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Health, safety and environment in the teaching of project management. The case of bachelor education in construction engineering in Norway

Tina Åsgård*

Western Norway University of Applied Sciences (HVL), Møllendalsveien 6-8, Postboks 7030, 5020 Bergen, Norway

Abstract

The construction industry uses project work as its main working method and is at the same time exposed to serious risks to health, safety and environment (HSE). Project managers play an important role to ensure high performance on HSE in construction projects, and the first position gained by many engineers after graduation is often the role of project manager.

This paper examines how different aspects of HSE are included in the teaching of project management (PM) in the bachelor education of construction engineers in Norway. The examination includes analysing learning outcomes, curriculum, teaching and final exams in PM courses at the three largest educational institutions in respect to graduating bachelors in construction engineering in Norway.

The findings show that the inclusion of HSE in PM courses varies and that students of construction engineering need to learn more about how to influence HSE in projects. Two elements are largely lacking in the education: 1) how to influence HSE performance during the early stages of construction projects, and 2) how to influence safety culture in projects. A stronger inclusion of these perspectives in teaching could improve the ability of future engineers to reinforce effective health and safety measures in the construction industry.

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* Corresponding author. Tel.: +47 55587651

E-mail address: tas@hvl.no

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1. Introduction

The Norwegian Working Environment Act [1] sets high standards for health, safety and environment (HSE), and systematic HSE work is crucial for the Norwegian model of labor relations [2]. In some industries, however, there are still challenges regarding the safety of employees. In 2017, seven people died while working on construction sites in Norway, making the construction industry the most dangerous business in the country [3].

The construction industry mainly organize their work processes in projects, and earlier research has shown that this kind of work organization effects safety performance, and that project managers are important influencers on HSE in the industry [4, 5]. An earlier evaluation found that newly educated engineers in Norway lack necessary competence in project management (PM) [6], despite the fact that many recently graduated engineers are employed as project managers. The evaluation suggests that the educational institutions are not able to provide their students with the competence in project work that is needed in Norwegian working life. In the same evaluation, employers reported that newly educated engineers also lack competence on HSE issues [7]. Therefore, it seems relevant to explore how aspects of HSE are included in the teaching of PM in the bachelor education of construction engineers in Norway.

2. Theoretical background

The definition of HSE by Hughes and Ferrett [8] is a useful starting point for the purposes of this paper:

- Health – protecting the bodies and minds of people from illness resulting from the materials, processes or procedures used in the workplace.
- Safety – protecting people from physical injury.
- Environmental protection – involves arrangements made to cover activities in the workplace which affect the environment, as well as the health and safety of employees and others.

This investigation is, however, limited to the HSE requirements under the provision of the Working Environment Act, and, thus, excludes HSE requirements concerning the outer environment, consumers and the wider public. The discussion below will focus on the health, safety and working environment of employees in the construction industry.

2.1. General HSE challenges in the construction industry

Internationally, the construction industry is regarded as one of the most dangerous industries [5, 9, 10], and earlier studies have identified some of the important risk factors regarding HSE related to the *working conditions* on construction sites. Some of these risks could be minimized or even eliminated based on technological development, improvements and innovations. Other risks, however, need to be addressed in a less technical manner.

The *sector demographic* of the construction industry creates HSE challenges. A status report on HSE in Norwegian enterprises [11], concluded that larger enterprises had more access to different HSE resources and, as a result, generally had better HSE performance compared to smaller enterprises. In the construction industry, there are many small enterprises that lack the required resources which could help improve HSE performance.

Several studies on the construction sector show a strong *production culture* in the industry, illustrated by great work pressures and short deadlines, often giving production priority over safety [4, 12]. Hence, some academics argue that health and safety activities need to be aligned with this culture of efficiency in order to be successful [13], indicating that the risk factors in the industry need also to be addressed on a cultural level.

The Norwegian construction industry employs a significant share of *foreign migrant workers*, mostly from Eastern Europe. Several studies show that factors such as language barriers, cultural differences and employment contracts giving migrant workers poorer working conditions and less training, all contribute to HSE challenges in the industry [12, 14]. Numbers from the Norwegian Labor Inspection Authority show that immigrant workers are overrepresented when it comes to fatalities and serious injuries in the construction industry [3].

2.2. HSE challenges in projects

The construction industry is a project-based industry. Almost all building and construction activities share the characteristics of projects, as outlined by Larson and Gray [15]:

1. An established objective
2. A defined life span with a beginning and an end
3. Usually, the involvement of several departments and professionals
4. Typically, doing something that has never been done before
5. Specific time, cost, and performance requirements

These characteristics of projects contribute to the context in which HSE work is carried out in the construction industry, which create specific HSE challenges to consider when trying to improve HSE performance in this sector.

Working in projects with an established objective often produces a strong production culture, as noted earlier. The goal of the project (the physical construction) becomes more important than the means of achieving it (without accidents). This logic is evident when looking at earlier studies conducted in the construction industry [4, 12].

A project is further characterized by having a defined life span with a beginning and an end. In the construction industry this is perhaps most evident when looking at the pressure to meet deadlines [12]. Also, several earlier studies show that the possibility to influence safety is far greater at the early stages of a project than towards the end [16]. Thus, it is important to be aware of HSE consequences during decision making at the early phases of a project, and the focus on HSE needs to be present in all the different phases of construction projects.

Construction projects are characterized by complex work processes involving many actors and different types of professionals involved at different stages, creating challenges related to coordination and cooperation on HSE [12]. Studies have also found that accidents occur more frequently when many subcontractors are involved [5].

When doing something that has never been done before (at least not in every aspect), it is difficult to lean on earlier developed procedures [15]. Procedures on HSE therefore need to be customized to specific HSE challenges in the specific construction project. Additionally, when the actors involved switch from project to project, it becomes more difficult to develop an enduring safety culture. Thus, the safety culture of *projects* rather than *companies* becomes even more important [17].

Finally, the success of a project is often measured by requirement specifications of the end product (client satisfaction), the time spent and costs involved [15]. As noted above, time spent is a major factor in the construction industry. According to a literature review by Swuste, Frijters and Guldenmund [16], studies from the construction sector also show a direct relationship between project financing and safety, indicating that when the financial goals of the projects conflict with goals on safety, profit usually wins.

2.3. The role of the project manager

Newly educated construction engineers quickly assume positions as project managers. The project manager is in charge of all the different activities and phases in a project, and must be able to handle the special circumstances of project work [15]. The project manager is also by law required to ensure adequate HSE performance in the construction project, as stated in the Construction Client Regulations [18].

Earlier studies document the importance of the project manager when it comes to HSE performance. A Norwegian study found that the attitudes of the project manager towards HSE were crucial for HSE work on construction sites [12]. A Chinese study found that the development of safety culture is important to improve safety performance [17], and highlights the influence of project managers as role models. In a Malaysian study, the project managers were identified as important actors already in the design phase of a construction project [9]. A U.S. study

suggests that safety must “become a value and a culture with clear commitment from all levels of management” [10], a point also made in an international literature review [16].

Based on the HSE responsibilities of the project manager, Teo, Ling and Chong [5] have developed a framework to help project managers to improve construction site safety. They identified four main factors that the project manager should focus on:

1. *The policy factor*: Ensure that safety rules and regulations are followed, and implement HSE as part of company policy.
2. *The process factor*: Limit the number of subcontractors and ensure they are able to provide a safe working environment, and implement effective communication and information transfer between the actors involved.
3. *The personnel factor*: Influence safety culture by showing commitment to HSE, and provide safety training for employees.
4. *The incentive factor*: Ensure that the monetary and non-monetary incentives in the project contribute to safety, and take the necessary disciplinary action when unsafe behavior occurs.

These factors are all relevant when examining how aspects of HSE are included in the education of future project managers in the construction industry.

3. Research methodology

The research presented in this paper is primarily based on content analysis of learning outcomes in subjects related to PM, and the corresponding curriculum, teaching and final exams of these subjects. Information has been gathered from the three educational institutions in Norway which graduated the most bachelors in construction engineering in the years 2014-2016, thus representing nearly 60 % of the total number of graduated students. The institutions studied are the Norwegian University of Science and Technology (NTNU), Oslo and Akershus University College of Applied Sciences (HiOA) and Western Norway University of Applied Sciences (HVL).

NTNU has three different educational programs for bachelor’s degrees in construction engineering – one at each of its three campuses. However, the NTNU campus of Gjøvik does not include teaching of PM in their educational program and is therefore excluded from further investigation. Thus, the analysis presented in this paper is based on analysis of a total of four different study programs: Two at NTNU (one on campus Trondheim and one on campus Ålesund), one at HiOA and one at HVL.

The learning outcomes and curriculum have been subjected to qualitative content analysis [19] to identify indicators of HSE focus in the teaching of PM. The analysis of learning outcomes and curriculum have been supplemented by information collected via e-mail contact with the four teachers in charge of the studied subjects. These informants have provided documentation on the teaching plans of the subjects and the final exams of the past three years. This has provided an opportunity to test whether what is stated in the learning outcomes is reflected in the corresponding literature and teaching, and also if the achieved HSE competences are measured in exams. The content analysis was partly data-driven and partly concept-driven, and focused on the occurrence and use of the terms *health, safety and environment (HSE)*, in *what way* the terms are mentioned and in *which context*. *Risk, working conditions* and *regulations* are other examples of terms commonly found within the field of HSE that are included in the analysis to detect other possible indications of HSE focus in the teaching of PM. A scoping literature study [20] was conducted to map earlier research on HSE challenges in the construction sector, HSE challenges of project work and the role of the project manager regarding HSE. The results of the scoping literature study form the basis for the theoretical background presented earlier, and for the categorization of the findings in this study.

4. Findings

All of the studied educational programs aim to teach their students some form of PM, although not always as a subject in its own right. The first step in collecting data was to identify the subjects taught that has stated learning outcomes concerning PM. The subjects with the most explicit focus on professional PM were selected from each study program for further examination. These subjects are all taught towards the end of the bachelor programs.

Although PM is taught to some extent in all the studied bachelor programs, it differs how and to what extent. Some have specific subjects in PM, while others include PM in the teaching of other subjects. In some of the institutions, PM is an elective subject, while in some institutions PM remains a core subject, requiring all their students to learn about PM.

4.1. NTNU Trondheim

At NTNU in Trondheim, the students can choose an elective subject in PM. This course is designed to include many different aspects of PM, such as how to organize projects, success criteria, the phases in PM, risk assessment, and planning. Neither the course descriptions nor the learning outcomes mention HSE explicitly.

This elective subject is offered to a wide variety of engineering students. The subject is not directed towards work in the construction industry, and the curriculum focus on general PM [21]. However, examples and illustrative remarks in the literature are largely collected from the construction industry, and HSE is mentioned from time to time even if it is not a general or specific focus.

Nevertheless, the final exams do not address specific challenges of HSE to PM and the HSE focus in teaching is lacking due to the more general approach of the subject not directed at the construction industry and its specific HSE challenges.

4.2. NTNU Ålesund

At NTNU in Ålesund, the students are required to attend the course *Building Management*. The subject includes different aspects of managing a building process, such as laws and regulations, fire safety, HSE, lean production and information technology in the construction industry. The learning outcomes explicitly state that the students should gain knowledge on the requirements of internal control regulations on HSE. According to the learning outcomes, the students should also achieve skills in assessing safety measures on a construction site.

The practical teaching of the subject includes many different aspects of HSE. Part of the course requirements includes visits to construction sites with focus on HSE, and the Labor Inspection Authority gives a guest lecture on safety on construction sites. The lectures also have a strong focus on project work, organization and the role of the project manager. The HSE focus seems to be most prominent in the construction phase of the project, but is also present to some extent when it comes to contract commitments. Furthermore, the course gives students knowledge on the Construction Client Regulations, the Working Environment Act and the different actors in HSE work and their responsibilities. Some of the specific HSE risk factors in the construction industry are also included, such as work at great heights and in trenches. Assessment of risks when it comes to HSE is also part of the course. Finally, the teaching in the course highlights ethics and corporate social responsibility (CSR) regarding working conditions. In two of the last three final exams, the students were asked questions related to HSE.

To summarize; the subject of *Building Management* at NTNU Ålesund is an example of teaching PM in the construction industry, while at the same time having an explicit and integrated focus on different aspects of HSE. The laws and regulations on HSE in the sector, which actors have HSE responsibilities and how to assess HSE risks on construction sites, are highlighted as important aspects of the course.

4.3. HiOA

At HiOA the subject of *Construction Process* is mandatory for all bachelor students in construction engineering. The subject includes elements such as the phases of a construction process, the roles and responsibilities of different actors, laws and regulations that apply in the sector, and the implementation of new technology and organizational innovations in the industry. The learning outcomes state that the students should gain knowledge on HSE in the construction industry as well as acquiring the necessary skills to plan HSE measures and to carry out a simple risk assessment.

The main curriculum of the subject is a book on general PM [15]. The book gives a thorough introduction to the field of PM, though it is not designed for the challenges in the construction industry specifically. The book provides a wide perspective on PM, which includes the role of the project manager. The curriculum, however, also includes

other literature specifically designed for the construction sector, such as what happens in the early phases of a construction project, and the challenges of working interdisciplinary in the sector. The Construction Client Regulations are also part of the course reading. Both guest lecturers and the main teacher of the subject give lectures regarding safety on construction sites as part of the course requirements.

4.4. HVL

At HVL's campus in Bergen, the subject of *Entreprise and Constructon Site Operation* is mandatory for students specializing in project and construction management. At HVL' campus in Førde, the same subject is mandatory for all students in construction engineering. The subject focuses on the planning and operation of construction sites which includes choice of contract form, the organization of a construction site and risk assessment. These are all elements mentioned in the learning outcomes of the subject, however HSE is not explicitly mentioned.

The actual teaching has a strong emphasis on the principles of lean production in PM and HSE work related, and includes elements such as general PM and the role of the project manager. Different elements of HSE are also emphasized throughout the course, with a focus on laws and regulations in the sector regarding HSE. The students visit construction sites as part of the course, and are given assignments which involve examining HSE in ongoing construction projects. The course emphasizes the goal of "no damage to people" as one of the basic success criteria for projects. The teaching also includes some elements concerning migrant workers, the need for training of employees, working environment factors and ethics in the construction industry.

A substantial part of the curriculum is dedicated to explaining the HSE regulations that apply in the construction industry and how they should be implemented in the construction process. The final examination of the students consistently asks for reflections on topics related to HSE.

Many different aspects of HSE are highlighted as integral parts of PM in the subject of *Entreprise and Construction Site Operation*. Even though the learning outcomes do not specifically mention HSE, the topic is highly present in the actual teaching of the subject.

4.5. The findings summarized

The focus on HSE varies in the teaching of PM. When aspects of HSE are included, most of the studied subjects emphasize the HSE laws and regulations that apply in the construction industry, risk assessment and safety measures on construction sites. Most of them also emphasize practical working life input in the form of excursions to construction sites and/or guest lecturers from the industry. Knowledge on HSE is, for the most part, required in final exams. Only NTNU Ålesund, however, seems to include HSE when discussing different types of contracts, and only HVL seems to focus explicitly on the HSE challenges of dealing with foreign migrant workers.

5. Discussion

5.1. General HSE challenges in the construction industry

Not all subjects in this study include the general HSE challenges in the construction industry found in earlier research in the teaching of PM. NTNU Ålesund, HiOA and HVL all focus on specific safety risks on construction sites, such as working at great heights. Thus, some of the *working conditions* on construction sites that seem to increase the risk of injuries and fatalities are included in the teaching of PM in their educational programs.

Another element of importance to HSE in the construction industry is the *production culture*. However, the cultural aspects of PM, is not a main priority in the courses studied. Even though most of the subjects taught do include some ethical components, the importance of project culture to HSE performance and how project cultures establish and evolve seem to be lacking in the teaching of PM.

The amount of *foreign migrant workers* in the sector is another challenge that do not seem to be prioritized in the teaching of PM for future construction engineers. Even though this is a challenge subject to much public debate, only HVL mentions this topic when teaching students PM, as indicated in the collected data.

Thus, some of the general HSE challenges in the industry, such as physical working conditions that increase the risks of working on construction sites, seem to be included to some extent in the teaching of PM. This is illustrated by the fact that all of the studied subjects include risk assessment in their learning outcomes. Other more non-technical risk factors, however, seem to be lacking, despite having great influence on HSE performance.

5.2. HSE challenges in projects

There are some specific HSE challenges encountered when working in projects in general, and especially in the construction industry. The subjects studied focus on general aspects of PM. The teaching focuses on different types of contracts and common working methods when working in projects. Generally, less attention is paid to HSE at the early stages compared to the later stages and what happens at the construction site.

In most of the subjects taught, there tend to be a strong focus on the laws and regulations that require the construction client to protect the employees from health and safety risks when planning and executing construction work. However, the focus of the teaching, seems to be how to coordinate the activities and actors involved at the construction site, and not the decisions leading up to this point. The complexity of the work processes – which is a major concern in protecting HSE in the construction industry – seems to be well covered in the teaching of PM. The teaching generally also focus on the advantages and disadvantages of different forms of contracts, but only NTNU Ålesund considers HSE specifically in this context. As shown earlier, there tend to be more accidents when more subcontractors are involved, and the larger companies have a better track record on HSE performance compared to smaller ones. These issues should be considered when making contract decisions.

When considering specific HSE challenges relating to projects, it seems that the teaching of PM focuses on the later stages of the project process. This is also suggested by the title of some of the subjects taught, such as *Building Management* and *Construction Site Operation*. The focus on the construction phase of projects is perhaps understandable as most accidents in the sector happen during construction. However, it can also be a challenge when it comes to attempting to improve HSE performance. As previous research has shown, the possibility to influence safety decreases the closer you get to the actual construction. One could therefore argue that the students need to learn to evaluate HSE consequences of decisions made in all phases of PM, and especially the early phases.

5.3. The role of the project manager

Earlier studies have shown the importance of the project manager when it comes to HSE performance in the construction industry. The suggested framework of Teo, Ling and Chong [5] on how project managers can influence safety, is considered in the following as a way of evaluating the subjects studied.

The *policy factor (1)* seems to be well included in the subjects taught at the studied institutions, as most of them focus on teaching their students important laws and regulations on HSE that apply in the construction industry and how to implement these through the working methods taught as part of the subjects. At HVL the students learn that the goal of “no injuries” should be included in the success criteria of construction projects and implemented as part of the company and/or project policy.

The *process factor (2)* is also to some degree included in the teaching. The students learn about the importance of coordinating the different actors involved in a project, and how to implement such coordination. The students do not, however, learn about the specific HSE benefits of limiting the numbers of subcontractors involved.

Turning to the *personnel factor (3)*, the focus would be on the project manager as a role model committed to HSE and trying to influence the project culture. Although some of the subjects taught do cover the need for the project manager to create well-functioning teams, the cultural aspects of projects do not appear to be emphasized.

The final factor, is the *incentive factor (4)* focusing on what and how actions are encouraged and/or punished during the work process. Does the project manager monitor and act when unsafe behavior occurs, or does he/she look the other way as long as progress is being maintained? What incentives are in place to motivate safe behavior? These aspects of HSE seem to be poorly covered in the teaching of PM, according to the collected data.

6. Conclusions and suggestions

When examining how aspects of HSE are included in the teaching of PM in the bachelor education of construction engineers in Norway, the findings vary. At NTNU's campus in Gjøvik, the investigation of the education program found no subjects where PM was a focus. Consequently, aspects of HSE in the teaching of PM could also not be found. At NTNU in Trondheim, the subject of *Project Management* is an elective subject for all the different disciplines of engineering, making this a general course in PM not focusing explicitly on the challenges connected to the construction industry. The learning outcomes of the subject do mention risk assessment, however, neither the curriculum nor teaching focus on HSE.

The other subjects studied, put PM into a specific construction industry context. The HSE focus is highly present in all these subjects, however, they tend to focus more on the technical and organizational aspects of HSE and less on the cultural aspects. In addition, the teaching of HSE tends to focus more on the construction phase of the project process than on the early project phases. Earlier research on safety in the construction industry emphasizes both the importance of project culture when it comes to HSE performance and the opportunity to influence HSE performance in the early phases of a construction project. Both elements are important responsibilities for the project manager.

After graduation many engineers are employed as project managers with responsibility for HSE. Their education should provide them with competence on how to perform such responsibilities. This examination shows that this goal is accomplished only to a certain degree and that there is room for improvement. The educational institutions should aim to teach all bachelor students in construction engineering about PM with an explicit and holistic focus on important aspects of HSE in all phases of the construction project. This could increase the ability of future engineers to reinforce effective health and safety measures in one of the most dangerous industries in the world.

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