

At SIMAC learning on an overall level is based on a constructivist educational approach. Reflection is recognized as a main aspect of learning, both for students and teachers. Teachers are free to choose teaching method to facilitate and support students' learning. Focus is on students' construction of knowledge, instead of transfer of knowledge. One of SIMAC's core values is "the student in centre" i.e. all the learning takes places with and around the students. The student is given the resources and facilities to engage in the learning process in several layers, including fellow students, study groups, tutors and teachers, as well as physical resources such as laboratory facilities and simulators. At SIMAC it is recognized that learning is an active process, where learners constructs new knowledge based on prior knowledge. The students work form support collaboration and interaction with other students, tutors and teachers as part of the learning process. SIMAC uses systematically group work, as part of the learning process. Study groups of the size of 3 to 6 persons are the main form of student organization. The applied teaching methods used include discussion, dialogue, lecturing, advising, assignments, exercises, cases and projects (SIMAC 2014) (SIMAC 2015). Below in Figure 1 is an illustration copied from the course catalogue of the Marine engineer education. It shows the intended development of the students' academic achievements. The students included in this research belong in the "Basic theory" section.

	Workshop/Frederiksø	Basic theory	Specialisation
Student goals:	• Motivated for study • Safety skills • Basic trade skills • Prepared for seagoing service/apprenticship	• Ready to study • Technical and academic foundation • Prepared for thesis	• Self-developing • Ability to disseminate one's own technical skills • Prepared for the profession
Focus:	• Inclusion • Group relationships • General education	• Educational theory and dissemination • Technical knowledge • Technical and academic skill-sets • Group relationships • Opinion formation	• Technical and academic expertise • Interdisciplinary professional collaboration

Figure 1 - Student academic progress (SIMAC 2014, 7)

3.1.5 Support facilities

As support facilities for the students' learning, two main facilities at SIMAC is available, namely the Open Learning Centre (OLC) and tutors. The OLC is involved in the students learning by supporting their search for information. The tutors are elder students that support fellow students in their project work,

3.2 PBL course at SIMAC

The PBL course at SIMAC is implemented in a single 5 ECTS course in BM5. The course topic is Automation and Process analysis. The PBL is implemented in the course by two modules, combining a practical problem with lectures about process tools, i.e. collaboration, PBL and reflection. The students are taught specific process tools as part of PBL as educational model. The students' learn about the PBL model, structured group work, including the use of different roles such as secretary and chairman. As part of the documentation, they make a process analysis of their learning process. The process analysis includes a description and analysis of their learning, their collaboration as a group and collaboration with the facilitator. Besides this, the students use peer learning, discussion and student presentations as part the learning process.

The PBL course is divided up into two different modules. The first includes development of a basic electrical control system and the second module builds upon this, by including computer based programming and the possibility of more complex problems and more advanced solutions. The students are given a high degree of freedom within the boundaries of the topic to develop a solution for a control system of either a predefined machine or a machine of their own choice. The time frame is about 4 weeks for each module. At the end of each module, student groups present their solution and their process.

The intention with the PBL course, besides the construction of professional knowledge, is the development of students' SDL skills as well as their collaborative skills. The students use a 7 step PBL model as the basis for their work, and document the process, as they identify, work and solve their problem.

Chapter four - Research methodology

In this chapter the research methodology will be presented, together with the research variables and research instruments.

4.1 Methodology

This section presents the research design, data collection and the data analysis procedure that has been found most suitable for addressing the research questions.

The overall framework for the research methodology is a mixed method design. The reason for choosing a mixed methodology research design is to strengthen the validity of the collected data. The qualitative data is used to illustrate and explain quantitative findings. (Creswell and Clark 2011). This is done by implementing the data set from the qualitative research into the analysis framework of the quantitative research. This research utilizes a quantitative priority where greater emphasis is made on the quantitative data collection and the qualitative data collection is used to support the quantitative findings. The mixed research methodology consist of an embedded design, as shown below in Figure 2.

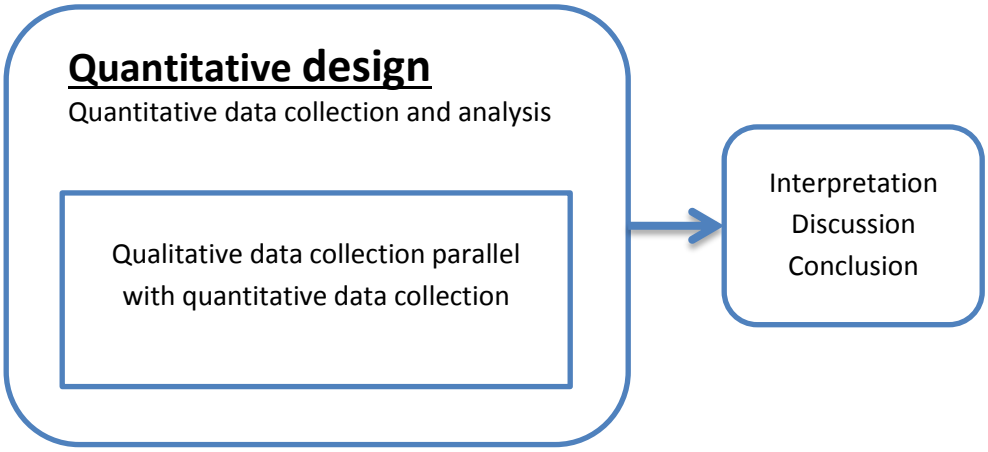

Figure 2 - The embedded design (Creswell and Clark 2011)

The collection of the supporting data set, in this case the qualitative data will be done concurrently with the quantitative data collection. The combination of both quantitative data collection by questionnaires and qualitative data collection by means of interviews is to strengthen the validity of the collected data. Questionnaires and interviews have differing and possibly complementary strength and weaknesses. Data from questionnaires can in general be viewed as more objective, and can be used to create more generalizable results due to large sample sizes. Quantitative data from questionnaires can though be influenced by many factors, i.e. such as faulty questionnaire design, respondent unreliability or misunderstanding of the questions (Harris and Brown 2010). Qualitative data collected by interviews are based on personal interaction and can therefore not be categorized as neutral data and can lead to negotiated and contextually based results. Due to the nature of interviews, sample size is often relatively small, and the results can be difficult to replicate or generalize. (Harris and Brown 2010).

The framework of the quantitative and qualitative data collection is shown below in Figure 3. It is not a chronological list, as most of the data collection is done at the same time. BM4, BM5 and BM6 are names of classes in which data is collected. Four sets of quantitative questionnaire data sets are collected and two sets of qualitative interviews are conducted.

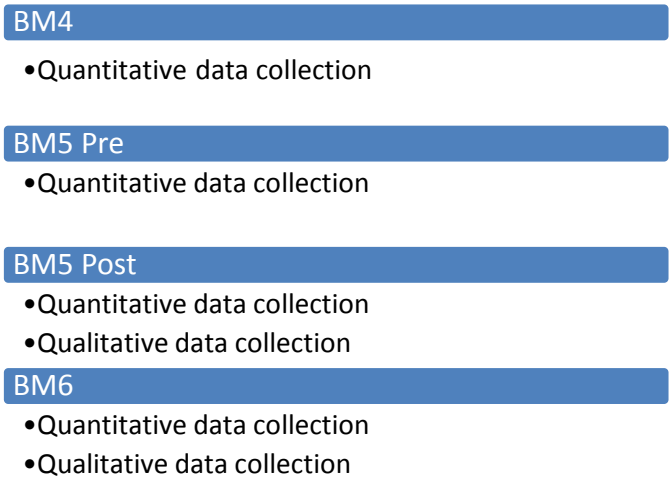

Figure 3 - Diagram illustrating the measurement framework of the quantitative and qualitative data collection.

The data is collected across three consecutive semesters, namely BM4, BM5 and BM6. All the datasets are, except for the BM5 Pre data set, collected in the latter part of the 2014 fall semester. The BM5 Pre dataset is collected in the beginning of the 2014 fall semester. With regards to the BM5 semester, quantitative data is collected before and after the PBL course.

4.2 Research method

To make the research questions measurable, the following variables have been identified as shown below in Figure 4.

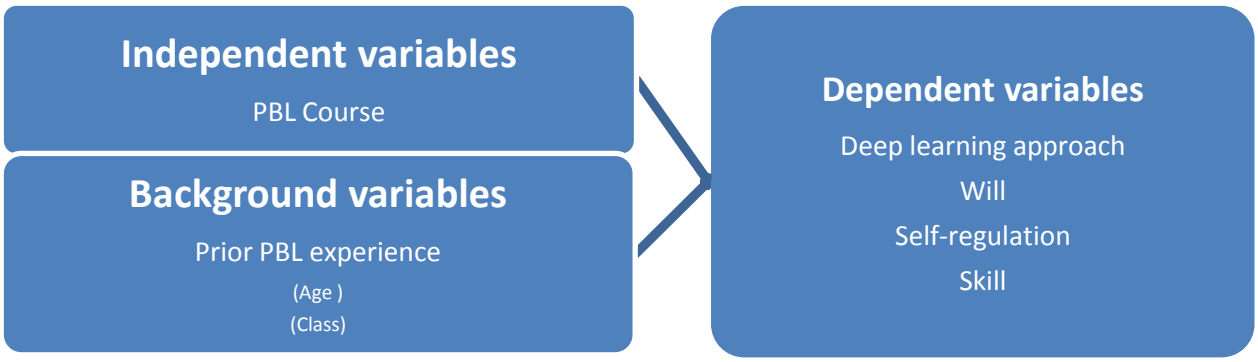

Figure 4 - Research variables

The independent variable is the hybrid PBL course. The background variable has been identified as prior experience with PBL. The variables age and class will also be collected as demographic information. The dependent variables have been identified as deep learning approach as well as will, self-regulation and skill in relation to SDL.

The measurement of the dependent variables is made operational by using the Learning and Study Strategies Inventory (LASSI) questionnaire as well as The Revised Two Factor Study Process (R-SPQ-2F) questionnaire.

The research will be a comparison on the basis of the dependent variables and the pre-decided background variable. Prior PBL experience has been selected specifically as background variable, to be able to sort data collected and to explore any possible links or development in the dependent variables

Students learning approach can be divided up into deep and surface learning approach. The score of both deep and surface learning approach gives a measurement of how engaged the students are in the learning situation, and of the level of their learning activities. Surface learning approach involves the minimum learning activities needed to achieve the intended learning outcomes, i.e. note taking and memorizing and can often be found in a passive teaching environment. Deep learning approach involves a higher level of engagement. The learning activities could include applying and theorizing and can often be found in an active teaching environment, i.e. the use of PBL. (Biggs 1999) (Biggs and Tang 2011)

The variables of deep and surface learning approach can both be divided up into “motive” and “strategic.” In the analysis in this research focus will be on students’ level of deep learning approach. Students’ scores of SDL, represented by the dependent variables Will, Skill and Self-regulation, will be analysed in relation to students scoring above or below average of the deep learning approach score.

The will variable is an expression of students’ attitude and interest in the education, their self-discipline and self-efficacy. The self-regulation variable is an expression of how students manage and control their learning process, by using their time effectively, focusing their attention and maintaining their concentration as well as reflection about their learning outcomes. The skill variable is an expression of students’ learning strategies, skills and though processes in relation to

identifying, acquiring and constructing meaning for new information as well as how they prepare for and demonstrate new knowledge in assessment situations or similar. (Weinstein and Palmer 2002)

4.3 Research instruments

4.3.1 Learning and Study Strategies inventory test (LASSI test)

To gain quantitative data, the researcher uses the Learning and Study Strategies Inventory (LASSI) questionnaire. LASSI is a statistically valid and reliable tool for measuring students' awareness about and use of learning and study strategies related to skill, will and self-regulation components of self-directed learning. The tool is both a diagnostic and prescriptive measure, that includes both covert and overt thoughts and behaviours that can relate to successful learning and which can be altered through educational interventions. The tool is diagnostic, as it gives a score of ten sub-elements within will, skill and self-regulation in relation to learning. It is prescriptive, as the measured student score can be used to gain insight in the elements that needs to be strengthened. The tool is an effective way to promote self-reflection and identify the areas of strengths and weaknesses of students in relation to their learning. The ten sub-elements that are measured within the three main components are (Weinstein and Palmer 2002):

- **Self-regulation**: Time-management, self-testing, study aids and concentration.
- **Will**: Anxiety, attitude and motivation.
- **Skill:** Information processing, selecting main ideas and test-strategies.

A short description of each sub-element is shown in Figure 5 below.

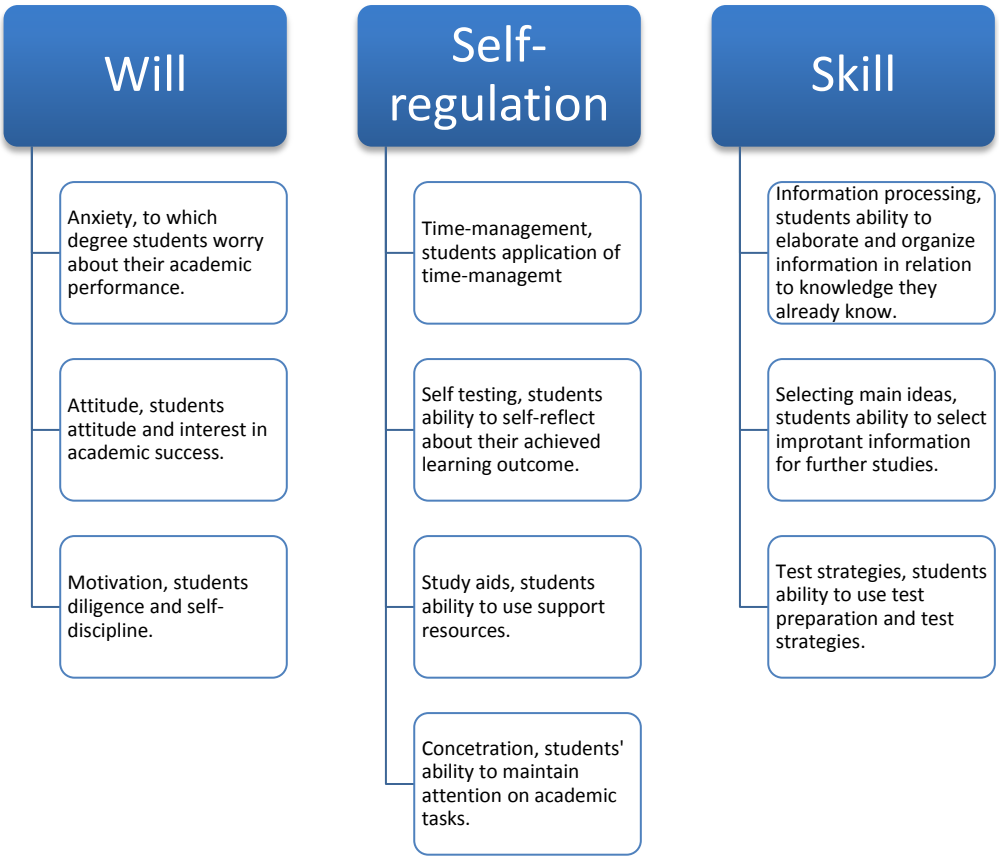

Figure 5 - Description of sub-elements of the three main components of the LASSI test. (Weinstein and Palmer 2002)

The mean scores of the components Will, Skill and Self-regulation will be used in the presentation of the results of the test. If results presented are particularly interesting or statistically significant, relevant sub-elements of components will be presented.

4.3.2 The revised Two Factor Study Process Questionnaire (R-SPQ-2F)

To gain quantitative data about students learning approach, the researcher will use the revised two factor questionnaire (R-SPQ-2F). The questionnaire is made by John Biggs et al. to measure students learning approach. (Biggs, Kember and Leung 2001)

The questionnaire consists of twenty questions, which assess both deep learning and surface learning approach. The students use a five-point Likert scale to score the questions. The score is calculated based on a pre-defined scoring key and adds up to two total scores, one for each learning approach. The score of deep learning approach and surface learning approach can be further divided up into a strategic or motive approach. (Biggs, Kember and Leung 2001)

The R-SPQ-2F questionnaire is intended for measuring the students learning approach in a specific learning context. (Biggs, Kember and Leung 2001). When administrating the questionnaires in this research, care is taken by researcher to make students think of their entire education and general learning when answering the questions.

4.3.3 Interview

To collect qualitative data, semi structured group interviews will be conducted. Selected student groups from each class will be interviewed. The respondents are selected randomly in the target classes. Three groups of two students will be selected for the interviews.

There will be no exercise or training provided prior to the interview to avoid biased and fabricated evidence during the interview. Good interview practice includes designing a good survey instrument which standardizes the interview process (Floyd 2009). As a survey instrument an interview guidebook has been developed.

To ensure clarity and validity of the questions included in the interview guidebook, a pilot test will be conducted prior to the actual interview. This is to minimize error and bias by the interviewer, which can influence respondents' answers during the interview process. The guidebook can be seen in appendix A. The guidebook is developed in Danish, as the interviews are conducted in the students' native language to minimize misunderstandings and secure reliability and validity of the interviews.

All interviews are digitally recorded and transcribed verbatim by the researcher. Each participant will be assigned a pseudonym for analysis and reporting purposes. The transcriptions of the interviews can be seen in appendix B, and the translation of citations can be seen in appendix C.

Chapter five – Presentation of collected data

In this chapter collected data will be presented accordingly to the research questions. First the quantitative data collected will be presented and then the qualitative data.

The process of evaluating students' perceptions of their SDL abilities is complex and time-consuming. Quantitative data were collected by the means of standard questionnaires. Qualitative data were collected by the means of interviews. The LASSI questionnaire gives a score consisting of 10 components, which can be divided up into three items; Skill, Will and Self-regulation. The R-SPQ-2F questionnaire gives a score of both students deep and surface learning approach.

5.1 Quantitative data

In this section the quantitative data will be presented. The respondents are divided up into three different classes, namely BM4, BM5 and BM6. In the BM5 class, two quantitative measurements were conducted, one before and one after the PBL course. These two measurements are named BM5 Pre and BM5 Post.

First the demographic data will be presented. Following this, data that shows impact on students' perception of their SDL skills and deep learning approach as a result of a specific PBL course is presented. After this, data that shows students' perception of SDL skills and deep learning approach in relation to general PBL experience is presented. Lastly, data that shows students' perception of their SDL skills in relation to their level of deep learning approach is presented. For each presentation of data, the overall results are presented first, and if any of the underlying components shows particular and/or significant results they are also presented.

All collected quantitative data can be seen appendix E, as well as the data processing, including F-test and T-test, performed to check for difference in variance and significances.

5.1.1 Demographic data

The total number of respondents was 98. Two of the responses were discarded because of incompleteness, so a total of 96 respondents are presented in this collection of quantitative data, as shown below in Table 1.

	Frequency	Percent
Total number of questionnaire respondents	98	100 %
Number of discarded questionnaire respondent	2	2,0 %
Number of respondents used in the data analysis	96	98 %

Table 1 - Number of quantitative questionnaire respondents

The distribution of respondents in each class can be seen in Table 2.

	Frequency	Percent
BM4	30	30,6 %
BM5 Pre	22	22,1 %
BM5 Post	22	22,1 %
BM6	22	22,1 %
Total	96	100 %

Table 2 - Number of respondents in each class.

As part of the demographic information gathered, respondents were asked if they had previous experience with PBL. The result hereof can be seen below in Table 3. Regarding BM5 Pre and BM5 Post results, only results from BM5 Post is used in this table. This is in order to avoid using results from the same students twice.

	Frequency	Percent
Respondents with PBL experience	43	58,1 %
Respondents without PBL experience	31	41,9 %
Total	74	100 %

Table 3 - Respondents with PBL experience

As shown in Table 3 above, a little more than half, i.e. 58.1 % (n=43) of the respondents had prior experience with PBL.

5.1.2 Specific PBL course results

In Table 4 below, the results of the questionnaires given to the students before and after the specific PBL course are presented. It shows the mean score of deep learning approach and the mean score of Will, Skill and Self-regulation components of the measurement of students' perception of their SDL skills.

Measurement item	Mean		Frequency	Std. dev.	t-stat	Sign.
Deep learning approach	BM5 Pre	3,18	22	0,61	0,30	0,77
	BM5 Post	3,24	22	0,70		
Will	BM5 Pre	48,00	22	27,56	0,52	0,60
	BM5 Post	52,14	22	24,67		
Self-regulation	BM5 Pre	40,10	22	23,10	0,48	0,63
	BM5 Post	43,25	22	20,10		
Skill	BM5 Pre	51,61	22	23,14	0,49	0,63
	BM5 Post	54,98	22	23,04		

Significant at the level <0,05

Table 4 - BM5 pre and post measurements

No statistically significant differences of the variables can be observed, when comparing the results of BM5 Pre and BM5 Post. Even though, no statistically significance can be concluded, all mean scores increases from BM5 Pre to Post indicating some level of development in relation to students' deep learning approach and their perception of their SDL skills.

The item Deep Learning Approach is composed of the two components Motive and Strategy, as shown below in Table 5.

Measurement item	Mean		Frequency	Std. Dev.	t-stat	Sign.
Deep Learning Approach: Motive	BM5 Pre	3,32	22	0,78	0,49	0,63
	BM5 Post	3,43	22	0,70		
Deep Learning Approach: Strategy	BM5 Pre	3,05	22	0,59	0,04	0,97
	BM5 Post	3,05	22	0,78		

Significant at the level <0,05

Table 5 - Deep learning approach components; motive and strategy

As it can be seen, a small increase in mean score of Deep Learning Approach Motive is measured. The difference is, however, not large enough to be statistically significant. The mean score of Deep Learning Approach Strategy is almost identical in both measurements, thus indicating no development.

5.1.3 PBL or no PBL experience results

In Table 6 below the measured results of students with or without prior PBL experience is shown and how they relates to the students perception of their SDL skills and Deep Learning Approach. As part of the questionnaire given to the students, they were required to indicate if they had PBL experience or not. A little more than half of the students have experience with PBL.

Measurement item	Mean		Frequency	Std. Dev.	t-stat	Sign.
Deep learning approach	PBL	3,25	43	0,61	1,21	0,23
	No PBL	3,08	31	0,55		
Will	PBL	52,62	43	23,21	1,96	0,05
	No PBL	42,28	31	21,26		
Self-regulation	PBL	43,24	43	21,12	-0,51	0,62
	No PBL	45,39	31	15,38		
Skill	PBL	56,62	43	19,68	2,15	0,03
	No PBL	46,86	31	18,65		

Significant at the level <0,05

Table 6 - Prior PBL experience results

The results above show a statistical significance of the item Skill, when comparing the two groups. The Skill item of the group with PBL experience shows (mean = 56.62, standard deviation = 19.68) and the group with no PBL experience shows (mean = 46.86, standard deviation = 18.65); (t = 2.15, p = 0.03). These values indicate a significant difference between the two groups.

In the items Deep Learning Approach and Will, the mean scores of the group with PBL experience is much higher compared to the mean scores of the group without PBL experience, though none of these results are statistically significant. The item Self-regulation shows that the group without PBL experience have a slightly higher mean score compared to the group with PBL experience, but the result is not statistically significant.

The measured item Deep learning approach does not show any significant difference between the group with PBL experience and the group without PBL experience. But when looked into the two components of the item Deep Learning Approach, namely Motive and strategy, an increase in mean score of both components in favour of the group with PBL experience is observed. The increase of mean score is, however, not large enough to be statistically significant. This can be seen below in Table 7.

Components of deep learning approach	Mean		Frequency	Std. Dev.	t-stat	Sign.
Deep Learning Approach: Motive	PBL	3,38	43	0,65	1,52	0,13
	No PBL	3,14	31	0,73		
Deep Learning Approach: Strategy	PBL	3,12	43	0,66	0,62	0,54
	No PBL	3,03	31	0,53		

Significant at the level <0,05

Table 7 - Deep learning approach components; motive and strategy

The Will item consist of three subcomponents, namely Anxiety, Attitude and Motivation. Looking at the specific components, as shown in Table 10 below, only the component Attitude shows a statistically significant difference.

Components of Will item	Mean		Frequency	Std. Dev.	t-stat	Sign.
Anxiety	PBL	58,49	43	28,17	1,56	0,13
	No PBL	49,06	31	26,22		
Attitude	PBL	53,86	43	31,09	2,09	0,04
	No PBL	39,68	31	25,39		
Motivation	PBL	45,51	43	30,42	1,05	0,15
	No PBL	38,10	31	29,25		

Significant at the level <0,05

Table 8 - Components of will items, i.e. anxiety, attitude and motivation

The Attitude component of the group with PBL experience shows (mean 53.86, standard deviation = 31.09) and the group with no PBL experience shows (mean = 39.68, standard deviation = 25.39); (t = 2.09, p = 0.04). This indicates that students with PBL experience have a more positive attitude towards learning and achieving academic success.

When comparing the mean scores of the group with PBL experience and the group without PBL experience, the group with PBL experience shows a higher mean score of the components Anxiety and Motivation. The difference in mean scores between the two groups can, however, not be said to be statistically significant.

The Self-regulation component consists of four subcomponents, namely Time Management, Self-testing, Study Aids and Concentration. None of these components shows a statistical difference, so they are not presented any further.

The Skill item consists of three components, namely Information processing, Selecting main ideas and Test strategies. The mean scores of the subcomponents are shown below in Table 9.

Measurement item	Mean		Frequency	Std. Dev.	t-stat	Sign.
Information processing	PBL	66,77	43	27,79	0,44	0,66
	No PBL	64,35	31	26,64		
Selecting main ideas	PBL	50,86	43	27,25	2,04	0,045
	No PBL	37,77	31	27,34		
Test strategies	PBL	52,23	43	26,57	2,20	0,03
	No PBL	38,45	31	26,69		

Significant at the level <0,05

Table 9 - Components of skill item; i.e. information processing, selecting main ideas and test strategies

The Test strategies component show a statistically significant difference between the group with PBL experience and the group without PBL experience. The test strategies PBL group shows (mean 52.23, standard deviation = 26.57) and the group with no PBL experience group shows (mean = 38.45, standard deviation = 26.69); (t =2.20, p = 0.03). This indicates that students with PBL experience use a higher level of test preparation and test taking strategies.

The Selecting Main Ideas component also shows a statistically significant difference between the two groups. The group with PBL experience shows (mean 50.86, standard deviation = 27.25) and the group with no PBL experience group shows (mean = 37.77, standard deviation = 27.34); (t =2.04, p = 0.045).This indicates that students with PBL experience are better to select main ideas to work with.

The component Information Processing show a small increase in mean score comparing students with PBL experience and students without PBL experience, and again students with PBL experience have the highest mean scores.

5.1.4 Deep learning approach results

In this section, results from the questionnaires have been sorted by mean score of deep learning approach. The group has been divided into two. One group with a mean score of deep learning approach above average and one group with a mean score of deep learning approach below average. The results of this can be seen in Table 10 below.

Measurement item	Mean		Frequency	Std. Dev.	t-stat	Sign.
Will	Above average	57,90	38	20,32	4,10	0,00
	Below average	38,14	36	21,12		
Self-regulation	Above average	52,94	38	16,76	4,68	0,00
	Below average	34,85	36	16,46		
Skill	Above average	58,18	38	20,67	2,63	0,01
	Below average	46,57	36	17,00		

Significant at the level <0,05

Table 10 - Above or below deep learning approach mean score results

As the table shows, statistically significant differences can be observed for all measured items, when they are sorted by above or below average score of deep learning approach. Students with a deep learning approach above average have the highest score in all items.

The Will item show a statistically significant difference. The group with a score of deep learning approach above average shows (mean = 57.90, standard deviation = 20.32) and the group with a score below mean shows (mean = 38.14, standard deviation = 21.12); (t = 4.10, p = 0.00).

At the same time, the item Self-regulation also shows a statistically significant difference. The group with a score of deep learning approach above average shows (mean = 52.94, standard deviation = 16.76) and the group with a score below average shows (mean = 34.85, standard deviation = 16.46); (t = 4.68, p = 0.00).

The Skill item also shows a statistically significant difference. The group with an above average score of deep learning approach shows (mean 58.18, standard deviation = 20.67) and the group with a score below average shows (mean 46.57, standard deviation 17.00); (t = 2.63, p = 0.01).

In Table 11 below, the subcomponents of each item of Table 10 is presented, to show which specific components results in significant differences between the two groups, i.e. students with an above average or below average mean score of deep learning approach.

Measurement item	Component	Mean		Frequency	Std. Dev.	t-stat	Sign.
Will	Anxiety	Above average	56,32	38	27,65	0,57	0,57
		Below average	52,57	36	27,78		
	Attitude	Above average	58,18	38	28,19	3,27	0,00
		Below average	37,08	36	27,21		
	Motivation	Above average	59,21	38	26,83	6,05	0,00
		Below average	24,67	36	21,92		
Self-regulation	Time management	Above average	60,13	38	20,88	4,34	0,00
		Below average	38,50	36	21,98		
	Self testing	Above average	37,11	38	26,68	2,45	0,00
		Below average	22,92	36	22,87		
	Study aids	Above average	55,82	38	26,18	2,34	0,02
		Below average	42,25	36	23,59		
	Concentration	Above average	58,71	38	25,26	3,99	0,00
		Below average	35,75	36	24,12		
Skill	Information processing	Above average	69,08	38	20,92	1,26	0,21
		Below average	62,25	36	25,49		
	Selecting main ideas	Above average	52,92	38	29,42	2,47	0,02
		Below average	37,42	36	24,04		
	Test strategies	Above average	52,53	38	28,16	2,00	0,049
		Below average	40,06	36	25,21		

Significant at the level <0,05

Table 11 - Components of measured items sorted by above or below average score of deep learning approach

As it can be seen, a statistical significance can be measured in all components except for the Anxiety and Information processing components. All components also show an increase in mean score when comparing the group with a score of deep learning approach above average with the group scoring below average.

5.2 Qualitative data

In this section the qualitative data will be presented. The data are based on transcriptions of interviews conducted with students with PBL experience. The interviews were conducted in Danish language; hence the transcriptions are also in Danish. The transcriptions are available in appendix B. Relevant citations in relation to the research themes have been translated into English, to be presented in this chapter. The translation of the citations can be seen in appendix C. Care has been taken when making the translations to maintain the original meaning of the citations. The citations will be presented, grouped by themes in the following order:

- Background data of interviewed persons
- Deep learning approach
- Will
- Self-regulation
- Skill

5.2.1 Background data of interviewed persons

Person A	Gender: Female Age 25 years old PBL experience: 4 years
Person B	Gender: Male Age: 41years old PBL experience: ½ year
Person C	Gender: Male Age: 23 PBL experience: 5½ year
Person D	Gender: Male Age: 21 PBL experience: 5½ year
Person E	Gender: Male Age: 35 PBL experience: ½ year
Person F	Gender: Male Age: 27 PBL experience: ½ year

Table 12 - Background data of interviewed students

5.2.2 Citations from interviews

In Table 13 below, citations are shown for each interviewed person, illustrating their deep learning approach.

Person A	We are adults, so we are responsible for what we can learn about a given topic.
Person B	There is no point in just writing the answer. You gain experience all the time, a little more than just the necessary.
Person C	Instead of writing about the easiest topic, we chose the one we find most interesting.

Person D	When writing an assignment, you don't have to know all about a topic, you can always find out as you make the assignment.
Person E	Theoretical knowledge about a topic is important, but you also need practical knowledge to fully understand it We have just written a case, where I chose to write about something else than just an example from a textbook. It motivates to write about something unknown.
Person F	You really first know how to do it, when you start to use it. In the end I remember by making multiple repetitions.

Table 13 - Deep learning approach interview citations

In Table 14 below, citations in relation to skill are presented.

Person A	Well, I think oneself is completely responsible for how much you learn.
Person B	It is difficult to get started with, but the learning outcome is high (about PBL and definition of learning outcomes).
Person C	We have tried to use the model in this project, to reflect about what we learn when we use it (about the use of PBL model)
Person D	Now we can really see what we can achieve with the model and what the goal with it is (about the use of the PBL model)
Person E	
Person F	

Table 14 - Skill interview citations

In Table 15 below, citations in relation to self-regulation are presented.

Person A	… The time has simply been used. I have not had time to prepare for new topics.
Person B	The difficult topics, if time permits (about what to study first)
Person C	I manage my time after which assignments I have to hand in.
Person D	I manage my time accordingly to what assignments I have to hand in.
Person E	I have to manage and prioritize what I spend my time on.
Person F	I do more work, If I feel I have not reached my intended learning outcomes.

Table 15 - Self-regulation citations

In Table 16 below, citations in relation to will are presented

Person A	When doing something you are good at, it is easier to find motivation. … Even though you want to learn it, it is also the easiest part to skip (about motivation and difficult topics).
Person B	Though it is the easiest to skip, I try to prioritize the topics I find difficult. If the frustration gets too high learning a topic, it is easier to find an easier topic and get a sense of achievement.
Person C	You are really motivated to learn all about a topic and even beyond, so you can answer all questions asked (about motivation and type of examination).
Person D	I become more motivated, when there is an examination in the end.
Person E	
Person F	You have to create your own motivation, to learn beyond the planned learning outcomes of the course (about motivation).

Table 16 - Will interview citations

Chapter six - Analysis and discussion

In this chapter the data collected will be discussed. The data will be discussed in the same order, as presented in the previous chapter, i.e. first the quantitative data collected before and after the PBL course of the BM5 class, then the data in relation to PBL experience, followed by a discussion of the data in relation to deep learning approach. Finally the qualitative data obtained from the interviews will be related to the discussions of the quantitative results.

6.1 How a PBL course relates to SDL and deep learning approach

The data obtained before and after the PBL course conducted in BM5, namely the datasets BM5 Pre and BM5 Post show no significant differences in the comparison of the results of the two quantitative questionnaires. However, it should be noticed that even though no significant differences could be measured, as shown in table 4, all mean scores increase from the BM5 Pre to the BM5 Post measurement. This could indicate a tendency of improvement. A reason why no significant difference can be measured could be that 10 out of the 22 respondents already have prior PBL experience, with an average of 5.4 years of experience. This could explain why a short PBL course, does not foster significant immediate results, as nearly half the respondents have experience with the work method beforehand. The limited number of respondents, the anonymity of the data collection method and that the pre and post questionnaires have not been paired limit the possibility to measure the results of only students with no PBL experience before the PBL course.

6.2 How PBL experience relates to SDL and deep learning approach

The qualitative data obtained and sorted by PBL experience or no PBL experience, shows an increase in mean score of three out of four items, as shown in table 6.

Students with PBL experience scores a significant higher mean score of the Skill component of the LASSI test. The higher score of the skill component indicates that students with PBL experience have better abilities of identify, acquire and construct meaning of new knowledge. The skill item is made up of the three components as shown in table 9; information processing, selecting main ideas and test strategies. Of the three components, statistically significance can only be observed in the components selecting main ideas and test strategies. This indicates that students with PBL experience have better abilities of selecting important information for further studies and is better to prepare for and take tests. Regarding the information processing component, only a slight increase in mean score is observed for students with PBL experience, and the difference is not statistically significant. However, this can indicate that students, regardless of PBL experience or not, have the same ability level of knowledge acquisition and relate new knowledge to prior knowledge. The reason for this can be, that the students participating in this research, attends the same class and therefor is experiencing the same material and teaching methodology.

The item Will, shown in table 6, shows no statistically significance, however, a large increase in mean score can be observed. When looking into the subcomponents of the Will item, namely anxiety, attitude and motivation, a significant difference can be observed regarding the component attitude. Students with PBL experience have a more positive attitude towards learning and academic success. It can also be interpreted as students with PBL experience have a better understanding of how academic success relates to their future life goals.

The subcomponents Anxiety and Motivation of the Will item, also show a large increase in means scores in favour of students with PBL experience. A reason for this could be that students with PBL experience takes more responsibility of

their own learning, and therefor feel greater anxiety, if they are not to succeed. The increase of responsibility of their own learning can also be explained by the higher score of motivation, as students tend to take more ownership of their own learning and are therefore involved in their own learning on a higher level. This also relates well with the observation that, those students with PBL experience scores higher in Deep Learning Approach, as it can be seen in table 6. Looking at table 7, it can be seen that it is especially in the Deep Learning Approach subcomponent Motive that students with PBL experience scores higher. This can indicate that students with PBL experience have an intrinsic motivated interest in their learning, and is more motivated to use a Deep Learning Approach to achieve academic success.

This can also be observed in the following two citations from interview person B and C, whom both have several years of PBL experience.

"Though it is the easiest to skip, I try to prioritize the topics I find difficult" (Person B)

"You have to create your own motivation, to learn beyond the planned learning outcomes of the course (about motivation)" (Person F)

This indicates that students are aware of their own motivation and are able to prioritize what they need to learn.

The students with no PBL experience scores slightly higher in the Self-regulation component, but again the data is not statistically significant. The reason for the little difference in Self-regulation between students with and without PBL experience can be that they are attending the same education at the same institute, thus being part of and influenced by the same educational environment. The students have all the same assignments to do, the same lectures to attend and the same examinations in the end, thus requiring the same needed level of Self-regulation to succeed.

In general, the interviewed students all said they had to plan their work load accordingly to the assignments they have to hand in during the semester, as illustrated below by the citation of interview person D:

"I manage my time accordingly to what assignments I have to hand in"(Person D)

Students' high workload and use of PBL as methodology, can also explain why students with PBL experience score lower in Self-regulation. If the level of frustration, in relation to students' management of their time, gets too high, they can feel inadequate. PBL as a teaching methodology can be very time consuming for the students to use. This, combined with many obligatory assignments during the semester, can create a high level of frustration, especially among students with a high level of deep learning approach since they don't have the time to attain the academic success they aim for. The frustration and need to prioritize their time can also be seen in the following two citations by person A and B:

"… The time has simply been used. I have not had time to prepare for new topics." (Person A)

"The difficult topics, if time permits (about what to study first)" (Person B)

However, students were also seen to be successful and aware of how they manage their learning, as it can be seen in the following citations by person C and F:

"We have tried to use the model in this project to reflect about what we learn, when we use it (about the use of PBL model)" (Person C)

"I do more work, if I feel I have not reached my intended learning outcomes." (Person F)

So overall, the students indicate that they are reflective about their learning, but are also realistic about how they need to prioritize their limited time.

6.3 How deep learning approach relates to SDL

When looking at the results from the questionnaire sorted by a mean score of deep learning approach above or below average in table 10, significant differences can be seen in all items, i.e. will, self-regulation and skill. This indicates that students with a high level of deep learning approach are highly focused on their SDL skills. The responses from the interviews highlights that students in general are aware of their own learning, but the interviews also indicates different approaches to learning. Difference in exam preparation can be seen when comparing the following two citations from the interview of Person E and Person F. They have an equivalent study experience and PBL experience.

"Theoretical knowledge about a topic is important, but you also need practical knowledge to fully understand it" (Person E)

"In the end, I remember by making multiple repetitions. " (Person F)

Students with a deep learning approach tend to take responsibility for their own learning. This is also supported by the following citations from the interview of Person A. Person A has 4 years of experience with PBL.

"We are adults, so we are responsible for what we can learn about a given topic" (Person A)

"Well, I think oneself is completely responsible for how much you learn" (Person A)

Looking at the number of respondents with a deep learning approach above average, 24 of these respondents have PBL experience, whilst only 14 respondents do not have PBL experience. This indicates that students with PBL experience tends to use a higher level of deep learning approach more often, though when comparing students with a deep learning approach below average, 17 of these have no PBL experience whilst 19 have PBL experience. This indicates that, even though students have PBL experience, they may not necessarily use a higher level of deep learning approach.

Encountering a problem as the first part of a learning process can act as a motivation factor in the application of problem-solving. Students with PBL experience appears to be aware of this, hence referring to the following citation from interview person E, though he only has half a year of experience with PBL.

"We have just written a case, where I chose to write about something else than just an example from a textbook. It motivates to write about something unknown" (Person E)

On the other hand, deep learning approach and PBL experience can not always be directly correlated, since students can chose to focus on the assessment of a course instead of the intended learning outcomes. This is indicated in the following citation from interview person D, who has 5½ years of PBL experience.

When writing an assignment, you don't have to know all about a topic, you can always find out as you make the assignment. (Person D)

When looking at the subcomponents of which the items Will, Skill and Self-regulation are made up of, only the components Anxiety and Information Processing does not show a statistical significant difference. The lack of difference of the anxiety component can again be explained by the students attending the same classes and have same examinations. The lack of significant difference of the Information Processing component can indicate that students have the same

abilities of acquiring new knowledge and relate it to prior knowledge to create new knowledge. Again an explanation can be that the students attend the same classes, and they are there for influenced by the same education environment.

However, in general the results of the students with a deep learning approach above average are higher in all aspects of both the R-SPQ-2F test and the LASSI test It indicates that these students have a higher degree of awareness of their learning approach and SDL skills in general. But whether they have a deep learning approach, as a result of their higher level of SDL skills or they have a higher level of SDL skills, as results of their learning approach cannot be identified from these results. However, the results identify valuable information in the context of students learning and their learning approach, so focus on future models of PBL courses could be to teach students explicit SDL tools or increase students work with a deep learning approach perspective.

6.4 Discussion of reliability and validity of measurements

The limited number of respondents in relation to both the quantitative and qualitative data collection has a limitation on the validity of this research. The limited number of quantitative respondents limits the possibility of extracting detailed data to make generalisations from, since the number of respondents is too few, when the data is being filtered and sorted by different variables. The amount of qualitative interviews is limited to only three interviews with six students, which means that only six percent of the students were interviewed.

Much effort has been made to ensure the consistency of the measurements. The students were given a brief introduction to the questionnaires and the underlying intention with them. However, the students' native language is different than those of the questionnaires, most students being Danish and the questionnaires being written in English. This can have resulted in interpretation errors or misunderstandings of the questions. The students had the opportunity to ask for interpretation of words or questions if necessary.

The responses may also have been influenced by the educational setting the respondents were in at the time of the employment of the questionnaires. This is especially seen to be a problem with the quantitative data, as they were collected, while the students were attending a specific class. The respondents can therefore have been influenced by how they think about the specific subject and how they see themselves as students in that specific subject instead of their education as a whole. Regarding the qualitative data, this is not seen as such a big problem, as the students were taken out of their educational situation, when participating in the interviews and they were asked questions about their education in general. However, the result hereof can be that the results relates to a more specific situation and not their entire learning environment, though much effort was made to avoid this by the brief introduction given to the students prior to the data collection.

6.5 Summary of discussion

Overall the results from the previous chapter have been discussed in the light of both the quantitative and qualitative findings. The quantitative data indicates that students with a deep learning approach above average significantly differ compared to students with a below average deep learning approach.

The qualitative data from the interviews indicates that students are aware of how they learn, but they differ much in how they explain their preferences. It is learned from the interviews that the students are aware of their own responsibility of learning and use the tools they learn in new contexts. However, it is also learned that students tend to go back to rote learning when preparing for exams.

Chapter seven – Conclusion and further studies

7.1 Conclusion

In this chapter, the conclusions based on the discussion in the previous chapter will be presented and referred to relevant theories and studies. Following this, recommendations for future research will be done.

What is the relationship between students' perception of their self-directed learning skills and deep learning approach in relation to a specific PBL course?

In this study it was tested if PBL had an immediate influence on students' deep learning approach and on their development of SDL skills. Students' level of deep learning approach was also compared to their relative level of SDL skills.

It was found to some extent that, participation in a PBL course were associated with a small, but noticeable increase in students' perception of their SDL skills as well as in their deep learning approach. Lee, Mann and Frank (2010) have conducted a research in a hybrid PBL environment and they found that students' perceived SDL skills, are positively influenced by the PBL environment. The findings in this research indicates the same tendency as those of Lee, Mann and Frank (2010) and lends support to that a PBL course tends to increase students perceived SDL skills.

This study therefor indicates that the benefits gained from a PBL course may be increase of students' perception of their SDL skills and a positive impact on their deep learning approach.

However, some limitations are worth noting. Although improvements could be measured in relation to deep learning approach and SDL skills, these improvements are not significant enough to be statistically valid. Future work should therefore include follow-up work, designed to evaluate whether the SDL skills and deep learning approach are retained in the long term and also whether they continue to improve their SDL skills.

What is the relationship between students' perception of their self-directed learning skills and deep learning approach in relation to PBL experience?

It was found that prior experience with PBL appears to have a positive influence on students' deep learning approach and level of SDL skills. The result of this study is analogue with Tracey Papinczaks (2009) study, verifying that PBL is supporting their learning, and that deep strategic learners are more efficacious. This study, therefore, indicates that students with PBL experience enhance their SDL skills and demonstrates a higher degree of deep learning approach. This study shows an tendency of increase in deep learning approach with PBL experience. This tendency is aligned with the research by Downing, Shin and Kwong (2007) which show that PBL enhances students' level of metacognition more than a traditional learning environment. .

The increase of the mean scores of deep learning approach, will and skill are also all positive in relation to the students learning. However, Biggs (1999) states that even though students are forced to use a deeper learning approach, limitations apply. Even under the best teaching, some students will still tend to use a surface learning approach. According to Biggs, students approach to learning can often also be seen to be a response to the assessment method, if the curriculum, teaching and assessment are not properly aligned. However, the students with PBL experience in this research scores a higher mean score of deep learning approach, which is similar to what Biggs suggests. Biggs suggests that PBL creates a higher degree of student activity and engagement and hereof also fosters a deep learning approach by students. (Biggs and Tang 2011)

The backside of using PBL extensively is that students also can feel they do not have the time or abilities to succeed. Abrandt Dahlgren and Dahlgren (2002) have conducted a study to analyse how students conceive of the meaning of PBL. The findings of their research showed that students in two out of three disciplines found uncertainty of what to study. This and the limitation of time were also encountered by the interviewed students of this research.

In this research, especially the result of the skill component is promising, as the data show an increase large enough to be statistically significant. The subscales indicate that students with PBL experience have an especially better ability of selecting main ideas and employ better test strategies. This can be translated into students making greater efforts to achieve academic success.

The research results are encouraging and should be validated in a larger cohort of students. It would be beneficial with a larger cohort, to identify the effect the number of years of experience with PBL could have on learning approach and SDL skills.

What is the relationship between students' perception of their self-directed learning skills and deep learning approach?

It is also learned from this research that students with an above average deep learning approach are prone to show higher levels of SDL skills, compared to students with a below average deep learning approach. The result of this is in good agreement with Biggs (1999) theory about the benefits of a deep learning approach. Furthermore, 24 of the total of 38 students with an above average learning approach have prior experience with PBL. The results show a statistically significant difference in all measured items and subscales of each item, except for Anxiety and Information Processing. This implies that students with a high level of deep learning approach are more aware of their cognition, metacognition and self-regulation, than students with a low level of deep learning approach. This indicates that students' that uses a high level of deep learning approach also have a high perception of their own SDL skills. This also supports the research done by Moshe Barak (2010), and the compensative model he suggests for self-regulated learning in technology education. Teaching students problem-solving strategies help them improve their individual thinking and reflection about their learning.

The results of this part of the research are promising and should be explored with further studies to validate the correlation between SDL and deep learning approach in a PBL environment. Further work should also include a more detailed research on how SDL and deep learning approach affects one another.

This research and Lifelong Learning

As stated in the introduction of this research, the overall background of this research is a wish of elucidating how Lifelong Learning skills are integrated and developed in formal education, by examining students' use of PBL, their learning approach and ability of SDL.

The results of this research indicate that the use of PBL and SDL are beneficial in relation to the development of Lifelong Learning skills, though no final conclusions can be made. For more definite conclusions to be made, a research over a longer time period is required. It is indicated by this research that students with a high level of deep learning approach are prone to employ a higher level of SDL, thus indicating a higher ability of Lifelong Learning skills.

7.2 Recommendations for further studies

This research investigates the possible interconnection of SDL skills and deep learning approach, in several contexts. In relation to a single PBL course, PBL experience in general and finally level of SDL skills in relation to level of deep learning approach. However, limitations of this research are present, especially in the short period of data collection and minor cohort of samples. Further research could beneficially employ a long term study as well as larger cohort of samples.

As an extension of this, further research may be done to explore a more detailed interconnection between deep learning approach and SDL skills in a PBL environment, not just students' perception of their own SDL skills. The findings of this research are promising, but the underlying mechanisms of the connection between SDL, PBL and learning approach remain to be determined. Further research should also include long term study of Lifelong Learning, to evaluate if a deep learning approach is sustained and if SDL skills are continuously developed.

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