VETNET
European Research Network
Vocational Education and Training

Heinemann, L., & Deitmer, L. (2019). New forms of learning and teaching and organisational change – a case study at the building industry. In B. E. Stalder & C. Nägele (Eds.), *Trends in vocational education and training research, Vol. II. Proceedings of the European Conference on Educational Research (ECER), Vocational Education and Training Network (VETNET)* (pp. 161–169). https://doi.org/10.5281/ zenodo.3379373

New Forms of Learning and Teaching and Organisational Change – a Case Study at the Building Industry

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Abstract

This paper discusses comprehensive experiences of an ongoing and complex innovation process, driven by new requirements as a result of digitisation at the construction industry and by new examination regulations. Complex work and learning tasks (orientation on large building projects) were taken from the foremen's occupational reality as a source to (re-)organise the various fields of instruction, enhancing the foreman with the necessary technical and social work-process knowledge. The project DigiProb introduced digital tools and media and project-based forms of learning and teaching in the area of further vocational education and training at a training provider in the construction sector belonging to the German building industry. Starting with the change of work and technology in several building occupations we discuss the challenges this development poses for the foremen. The second part of the results section focuses on the training of the foremen at the side of the building education provider including measures to improve curricula and the digital learning environment.

Keywords

building and construction industry; digital tools and media; general foreman; further vocational training and education; mixed method approach

1 Method

In this project, we carried out a mixed-method design using an array of quantitative and qualitative methods. First, we conducted 20 interviews with those lecturers most involved in the courses as well as the training provider's management staff. These interviews were analysed using MaxQDA in order to group the interviews' contents around the most pressing issues.

As part of the new examination system (see below) foremen are required to do a work project on site and reflect on it. These materials were analysed in terms of how interdisciplinary content is actually intertwined in carrying out real complex work tasks in the world of work.

Furthermore, in the tradition of accompanying research, we organised monthly meetings of a group of lecturers developing the tasks that should structure the new course system stronger

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relating the different lecture's contents to each other. Here, regular group discussions were carried out and evaluated (Deitmer, Heinemann, & Müller 2018).

When the tasks were piloted in courses at the training provider, we carried out various online surveys for learners and teachers/trainers as well as interviews with course participants and participatory observation at the classrooms.

Finally, the usability of the digital tools was not only evaluated from a technical point of view but also (again, using short questionnaires as well as in-depth interviews) in terms of their potential to organise the content in a way that bridges domain-specific knowledge and stronger relates it to actual complex tasks.

2 The project

In the following sections we will present results from the final evaluation of the Project (DigiProb, 2019) in relation to the changing role of the general foremen, the challenges of further education and training providers, the challenges of the lecturers as well as course participants. Experiences with implementing lecturer working groups in order to supper greater building projects as well as evaluation results from testing the lecturer platform and the app Learning Toolbox (LTB) developed in this project will be discussed.

The project used the idea of complex learning tasks (work and learning projects) that were taken from the foremen's occupational reality as a source to (re-)organise the various fields of instruction, enhancing them with the necessary work-process knowledge. The second set of measures was the development of a digital learning and organisation environment, including Learning Toolbox-App for the students and a collaboration lecturer digital platform in order to help the lecturers to reorganise the materials according to these tasks and to enable them to collaboratively develop complex learning tasks (projects). The process of developing such complex learning tasks not only fosters the bridging of course material that used to be provided by different lecturers as isolated modules, but it also supported better identification with the courses as a whole and the role as a lecturer (Deitmer, Heinemann, & Müller, 2018).

2.1 Change of work and technology in Building and Construction

In the building and construction sector many technical innovations take place and are currently changing work and technology within this sector.

- new digital planning technology in the building and construction work like Building Information Modelling (BIM). BIM can be understood as a co-operative computer aided working design method which combines different technical domains and building disciplines such as main raw construction, technical equipment etc. It is represented by strong and extended virtual software artefacts which go beyond computer aided design tools (CAD) an is usually a 3D model of a building plus information on time and costs (Deitmer, Heinemann, & Müller, 2016)
- prefabrication of building segments. This calls for the foremen to command the newest communication technology in order to co-ordinate logistic processes of just in time delivery.
- more complex building standards to meet higher demands on energy consumption and other environmental requirements. The number of building regulations have been more than doubled in the last 15 years and make knowledge about new building technology and building work processes a challenge. Here continuous support by media information tablets is a big need.
- new materials are applied in a massive way which changes the work processes in several building occupations as e.g. brick laying when bricks are not anymore brought together by

using cement but are glued with plaster changing many details of the construction work process (Deitmer & Heinemann, 2015).

Altogether, this leads to entirely new requirements of work processes performed by the skilled construction workers and foremen involved, above all with increased demands for specialist skills and process expertise. Both in initial training and in further education, new training contents must be taught as well as translated methodologically and didactically into practice-oriented vocational training in construction.

2.2 The foreman

Foremen are the 'quality improvement managers' for work and business processes on the building site and manage the co-ordination of different trades from armoured concrete builder and bricklayer up to special supply domains such as completion trades like e.g. carpenters, stone and tile layers, and dry-wall builders. The foreman's tasks consist of assuring quality of work and organisation on the building project and under construction workers on a day to day base. The knowledge and skill domains he has to deal with can be grouped into three areas:

- building technology: e.g. building machinery, materials, logistics, pre-fabrication, new and innovative approaches such as BIM and building apps
- building site project coordination and management: e.g. to ensure quality of work- and business processes (preparation, realisation and assessments), documentation, measurements etc.
- employee management: adequate personal planning and team management processes (including responsibility for apprenticeship); regarding the building workers including apprentices: personal safety on building site, conflict management, team development, and coordination.

Therefore, he acts as a 'living communication interface' between employees, apprentices, suppliers, planners (architects, civil engineers, safety experts and building technicians), corporate building and construction headquarters, competent building authorities.

2.3 The examination system

The writing and compilation of a building project thesis is a key element in the renewed construction examination system aiming at action and project oriented learning. Preparing, analysing, writing and assessing a building project builds "connecting bridges" between the daily work practice of a foreman and the technical knowledge acquired during courses. Here is the chance to follow a project in a more general perspective and undergo quality development processes like plan, do, control, act. By preparing and writing and defending the thesis the foreman gets a chance to undergo a holistic learning process connecting course knowledge and real practice. We analysed several of such cases in order to get a starting point for restructuring the courses at the training provider.

2.4 Courses at providers of further vocational training for foremen

Further vocational education and training in Germany's construction sector leading to general foreman is structured on three levels. In courses carried out at training providers normally belonging to the building industry, one first can attain the level of foreman ('Vorarbeiter'), afterwards the 'Werkpolier' and 'geprüfter Polier' (two different levels of general foreman). The last one is adequate of a master craftsman in industry ('Meister'). In order to cope with technological change and first of all to relate courses and exams closer to the world of work

and the actual general foreman's occupational profile (i.e. day-to-day management of construction sites) in Germany in 2012 the examination of further vocational education and training courses leading to the different grades of general foreman in construction was reformed towards action-oriented examinations (Meyser, 2013; Niethammer, Schmidt, & Schweder, 2013). Examination now focuses on a practical project (usually three weeks) that is carried out at the foreman's company in order to reflect on actual work. The examination mainly consists in an expert talk on this project as well as on typical foremen's work tasks and problems.

During the courses, the learners usually are released from work and the companies pay for the courses as well as the skilled workers' wages during course time. The actual way of carrying out the courses leading to the different grades of foreman is dominated by a number of various external lecturers as sideline activities (often engineers, technicians, architects, experts of suppliers, experts of building authorities and private personnel developer and consultants) that are providing specialised knowledge about their respective fields. A seven weeks course easily may be carried out by more than a dozen or more different lecturers. Furthermore, at the first two levels there are a number of specialisations (e.g. earthwork, sewage conduit construction, construction site safety), that only refer to sub-groups of learners according to their individual fields of work.

The lecturers come from the whole of Germany and are specialists in their respective fields. But this setting makes it difficult, though, to relate the lessons' contents to one another and to enable the learners to grasp the whole picture of a foreman's work - the necessary work-process knowledge (Boreham & Fischer, 2009; Fischer, Boreham, & Nyan, 2004).

The challenge in the project we undertook was to introduce action-oriented forms of learning and teaching into this setting. Fortunately, lecturers' as well as learners' motivation for such an endeavour was quite high. Still, the way courses and examinations are organised overall meant lengthy labour in order to at least partly achieve the aim of stronger relating course contents to the foreman's occupational reality.

Altogether the most important conditions we found were:

The education provider mainly acts as an organising entity, providing infrastructure, copied learning materials of the lecturer, schedules and a basic pedagogical concept:

- Lecturers are spread all over northern Germany and only temporarily contracted; they are very often not pedagogically skilled and don't have an overview over the structure and contents of the courses as a whole.
- Mostly they don't know other lecturers (besides some private contacts) and do not have any chance to collaborate with others. Since participants have to be released from work, the courses are held under high time pressure.
- Since many lecturers feel forced to overload their lessons with factual general and basic information on special technology or building management, students are missing time to reflect and train the study matter. Moreover, they have to transfer the study matters into their field of work practice as a new foreman and evaluate the significance of the special teaching subject by themselves.

2.5 Reorganising course structures

The project's basis was that stronger cooperation in between the lecturers should help to better integrate different kinds of courses. Small groups of lecturers can share their individual course content for greater interoperability between the different learning units. This should lead to stronger interrelations between the learning units and can be formed into mutual building process projects where a bigger building project can be the target for the whole course. Technology, organisation process and the tasks of the foreman can be put into the centre of the course. In the long run, bigger units of groups of lecturers can be build.

Using a digital lecturer platform to organise the manifold building technology sub-topics (tunnel and channel construction, underground construction, and building above ground level) is making it easier to pool the different steps in the building process. This can help course participants in their learning processes to build up a stronger orientation towards integrative building construction processes. They can follow their role as coming building quality managers and be able to time the work and oversee the interoperability of different kinds of building task.

Finally, a mobile app that was developed in the European Framework project 'Learning Layers' was reconfigured in order to deliver the content to the learners in a way that fits these organisational principles – the Learning Toolbox (LTB). Here, the foremen get the content according to the structure of the course and are able to develop and share materials.

Building working groups under course lecturers

Three measures were undertaken and evaluated in the DigiProb project to prepare lecturers for this new kind of course programmes: In the development phase of the project a group of lecturers at the training provider began to develop a work oriented learning task which is able to integrate different building tasks into a larger setting – building a motorway service centre. Such a project relates building occupations such as underground (street building, parking space, piping and sewage) and upper ground work such as mason, concrete worker and stack-builder in order to create functional buildings: gasoline station, restaurant, hotel and recreation grounds and allowing the foremen to be confronted with managing a building site in its complexity.

This kind of creation of occupation-related tasks out of different levels of technical, work process or personnel management domains was carried through in monthly face-to-face meetings as well as by use of a digital platform which was especially constructed for the lecturers.

Though the process did not work as envisaged because of programming problems, the potential of such a platform in a setting where face-to-face meetings are not possible (i.e. outside a project environment) was clearly visible.

The meetings of up to 18 lecturers served to empower the lecturers to create complex and integrated work and learning tasks by making use of the online digital. In this series of meetings the following topics were tackled:

- What are the characteristics of such a "complex and challenging and problem oriented task" in terms of content as well as vocational pedagogy?
- What themes should be covered in the particular courses?
- What features do we need of the digital platform to allow the development of different kind of complex tasks online?

After dealing which such questions other questions occurred: How many co-ordinators for are needed for smaller and larger projects? What is their role? What does the platform? When and where physical meetings of which kind are needed? How is the lecturers work honoured and controlled?

For selection and design of the work tasks the following criteria have been guiding for lecturers:

- **Occupational reality**: selecting such work tasks that reflect typical and complex work processes in construction above and below ground including earthwork, street and sewage etc.
- **Work process knowledge**: the work task refers to work processes in a tripartite structure in combining different knowledge domains such as knowing that, knowing how and knowing why.

- **Shaping potential**: Tasks allowing foremen to be able to reflect on a holistic competence level which goes above functional competences. Each of the tasks is open enough so different pathways can be followed to reach a satisfactory solution.
- **Providing holistic solutions that cover work, technology and process**: The work tasks go beyond technical solutions encompassing the way the work process is organised as well as co-ordinating the different people working on it.

The work teams chose such work task that demonstrated a high level of inter-dependency to make obvious that co-ordination between the different work domains – e.g. earth work and construction and building of fundaments – is very relevant for the smooth processing and fine fitting of the different steps. In our example construction above and below ground meet and mesh.

The whole process of systemisation was carried out as follows:

- first brainstorming for the closer definition of the work task based on an analysis of previous experiences of work tasks commonly known by the lecturers to be suitable for foreman and general foreman.
- sequencing of sub tasks according to work order
- closer definition of sub tasks based on the sub task sequence structure; pedagogically designing the tasks for the work groups for the course participants
- internal validation in the group
- preparing for testing in different courses at the training provider
- evaluating the process and the results by interviews with lecturers and course participants as well as observation and class room shadowing

2.6 Fostering vocational learning by digital media

If one takes the approach to organise vocational learning in further education courses around complex work tasks, digital media gets a specific role. We tried to use digital media in order to foster vocational learning processes combining the acquisition of different forms of knowledge as ‘knowing that’, ‘knowing how’ and ‘knowing why’ (see Hacker, 1992). In order to better specify the role of digital media in this process, we developed a learning matrix showing the different steps of learning involved in the complex work tasks in order to decide if and in which way the use of software may foster the learning processes involved. This was then grouped for measures before, during and after the courses, and related to single lecturers, lecturers' interaction, single participants, participants' interaction and interaction between lecturers and participants.

It is important that everyone involved has a clear picture on when and for what purposes digital media plays a role here. In general, one may order the content of vocational learning processes into three areas: knowledge guiding action, knowledge explaining action and knowledge reflecting action (Hacker, 1992, p. 94). The first group, rule-guided knowledge, may be the easiest to foster by digital media. For occupational factual knowledge like knowing the regulation on slope and calculating it, one may use web contents in form of quizzes, puzzles, and so on. Knowing how is more related to the work process task. Here, the main point is to relate an isolated task to the work process as a whole - something especially important for foremen who have to organise the construction work under different domains. The third area deals with those questions that are posed by special cases that cannot be solved by the routine application of knowledge. For the latter two areas, we do not deal with factual knowledge but can enrich problem-based learning by digital materials.

In terms of soft- and hardware architecture, as well as organisational learning for the further education provider as a whole, these changes mean quite a challenge. For our project, we thus

developed a platform mainly for the lecturers to enable them to collectively work and exchange on the complex work tasks.

2.7 Implementing adequate digital tools and apps for the learners - the Learning Toolbox" (LTB)

The Learning Toolbox was developed in the European Framework project 'Learning Layers'. The guiding idea is to be able to organise content in a way that is suitable for project-based learning. In short, using 'stacks' for course units and 'tiles' for different forms of content, all kinds of contents can be provided in different formats on a smart phone and there is ample possibility to interaction and sharing of contents between lecturers, learners and between lecturers and learners. It also allows the creation and sharing of content by the learners themselves. The LTB was adapted to the DigiProb project to enable the teachers to create learning materials that allow the course participants to follow the complex work tasks according to the work process. At the different steps, small projects by the learners are possible.

The lecturers prepared their teaching scripts via the digital platform for the Learning Tool box. This changed the usual course preparation and planning because the lecturers were forced from the start to consider an application und user centred perspective. The lecturers regarded this change in the process of preparation as rather work intensive, but evaluated the overall process as rather. In every course stack also work experience tiles are now integrated where course participants are asked to load up own work experiences from real building projects, e.g. by annotated photos or videos. This new practice is enforcing the app users to reflect current own work practice.

The experiences during testing the LTB through selected lecturers showed that structuring content via knowledge tiles makes it easier for the participants to learn the contents. As all course participants already have a fair command of technical knowledge as well as occupational practice regarding the management of building projects at their building sites, assimilation of the additional knowledge delivered at the further education courses gets easier.

3 Conclusions

At the beginning of the project the main conditions providing challenges as well as resources to introduce change were:

- **Frame conditions**: Courses having to be carried out in winter and spring time, in as short a time as possible (between 4 to 7 weeks full time).
- **Participants' motivation**: This is quite high for all the learners out of the building and construction industry because they are eager to gain new levels in their professional career.
- **Lecturers**: Having very good factual knowledge of their field e.g. in building technology, devices and materials; building project management and personal management of different building domains on a building site; but mostly are not foremen themselves. Instead, civil engineers. architects or technicians predominate.
- **Exams**: Have been modified in order to be more in line with the actual foreman's job profile and expectation of modern building projects and processes. But often they are centralised and not carried out by the lecturers.
- **Teaching and learning processes**: Lack of well organised teaching materials including e-resources; restrictions on action learning because of time constraints; internal evaluation is carried out in a summative way.

The general foreman's role in the building industry has considerably changed in the last years. In Germany, examination procedures have been changed in order to cope with the foremen's new role. Still, there are severe restrictions put on the way learning is organised at VET and further education providers. Most severe here are the restrictions put on learning via

the organisation of courses - the companies' interest of having only a short, intensive course phase in the winter break is pressurising the instruction towards offering 'hard facts' in order to pass exams.

The innovation processes described have been set up via accompanying research aiming for better work process knowledge instead of restricting courses to technical knowledge that often is fragmented and difficult to assimilate to work practice. In order to achieve this we developed not only a digital collaboration platform for the lecturers, but also an integrative system to develop and set up complex work and learning tasks (work and learning projects) that were taken from the foremen's occupational reality as a source to (re-)organise the various fields of instruction, enhancing them with the necessary work-process knowledge. The support instrument for this step was the implementation of a Learning App: the Learning Tool Box.

As the learners as well as the lecturers show considerable motivation, some of the internal restrictions (e.g. lots of different lecturers in one course) can be overcome. Still, the aim to develop and establish sound forms of lecturer collaboration as well as a stronger orientation towards action-oriented learning only partly succeeded. One problem here simply are the resources to develop digital systems that can make the whole process easier and less time-consuming for the lecturers. As such systems have to reflect the needs of the lecturers' pedagogical co-operation, they are far more ambitious then moodle-like organisations of content – something software developers need some time to understand.

Co-operation and co-ordination amongst the different lecturers is a crucial thing. Qualifying and developing the lecturers' pedagogic and didactic approaches and abilities are a key essential. This included the competence of the lecturers to approach their teaching with a digital learning environment based on virtual spaces to share ideas and experiences up to specific learning apps such as the learning tool box.

The consequence of these changes is an increasing quality level of training in the construction industry. Institutions and trainers involved in vocational training, in particular outside the workplace, must make great efforts to not only maintain but above all to raise their level of training.

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