Chapter # 37

PROJECT-BASED TEACHING
Insights from Development in Teaching in Construction Management

John Lindgren[1] & Anna Isaksson[2]
University of Halmstad, Sweden
[1]School of Business, Innovation and Sustainability, department of Construction and Energy Engineering
[2]School of Health and Welfare, department of Society and Welfare/Leap for Life

ABSTRACT
Future engineers must be fluent in different technologies, methods, and methodologies requiring a high dynamic capability, in opposite to many students' behavior. Project Based Learning, student-centred with a dynamic approach to teaching where students study real-world problems and challenges, aims to increase dynamic capability. This research reports transforming a course in construction management into a project-based approach to stimulate students' intrinsic motivation, i.e interest in what is learned and the pleasure it brings. Course material has been developed in four rounds, ranging from 2022-2024. Course documentation regarding the execution of the course as well as documented student feedback was thematically reviewed and analyzed relation to the aim of this chapter. The development shows interesting challenges in teaching regarding the balance between showing results from the actual project vs. stimulation of creativity among students. Age and work experience positively affect how the students execute the projects. It also shows the significance of the course framing and variation of project set-ups. Our findings also show values in PBL for students' ability to handle changes in a world with many insecure influences and it is indicated that PBL requires a learning process over time both for students and teachers.

Keywords: project-based learning, problem-based learning, intrinsic motivation, flexible learning.

1. INTRODUCTION, MOTIVATION AND OBJECTIVES FOR THE

The authors of this chapter have extensive experience in teaching including different subjects at different university levels. These experiences and discussions with colleagues indicate that students are becoming less focused on educational exploration and critical thinking. In this chapter, the focus is construction engineering. Broo, Kaynak and Sait (2022) highlight that future engineers must be fluent in different technologies, methods, and methodologies and the Architecture, Engineering and Construction sector is no exception, where climate impact pressures and technological advancements sets demands on broad skills among its professions (Chacón, 2021). Hence, fast shifts in the surrounding world cannot always be foreseen and puts emphasis on a high dynamic capability, i.e. to adapt to upcoming circumstances to be competitive (see for example Meier et al, 2023) among the workforce of tomorrow. The construction sector in total has faced different waves of changes pushing development forward. For example, digitalization and development of digital tools has put pressure on the sector to change (Jacobsson & Linderoth, 2021). Another current pressure relates to increasing the sectors sustainability. The environmental dimension is for example under scrutiny since the sector contributes with 25 % of the total environmental impact (Ness & Xing, 2017; Wouterszoon Jansen, Van Stijn, Gruis, & Van Bortel, 2020), leading to several

different activities and initiatives taking place to reduce impact, for example use of more sustainable materials and reduction of traditional materials with higher environmental impact. Hence, construction engineers for today and tomorrow face a dynamic environment with a significant pressure to develop solutions for the future.

In this setting and under these circumstances, Project Based Learning can be a valuable teaching approach. This is, in its essence, student-centred with a dynamic teaching approach, where students study real-world problems and challenges (Kokotsaki, Menzies, & Wiggins 2016). According to Bradley-Levine and Mosier (2014) the focus in PBL is besides the students learning to apply knowledge and skills in projects. The learning process revolves around some type of open-ended question connected to current and relevant issues or problems. Students must take an active role in their understanding of related issues and students should be stimulated towards a life-long interest in learning. A typical project can be to start with some type of demand that needs to be fulfilled with frames that the students must keep within, then the students actively, through the support of a teacher works forward to narrow down the demand into a solution. A similar approach to this is Problem based learning, in which complex real-world problems are in focus to promote student learning, i.e., both concepts can promote the development of critical thinking skills, problem-solving abilities, and communication skills and possibilities to work in groups (see for example De Graaf & Kolmos, 2003). Perrenet, Bouhuijs, and Smits (2000) states that a similarity between the concepts is that they both emphasize self-direction, collaboration, have a multidisciplinary orientation and are founded in real-world problems. Hence, both approaches can be valuable in addressing challenges with students and their learning focus, as stated above. However, in this paper, project-based learning is the concept used, abbreviated as PBL. It can also be lifted that there are different ways of creating knowledge from real-world problems. Collins and Redden (2020) for example report on valuable experiences from experiential learning in construction engineering education, where students learn from making real construction work in relation to more theoretical exercises and state the need for understanding construction in practice. Hence, teaching methods with a close connection to real work can be useful to enhance understanding among students.

PBL accommodate demands on both teachers and students. PBL must align with the teachers philosophy of teaching, besides meeting other significant areas such as learning needs (Liu, Wivagg, Geurtz, Lee, & Chang2012). Grant (2002) highlights the significance of the teachers experience as a supporting factor for PBL. Compared to traditional teaching, the roles of both the teacher and the students change. A stepwise implementation enables teaching to develop in a more controlled way and the balance between student independence and support can be challenging (Marx, Blumenfeld, Krajcik, & Soloway, 1997). Martinez (2022) presents a similar view and states that knowledge and confidence in the design of the actual course taking place is important also implying a wide knowledge base as useful for a PBL approach. Grant also raises the importance of supporting the students interaction and also to handle conflicts. Ertmer and Simons (2006) also pinpoint that the creation of a culture of collaboration and teamwork can be a barrier as well as changing from an instructive to a facilitative role. Other barriers raised by Marx et al. (1997) is that project planning can be time-consuming, disorderly classrooms and that authentic assessments can be difficult to design.

Based on this background, this paper presents documented experiences involved in moving from a traditional teaching approach into a project-based approach regarding a course in construction management, undertaken four times with a new structure in which a PBL approach were developed. The paper aims to provide learnings for other types of education aiming to transform into this type of education based on the stated necessities and driving forces in the background. An overarching objective with this is to provide learning experiences for teachers wanting to develop their teaching with a PBL-approach.

2. METHOD

The results section of this chapter has two parts relating to the aim of this paper. The first part describes the origin for the change of and implementation to enable PBL and how it was designed. Since one of the authors of this paper handled this process, the description is done based on the same authors view about changes that were made, supported by reviewing different type of course documents. The second part of the results section describes how the course rounds were perceived and what kind of feedback the students provided. How students provided feedback is presented in the next paragraphs. In addition, the mean age and experience of the student groups are described, since changes in perception and action was identified as different depending on these issues

For Higher Vocational Education (HVE, see below under 2.1), the students had, as a part of the course assignments, to describe their learning process over the course, write a diary, and evaluate the execution of how the project group had been working together. In this, there was feedback on the course set-up and development. In addition, an evaluation was made by the program director, and the students filled out a formal survey. For Halmstad University (HU, see below under 2.1), the students were given an assignment to write a diary and an evaluation of the project and the project group. In addition, the students did a course evaluation at the end. Besides that, a structured evaluation was made in class to discuss the course and its execution in the final class. Altogether, the documentation of these activities is used to identify areas of improvement for the next round and is on an aggregated level which the students know that it is used for.

The findings is a result from studying the collected material through a thematic review and analysis, to find patterns and significant results in the data in relation to the aim of this chapter. Since one of the authors has been active in the development, this influences the interpretation of the development, and the information presented in this paper. However, the authors have aimed to provide facts that could be viewed as both positive and negative to create trustworthy results. In addition, the second author takes on an important role as critical reviewer besides giving the perspective of an outside view. This is a major part of creating credibility in the results, including reflection of the methods weaknesses and risks (Maxwell. 2012). The critical awareness of the method is also important to create trustworthiness, and here, the outside view of the second author is of central importance (Merriam, 1994).

3. DEVELOPMENT OF THE COURSE(S) IN CONSTRUCTION MANAGEMENT

In this section, the background of the course is described, as well as changes made over the different course rounds. The course has been given at two schools in different rounds, where the content differs due to level and overall education objectives.

3.1. Background and Changes to the Course

Several years ago, one of the authors worked heavily with transforming different engineering education programs from mostly so-called traditional teaching into a teaching approach based on project-based and problem-based learning. This covered half the teaching over one semester in each year of education. Experiences from this were overall sound, and some students already in the first semester produced impressive results in their projects and abilities to bring unexpected ideas and solutions. This positive experience has, from then on, been more or less a key ingredient in one of the author's teaching.

Regarding the Construction Engineering program at Halmstad University, there has been a discussion about how the development of teaching can be developed into a more problem-based approach and project-based approach, stemming from a discussion about the student's attitude toward their studies. In particular, teachers were experiencing a student attitude aimed at having very precise instructions that could provide answers, which in many cases is typical for courses in design that include dimensioning/calculations. Therefore, a change in the design of studies has been viewed as vital to stimulate explorative learning. The course in question for this paper is a course in construction management, basically covering the steps of building design and all activities needed to hand over a finished building. The course provides an overview of the construction process but does not go into depth in sub-areas since this is covered in other courses. Since the students had been complaining about the course being hard to grasp and lack of practical relevance, this provided a good opportunity to redesign the course. The teachers involved in developing the course over time have an interest in PBL and the experiences of its parts varied. The whole course set-up however, has been overall managed by one of the course teachers. The teachers involved have also experience of the subjects treated both from work-life and research.

In parallel, some of the involved teachers had a similar but shorter course at a 2-year education program, a Higher Vocational Education (HVE). HVE was a two-year education with a more practical orientation and included work practice. This course was given once a year but proved helpful as a first test of a revised course set-up, emphasizing project and problem-based learning. The student population was different concerning both age, no of students and experiences. HVE round one (HVE1) had an average age of slightly over 30 yrs and almost half were women and round 2 just under 30 yrs (HVE4) and around a sixth women. HVE was mainly consisting of students that had worked and came from many different backgrounds, including the construction industry. HU2 had an average age of slightly under 25 yrs and nearly half of the class were women. while HU3 had an average of slightly over 20 yrs with about a third of the class women.

The original courses, called HU, took place at Halmstad University and are part of two types of bachelor-level education programs, and HVE, taking place at the two-year education program mentioned above. HU consisted of lectures and exercises, and the exercises were 1 ECTS, a project assignment of 3 ECTS, and an exam of 3,5 ECTS credits. The project assignment was, in short, to create a document for procurement of a building project; the exercises revolved around using different types of projects and the exam about the course aims. The project covered time-planning and costs associated with the building project, and the course mainly had one day a week dedicated to teaching, while the rest of the time was dedicated to the student's studies. HVE had a bit of another set-up, with three days of classroom activities consisting of lectures and exercises. The whole course was then examined through a written exam.

When changing the courses the main objective was to go through the steps of building an industrial facility, including a warehouse, office, and social spaces. The students had project assignments relating to start-up activities and then had to conduct project activities related to a construction project from start to finish for each week. By doing this, the students should also be trained in visualizing and understanding systems and structures, which is essential in the construction sector (Mastrolembo Ventura, Castronovo, Nikolić, & Ciribini, 2022). In HVE, the students worked with the project, its assignments, and documentation in a PowerPoint presentation, with ongoing presentations of the project activities and feedback provided regarding the assignments. In parallel, the students had individual assignments to hand in each week, which were about answering reflective questions about that week's themes. For the HU course, the basic set-up was the same, but

the students had to conduct a report for the project, including a final presentation of the project. Since the HU course was larger in content and length, the assignments were also more extensive.

3.2. Feedback and Changes Over the Rounds

Each time the course has been executed, there have been changes. The first time the course took place was, as stated above, the HVE1. The second time was at Halmstad University (HU2), the third time at Halmstad University (HU3), and the fourth time at HVE (HVE4).

HVE1: The first time the course took place, it was deemed successful overall as it was considered interesting, but also with many areas the students wished to go deeper into. The course evaluation survey had a response rate of about a third of the class answering and a mean satisfaction value of 4,25 (out of 6). Main comments were that the structure of the learning platform was messy, and to many teachers involved and at times messy with the individual assignments and the communication between the teachers. On the positive side, though, it was good with the individual assignments and the projects. In addition, the course was considered interesting and valuable, and the teacher's knowledge was considered good with many new subjects. Judging from the learning process descriptions, the course was deemed successful overall, with about a sixth of the students disappointed but the rest satisfied (or more). A main reflection from the teachers was that the students were not challenged in different types of designs regarding the facility. It was also concluded that they should be provided costs at an early stage to enable an assessment of the design.

HU2: Based on HVE1, different groups were provided with different demand specifications and a more thorough review of different building systems and costs. It was added to the demand specification that the students should choose a possible customer to adapt the building towards. In this round, they were also given more frames to change the design and evaluate their design regarding cost and climate impact. Many of the student groups made a 3D model of the building in the software Revit, which was a good addition to the projects. A main complaint from the students was too much information and sources available and the extent of the report was hard to assess. Otherwise, the groups presented buildings with different designs/architecture. In the oral evaluation the amount of material was discussed, pointing at the necessity for students to learn how to find facts. The course evaluation had a response rate of about a third of the students answering and a general satisfaction index of 67 % (out of 100 %) On the positive side, the students found that the project and the exam were good and interesting, including the set-up with weekly assignments. Once again, the students complained about the learning platform's structure, and some thought the amount of work was too much, although a majority assessed it as fair.

HU3: This time, a demand specification was added to broaden the scope of buildings. In addition, a template with headlines and additional instructions was added to clarify the content of the report and the project. Making a 3D model using the software Revit also became mandatory. In the oral evaluation, students again raised the issue of too much material, once again with the point being that the students need to learn how to find facts. The course evaluation had a response rate of about a fifth and a general satisfaction index of 61 %. Once again, the students found that the project and the exam provided an understanding of all the parts of a project and that the high amount of practical work was good and interesting, including the set-up with weekly assignments. Also, the students complained about the structure of the learning platform and that the students found that the teachers were not synced, which had to do with a new teacher coming into the course previously unused to the course and its set-up.

HVE4: The added changes were used again, this time in the project. In addition, due to previous criticism, the main author took over more of the course to manage a more significant part of the course. Since these students studied a limited version of the project, the visualization in Revit was not part of the project, and some of the parts were smaller in the project. Again, the course was deemed successful overall as it provided good basic competence and many good learning areas, but more depth in some areas was stated as helpful. The course evaluation survey had a response rate of around 70 % and a mean satisfaction value of 4,7 (of 6). Some individual comments were that some parts could have a higher pace, and some students still felt that too many teachers were involved. However, judging from the learning process descriptions, all course participants expressed satisfaction with the course.

Planned for next round was that the students were given a real area to plan the building project on. The area was under planning within a municipality, where the buildings in the projects can be built. This addition was made to further enable different types of designs and projects and possibly also add possibilities for different types of architecture.

4. DISCUSSION AND FUTURE RESEARCH DIRECTIONS

Regarding the development of the course, the set-up has been in line with the teachers view of teaching (c.f. Liu et al., 2012). Experiences of PBL has though varied, but in this case mixed experiences have been useful. In line with Martinez (2022), the teachers' different experiences and interests have complemented each other and has enabled the execution in a satisfactory way. One of the key issues at hand with the course was to develop it and stimulate students' interest in the course subject, intrinsic motivation (Entwistle, 2009), i.e., motivation that comes from "*interest in what is being learned and feelings of pleasure derived from it*" (pp 20), and not from external rewards (extrinsic motivation). As seen from the evaluation summaries, there is a variance regarding students' satisfaction. An indication is, however, that older and more experienced students seem to cope with the approach better than younger students. This strengthens the fact that interaction and self-direction is important and needs extra support when needed. However, there is still a dilemma with several issues in the approach. Firstly, the structure of information can constantly be improved. However, the balance between providing very clear instructions and letting the students set the frames themselves seems to be an ongoing development route where more clarity can be improved, but the level of innovativeness in the projects must also be supported and encouraged. I e, this highlight that a balance between student independence and support can be challenging. It is however also clear that students need to be taught into the teaching approach, validated by the ongoing discussions held between the teachers involved, highlighting the students' preferences to traditional teaching. This is furthermore validated by the older students ease to work with PBL. Hence, it is about learning to learn according to PBL, which has been discussed as a way forward by the students. It also shows a connection the significance of learning from past experiences as stated in experiential learning (cf. Collins & Redden, 2020).

An example is that the students initially think the project is unclear, but it becomes more apparent as they go ahead. This phenomenon seems to be more stressful for younger students than older ones, and younger students ask more questions regarding what to do. In contrast, older students ask more questions about knowledge and its application. The students experience the setup differently depending on personal attributes and experience. At large, the HVE students generally, although being a smaller group, seem to have a greater interest in learning. In addition, the impression is also that they can manage undefined issues better

than university students, which most likely can be related to their experience in managing issues in real life. Hence, in this case it does not seem as if they are taught to search for knowledge, it is their responsibility to find it and they show this through their attitude. It can also be assumed that the older students through their work-life have a wider knowledge base that they can use, quite logically since real-world-problems are in focus when working practically. Hence, older students with work experience seem to have learnt how to work according to PBL, while younger students need to learn this and get used to not everything being clear at once.

There is also a challenge in how many teachers should be involved, and an easy conclusion seems to be that one teacher should have a majority of the course, validated by HU2 and HVE4 just to create a good thread through the course, but a set-up with different competences also provides a larger knowledge base for the students. A reflection is however that since this course is of a more basic level, students might appreciate a logic and coherent thread through the course instead of having many competences available, which might be more useful in a more advanced course. However, there is also a learning process among teachers to get into the approach, which is also valuable. As stated above, the number of teachers is also in direct correlation with the access to a larger knowledge base for the students. Reviewing the implementation process and the developments taking place over time, stepwise development and changes have taken place as in line with Grant (2002) and Martinez (2022). We can however also see that there is a new population coming in for every occasion of the course, implying that the same approach would have been useful for the same set of students over several courses. It is however apparent that the experience and maturity of the learners plays a decisive role in the execution of the courses.

Obviously, there are several ways to conduct research but if development proceeds this is one way forward. It could also be of interest to do more active research during the courses take place and interview students and teachers about how the course takes place and how it proceeds according to barriers and enablers raised in this chapter. Another way forward of interest is to explore the long-term impact of PBL for students taking part in the education, by interviewing these when they have work-experience and their reflections from a long-term perspective. It would be especially interesting to conduct a follow-up with the younger students after a few years work-experience and see if the age difference-impact on learning would be validated and receive feedback on how to design the teaching.

5. CONCLUSIONS

Based on previous experiences from project-based learning, course material has been developed in four rounds in a course in construction management. The course has revolved around a construction project. A main driver has been to increase creativity and variation in the projects but also to meet the students' wishes to improve the course. Working with problem-based and project-based learning is a learning skill, and handling undefined activities is a competence that also needs to be developed to manage changes in a real-life work environment. Development in steps as well as having teachers with PBL-knowledge is a significant factor to develop in line with having a fundamental interest in the teaching approach. Hence, the study provides an example of development work and experiences, which other working with PBL can learn from.

The course focused on an already conducted construction project, which was modified for each round so the students could create new frames for the project. Feedback was received during the course, and individually, students at the end of the course provided feedback to coming rounds. The results from this development show interesting challenges in teaching

regarding the balance between showing results from the real project vs stimulation of creativity among students, with a clear conclusion that age, and work experience have a positive effect on how the students execute the projects, I e the character of the population is decisive but also the ability to use the approach over several courses to develop the extent of PBL. It also directly shows the significance of the course framing and the variation of project set-ups in the course. Our findings also show values in PBL for students' ability to handle changes in a world with many insecure influences. It should also be acknowledged that learning among teachers is also a significant part of the development process. The wide frames of the set-up seem to stimulate creativity but also need to be balanced with good enough instructions. Based on the research presented, learning to learn with a PBL-approach also requires time to master, for both students and teachers, preferably on several occasions over time.

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AUTHORS' INFORMATION

Full name: John Lindgren
Institutional affiliation: School of Business, Innovation and Sustainability, department of Construction and Energy Engineering, University of Halmstad (Sweden)
Institutional address: PO Box 823, SE-301 18 Halmstad
Short biographical sketch: John Lindgren is a Senior Lecturer in Construction Management at the School of Business, Innovation and Sustainability at the University of Halmstad. His research mainly lies within sustainability in the construction sector. John has also conducted pedagogical and didactic research, where development of tools and strategies for gender mainstreaming in higher education is one area are but also on project- and problem-based learning in Higher Education. The research focuses on how different perspectives, tools and strategies can be implemented and what effects they bring into higher education. This provides insights into how Higher Education can be developed to meet educational challenges.

Full name: Anna Isaksson
Institutional affiliation: School of Health and Welfare, department of Society and Welfare/Leap for Life, University of Halmstad (Sweden)
Institutional address: PO Box 823, SE-301 18 Halmstad
Short biographical sketch: Anna Isaksson is an Associate Professor of Sociology at the School of Health and Welfare, Halmstad University**.** Her research primarily focuses on gender and diversity issues within working life and higher education, with an interest in pedagogical and didactic research. She has actively contributed to the development of tools and strategies for gender mainstreaming in higher education**,** aiming to foster more inclusive learning environments. Through her research, she explores how structural inequalities shape educational and professional settings, integrating a norm-critical perspective to challenge and improve existing practices.