Co-construction of Knowledge in Work-Integrated E-learning Courses in Joint Industry-University Collaboration

Monika Hattinger and Kristina Eriksson

1University West, Department of Engineering Science, Trollhattan, Sweden

Abstract—Blended e-learning in higher education targeting company knowledge needs, can support continuous competence development for practitioners in the manufacturing industry. However, designing for such efforts are technically hard but even more challenging when the design aim to stimulate collaborative learning activities that bring in practitioners work experiences as a valuable knowledge source in construction with other peers or teachers. How are practitioners’ experiences and research teachers’ knowledge co-constructed and integrated in case-based methodologies? This article examines three types of case-based methodologies with purpose to stimulate mutual knowledge construction. The studies take part in a longitudinal joint industry-university project from 2014 until 2016. Twelve courses were analyzed through focus group sessions with 119 practitioners from 15 different companies. Results show that 1) Virtual digital cases stimulate high technology learning but low collaboration with peers, 2) On-line collaborative negotiations both stimulate web-conferencing and high interactivity, and 3) Real workplace cases do not stimulate e-learning (low use), but stimulate high work-integrated learning and knowledge expansion.

Index Terms—Co-construction, work-integrated e-learning, case-based methodology, manufacturing industry.

I. INTRODUCTION

University e-learning education aims to support lifelong learning for practitioners in the manufacturing industry and strengthen their competence development integrated in work practice [1, 2]. However, traditional higher education courses are usually designed for individuals on campus and do not support work practitioners working full time. University campus courses are traditionally not designed for time independence, flexibility or collaborative e-learning [3]. Furthermore, they do not include practitioners’ knowledge based on their work experiences as a valuable source in knowledge construction with other peers and teachers. It is a demanding process to integrate practitioners’ workplace experiences as a valuable knowledge source when designing e-learning courses. Particularly it is hard to make useful choices of learning technologies that support a case-based approach including practitioners’ experienced-based knowledge.

The aim of this study is to explore how engineering practitioners and research teachers mutually co-construct knowledge in a case-based methodology. The research teachers are primarily performing production technology research and only part-time engage in teaching on advanced level. The practitioners are operators and expert engineers in the workplace. Given this, we explore the concept of co-construction of knowledge between practitioners’ and research teachers’ collaboration in e-learning courses through various forms of case-based methodologies. In the courses, different case-based methodologies are introduced to trigger different perspectives and learning in and through co-construction.

The empirical context is a new type of course concept developed within the industry-university collaborative project ProdEx, and offers a new educational practice, see Figure 1. In the figure’s lower left corner, post-secondary practical education is found. The lower right corner shows post-secondary higher vocational education (a Swedish model). In the upper left corner we find distance and online higher education defined by the university that targets individual students. These types are established forms in Sweden.

The ProdEx project comprises a network of industries and one university collaborating in a longitudinal design and implementation process of blended and work-integrated e-learning courses, since 2013. The blended e-learning courses are designed towards manufacturing industry target knowledge content for an effective and competitive production in a digitalized industry 4.0 [4]. Research in the project has explored e-learning activities and co-construction of knowledge in various forms, and between different actors; industry managers, industry practitioners and university research teachers [5].

Figure 1. ProdEx positioned among other professional educational models.
II. RELATED RESEARCH

In a knowledge-based economy, manufacturing companies constantly need to strive for a flexible and cost-effective production, meanwhile delivering high quality products and customer services in short-time [6]. Consequently, efforts with learning and educational projects across industry and university is a powerful way of integrating theory and practice in a process of co-construction of production technology knowledge. Tynjälä [7] put forward that scholastic learning should adopt specific features of workplace learning and workplace development of expertise.

A. Co-construction of Knowledge

There is today an ongoing debate on policy levels of the value of co-production, but little evidence on its value for professional work, expertise and knowledge [8, 9]. However, what happens in the concrete practices of such arrangements is less well known. Therefore we argue for a more practice-based approach through the concept of co-construction of knowledge [5]. Co-construction is open-ended between actors, and is the joint creation of a form, interpretation, activity, identity, skill, emotion, or other culturally meaningful realities [10]. The concept of co-construction contextualizes sharing, and giving from two or more perspectives. Further, the concept involves a social space in and between individuals, and across individuals and technological artifacts that prosper positive engagement and a certain excitement of new knowledge and learning [11-13]. This paper delineate how co-construction is developing between experienced industry practitioners and researchers in an e-learning practice.

B. Engineering Competences and Work-Integrated Learning

Engineering work is also about problem solving, improvement and continuous technological development. The production systems are highly automated and therefore engineering work consists of monitoring and controlling. However, reality is still far from an effective and fully digitalized work environment and new competences need to be strengthen continuously. Knowledge-intensive work pressure operators, engineers and manufacturing companies to assess new expert knowledge and adapt to changes that imply short-term flexibility instead of long-term perspectives [6].

To find sources and collaborations outside the company for strengthening practitioners integrated in work is one way for competence development [14]. Work-integrated learning (WIL) can be described as a combination of education and practice integrated in work. Work-integrated learning offers a combination of engineering education with engineering work practice on equal grounds for qualitative learning and knowledge development [7, 15-18].

III. RESEARCH CONTEXT AND METHOD

This paper is built on data collected within the ProdEx project, started in spring 2013 and will continue until spring 2020. About 25 different industry companies within the automotive and aerospace sector are engaged in a joint collaboration with a Swedish university. The industry network and the university collaborate around; competence mapping of engineering knowledge content, discuss implications for e-learning design of courses, and share the objective of strengthening expert engineering competences for future digitalized industrial work [19].

The different case-based methodologies explored are designed within 12 short university e-learning courses of 2.5 European Credits (ECTS), within the project ProdEx (Expert in Production Technology).

Figure 2. An industrial robot at PTC in Trollhättan.

A general ProdEx course of 2.5 ECTS is designed by:

Schedule: 5-6 weeks with maximum 2-4 lecture days at the Production Technology Centre (PTC, a laboratory center connected to the university). Additional web-conferences between the lectures are scheduled weekly.

Course material and tasks: instructional videos, authentic industry cases mixed with academic assignments, virtual and physical labs, written instructions, Power Points, books, articles. Materials published on the university LMS (learning management system) DisCo.

Communication and interactions through DisCo, chat and web-conferencing (Adobe Connect and Skype for business).

Examination through home assignments and case-methodologies, both digital and physical labs and cases. No written final exams.

Pedagogical philosophy: pedagogical strategies that activate participants constructing and contributing to the course. Bringing in their authentic and proven experiences closely related to personal skills and the companies’ production processes. This is viewed as a work-integrated learning pedagogical philosophy.

Courses comprise the knowledge subjects: industrial automation and machine security, negotiation skills for businesses, and machining and tribology.

To incorporate and strengthening the practitioners as part of the mutual knowledge construction within the courses, three different case-based methodologies were analyzed that variously aimed to activate co-construction of knowledge between peers (see Examination above). The study focus is on practitioners becoming active learning participants and how they mutually engage their knowledge contribution [20]. The case methodology was developed during design cycles of 12 courses from 2014 until 2016, as part of the whole course design inspired by the Action Design Research (ADR) (Sein et al., 2011).
Three case methodologies are included: Virtual digital case, Online collaborative negotiations and Real workplace case.

A. Data collection

The data collection was conducted by twelve focus group sessions, performed on the last day of class after the final examination. Each session creates a unique intervention and forms a meaning unit, in which participants’ together can verbalize their meanings, knowledge views and negotiate through group interactions [21].

The sessions were performed in forms of open discussions to trigger practitioners’ experiences of the course interventions. A semi-structured interview guide [22] was directing the open-ended dialogues followed by broad themes of e-learning technologies, communication, course format/modality, teacher support, examination, competence areas, work-integrated learning and future competence needs. The courses are categorized into three themes according to their specific knowledge subjects, see Table I.

<table>
<thead>
<tr>
<th>KNOWLEDGE SUBJECTS (THEMES)</th>
<th>COURSE SESSIONS</th>
<th>SESSIONS</th>
<th>PARTICIPANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Industrial Automation (4)</td>
<td>5</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Machine Security in Robotics (1)</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>Business</td>
<td>Negotiations Skills (3)</td>
<td>3</td>
<td>34</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>Machining (3)</td>
<td>4</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Tribology (1)</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Summary</td>
<td></td>
<td>12</td>
<td>119</td>
</tr>
</tbody>
</table>

TABLE I. KNOWLEDGE SUBJECTS SORTED IN THREE COURSE THEMES

IV. ANALYSIS AND RESULTS

To answer the research question of how practitioners’ experiences and research teachers’ knowledge are co-constructed and integrated in case-based methodologies, the transcripts were read through, coded and categorized the excerpts into a scheme with the overall category case methodologies, i.e. performed through a content analysis [21]. Codes were created continuously with support of the Quality Data Analysis system NVivo 11. The data was organized into the three knowledge subjects, see Table I. Three main categories turned out to be helpful to organize the results, Problems, Active learning and Work-integrated learning, in which we delineated how co-construction was developing. Through the excerpts we found what and how work-experiences and learning experiences were triggered within the three case methodologies. Results from the analysis together with a description of the three cases setup follow below.

A. Virtual digital cases

The case is a digital lab, designed and implemented by the software Camtasia and run on a single PC. The case aim to strengthening learning of PLC programming at an individual level. It includes PLC logics and tasks around solutions of how to perform various solutions. After a week of solving the case, participants meet in a Skype-conference session, discussing various questions and how they made their own solutions.

A problem raised is illustrated:

Operator 3: “I felt I would have enjoyed some more basic facts when you sit at home and do these assignments. How do these things really work? It was a fairly steep curve when you started with this.”

However, other more experienced practitioners meant the case was activating learning.

Active learning is shown as:

Operator 5: “It [the virtual lab] was very good.”

Another operator raised the importance of advancing their skills:

Operator 1: “We’ve historically worked with this kind of programming so I think it’s perfect. This is useful teaching material, and it’s also cheaper. With time you build more models. So that you can advance...”

They reflect on their own lack of theoretical knowledge from before, but eventually how they advance through working with the case, in iterations. Both individually and through negotiating it on-line with peers and research teachers.

Work-integrated learning is shown here:

Interviewer: Did you learn anything?

Engineer 1: “Yes, it (the virtual lab) was good, you got to work a lot yourself.”

Operator 4: “To get a foundation and to understand how it actually works, for instance when the PLC sends out signals and codes.”

Operator 2: “We will have extremely many signals in a machine controlled by PLC. At least in the lathe.”

They integrate and affirm their knowledge more in-depth, of how a PLC can be programmed and variations of how it can be useful for new work practices.

B. On-line collaborative negotiations

On-line collaborative negotiations were practiced through a predefined Harvard Case (H-case). The case was designed as an intervention with six participant roles, taking part during three hours. The chair had to keep track of time and direct the negotiations. The case can be solved in multiple ways and is usually hard to find a solution that reach a compromise between all six parties. This is an in-built pedagogy. We found that different groups had various strategies for solving the case. In some groups, discussions were loud, and in others, voices were only raised during certain phases to achieve as reasonable result as possible.

During the H-case, many participants felt they lacked time to negotiate with everybody and to consider different alternative solutions before voting according to their choices. Some felt that the initial written instructions were unclear on how to “perfectly” perform the case whereas others meant that the case lacked some authenticity.

Problems raised are illustrated:

Purchaser 2: “We should have practiced much more IRL before the web-conferencing... not many of us followed the instructions.”

Purchaser 1: “No, it was more like a game...more like playing monopoly. We practiced a lot of lobbyism by
writing in the web forum. Not the kind of lobbyism that happens in a real meeting.”

They are really negative towards the use of web-conferencing for handling negotiations and questioned the assigned roles in the H-case. Even if they had experiences of web-conferencing, they were not familiar with negotiation situations with customers and suppliers in web-conferencing media. It seems that the industry purchasers want particular instructions from the research teachers’ along with pre-defined instructions, to be able to come to closure. The design of the H-case is that it will almost never solved, because there are over 100 various solutions and hence no precise answer at the end, such as in real life. To overcome these problems and to realize the potential for active learning, meaning their new negotiation skills, they started to reflect upon their own learning.

Active learning is shown as:
Operator 2: “I think this really was an awesome H-case to learn so much in so short time, I am impressed.”
Another operator [3] follows up, and describes that:
“During a business negotiation, one needs to be calm, to not always claim to be right, rather to show appreciation of other perspectives than your own.”

Participants reflect further upon the intertwining of theory and practice.
Operator 4: “In real life, there is more background information... Now there was only the written instructions, so you had to invent things on your own.”

Following these discussions, triggered by the H-case, participants were engaged to integrate new knowledge integrated in work.

Work-integrated learning is shown here:
Operator 1: “My manager asks a lot and is actively engaged. I really have learnt new stuff from this type of soft skills course because I am aiming to transform my position from CAM-operator into becoming a service technician.”

Human knowing and experience based knowledge was intertwined with new negotiation skills knowledge through the H-case. Through mutual discussions between the practitioners in the focus groups, they were able to solve problems independently, even if they experienced that some case instructions were unclear.

They also highlighted that they had started to reflect more on themselves, and their own actions and talking, towards other people. They felt they could apply what they learnt in their work, and were satisfied with their personal development as part of future transformative actions in their work practice.

C. Real workplace cases
A turning and milling case, was to be managed and solved at the home company. They were supposed to get written and oral instructions from the research teacher. However, the instructions and prerequisites were either late communicated or solely orally gone through by the teacher. To be able to do the real workplace lab case, the participants had to interrupt the daily manufacturing processes at the home factory.

Problems raised are illustrated as:

Consultant 1: “We did not have time to find equipment to perform the lab. However, if the labs had been here at PTC I think it would have been easier.”
Operator 2: “We did not know it was pre-requisite to have a turning and milling machine at the home company.”

Even if there were problems to perform the lab, the task showed results that were deviating far from traditional campus solutions and new innovative solutions occurred.

Active learning is shown as:
Operator 2: “You must have your own machine, the material, and also tools to test. These are the prerequisites, otherwise you cannot solve the task.”
Operator 6: “However, the benefit was to take an example from the own factory.”

The problem situation with the turning and milling lab and accessibility to machines, evolved into suggestions on how the course could get showcases of a “perfect way of doing digital labs.”
Consultant 1: “It was nice labs, but only if you were able to perform them...”
Consultant 2: “I think a good solution would be web cast how to run the milling and turning machine. I mean to take a camera into the machine and make a video of how to perform it all and then put it on DisCo [LMS].”

They want to have a certain defined solution to their lab, to make sure they perform it right. Some practitioners did therefore not perform the lab at all, because they had no experience of running such machines, which on the other hand was not mandatory before the course started.

Work-integrated learning is shown here:
Operator 6: “Think we learned a good part from the demos that other participants solved. I for sure want to go into the next course, Tribology (step II). My manager wants me to continue.”

V. DISCUSSION AND CONCLUSION
The analysis of the longitudinal data, resulted in a broad variation of case methods as working tools for co- construction of knowledge. The cases activated both learning and contributions from the practitioners’ which stimulated advancement of their skills. Analysis of the results also generated evidence of user-experiences of mediated discussions through the three case methodologies. The different cases aimed at integrating active learning between practitioners for future transformations in work practices [15]. The results illustrate that the design of the case methodologies both includes theory-based instruction and experience-based practices, see Figure 2.
The cases are triggered and evaluated by the actors (practitioners and research teachers) through their use during the course, and evaluation in the focus group sessions. Hence, both actors’ experience (workplace vs research-based) were intertwined during the courses. Such intertwining stimulated co-construction and work-integrated learning.

The practitioners were co-construction knowledge together actively in the courses and in the cases. Even if some case instructions were unclear, practitioners were, through negotiations of the course instructions and content, able to solve problems independently. The focus group sessions themselves also turned out to be a session for problem solving and for raising issues. The results among the practitioners show that they reached deeper learning, how to reflect on conflicting situations and the importance of taking time before decision making in future solutions within workplace situations. They also highlighted that they had started to reflect more on themselves, their own actions and talking, towards other people. They felt they could apply what they learnt in their work, and were satisfied with their personal development as part of future transformative actions in their work practice.

In focus groups there were discussions on the new course material, concerning old problems versus new solutions, which illustrated signs to stimulate actions into meaningful production [23]. The case-based approaches within the courses were loaded with signs to stimulate practitioners’ intentionality and for them to feel comfortable to put forward, and contribute to new active learning built on their experience-based knowledge combined with new learning. The case-based approach in the courses therefore became a structured learning activity, that emphasized collaboration and knowledge sharing through co-construction including knowledge content and forms. This pedagogical strategy was stimulating co-construction of expert knowledge into mutual expertise. The courses became a joint collaborative adventure, and a respected activity for co-construction of expert knowledge. Overall results show that; Virtual digital cases stimulate high technology learning but low collaboration with peers. On-line collaborative negotiations stimulate web-conferencing and high interactivity, and Real workplace cases do not stimulate e-learning (low use), but stimulate high work-integrated learning and knowledge expansion.

This paper contributes to an understanding of a process of mutual and co-constructive learning between the practitioners and the research teachers, leading to new knowledge insights for the practitioners’ work practice. Hopefully this will influence future work-integrated transformations. We therefore argue that co-construction of knowledge, between practitioners and research teachers, can be encouraged within blended e-learning courses through collaborative case-based methodologies.

REFERENCES


The International Conference on E-Learning in the Workplace 2018, www.icelw.org


AUTHORS

Monika Hattinger, PhD in Informatics and Work-integrated learning and is with the department of Engineering science at University West, Trollhattan, Sweden (e-mail: monika.hattinger@ hv.se).

Kristina Eriksson, PhD in Mechnical Engineering and is with the department of Engineering science at University West, Trollhattan, Sweden (e-mail: kristina.eriksson@ hv.se)

Manuscript received March 14, 2018. This research was funded by the Swedish Knowledge Foundation (www.kks.se) and the Work-integrated learning research group at University West.

Published as submitted by the author(s)