Mind the Gap: A Collaborative Competence E-learning Model Evolving Between University and Industry

Monika Hattinger
University West

Kristina Eriksson
University West

This article arises from consideration of the effects of inter-organizational collaboration on participating partners, specifically from design-related activities and co-production of e-learning courses. The research focus is on critical factors for inter-organizational collaborative e-learning and co-production between university and industry. We describe the process of a six-year longitudinal collaborative action research project comprising six cases and three phases—initialization, implementation, and dissemination. The analysis is conducted from a multi-stakeholder perspective: managers, teachers, and practitioners. The overall aim is development of a sustainable collaborative competence e-learning model that will increase industrial employees' competencies. This work's main contribution is the finding that co-production of knowledge entails three levels of activities among actors: insight into the purposes and practices of others, capacity to transform the problems of a practice and build common knowledge together, and finally, the capacity to mutually co-produce knowledge acted upon for transformation in the workplace.

Keywords: University-industry collaboration, competence development, co-production, e-learning design, manufacturing industry

INTRODUCTION

This research grows from an examination of the effects of longitudinal and inter-organizational collaboration on the participating partners (Akkerman & Bakker, 2011a). In such collaboration the interest is on mutual design activities that evolve when an organization causes a change in the capacity of another, through knowledge sharing, knowledge building, and learning (Argote et al., 2000; Billett, 2002). Specifically, this research draws on critical factors of inter-organizational collaboration between university and industry, meaning effects from activities that interrelate co-production and e-learning design with the aim of strengthening industrial competence.

Inter-organizational collaboration has been the subject of substantial research interest within organization, management, and communication studies (Bourne, Harris, & Mayadas, 2005). There is also a growing body of research examining success factors within the field of health education (as cited in Bryman, 2012), as well as of education-related partnerships between universities and engineering companies (Colin & Tynjälä, 2003). Besides the benefits of inter-organizational collaboration these

studies, also raise the *complications* of inter-organizational collaboration including cultural differences, different time dependence, obstacles of mutual problem domain sharing, etc. (Bourne et al., 2005; Bryman, 2012).

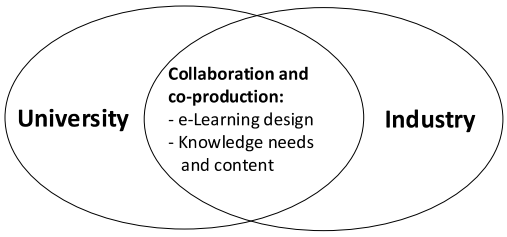
However, these research fields do not specifically consider aspects of university–industry collaboration that include and combine design-related knowledge and work (Chiasson, Germonprez, & Mathiassen, 2008). Design-related activities may cause dilemmas and conflicts in the process of co-production of knowledge and e-learning when developing an e-learning program (Davies, Coole, & Smith, 2017). Given this, we argue there is a further need for research on the effects of inter-organizational collaborative studies addressing interrelations of co-production and e-learning design.

We argue for a novel research program that takes a multi-perspective view of e-learning design and collaboration, one with an action research (AR) approach (as cited in Dubois, & Long, 2012), and ideally one combining AR with action design research (ADR) (Engeström, 2015). Combining AR with design research creates a way of thinking that interrelates technology, processes, and organization to understand design as its own culture of inquiry and action (Ford, 2015). Furthermore, AR with a design approach provides direction for *collaborative practice research* as a way to organize and conduct research based on close relationships between teachers and practitioners (Goldstein, 1999). On this basis, we highlight the need to use AR approaches with design implications to successfully build models of inter-organizational collaboration with the aim of co-production of e-learning courses targeting industry competence needs.

In this paper, we outline the ProdEx (Expert in Production Technology) project, a longitudinal project comprising inter-organizational collaborative competence activities between a university and a manufacturing industry network (focused in the aerospace and automotive sector) that began in 2013 and is on-going through 2020 (Govaerts & Baert, 2011). We have applied an overall collaborative AR approach throughout the project as shown by Goldstein (1999), comprising six cases from multi-perspectives actor views: two cases of industry managers, as well cases of teachers, course design process, course practitioners and alumni.

The overall aim is to develop a sustainable collaborative competence e-learning model (CCeModel) that will increase industrial employees' production competences. The question asked is: *What are the critical factors facilitating inter-organizational collaborative e-learning design and co-production between university and industry*? Given this question, we emphasize critical factors derived from the results of the various studies that advanced through AR and design-oriented actions toward the CCeModel. The process of co-production is analysed through two lenses: *the industry knowledge needs* and *the e-learning design of a course program* (Figure 1).

FIGURE 1
CO-PRODUCTION IN INTER-ORGANIZATIONAL COLLABORATION



In all six cases, the overall focus was to capture learning and design activities at the systemic intersection between university and industry (managers and university project group) and between teachers and engineering practitioners. In this paper, we first look back and outline lessons learned from the two ProdEx project phases of initiation, and implementation (cases 1–5), and then highlight upcoming challenges of the on-going, final phase of dissemination (case 6).

The remainder of this section offers an overview of the theoretical framework regarding work-integrated learning, co-construction of knowledge, and e-learning design of courses. It ends with theories

on learning while boundary crossing. Section 3 outlines the ProdEx project. Section 4, research method, shortly describes how the six cases were approached. Section 5, outlines overall findings from each of the six cases, organized by phase: initiation, implementation, and dissemination. The discussion in Section 6 outlines the challenges, critical factors, and resolutions required for successful inter-organizational collaborations for a CCeModel. Section 7 describes the main contributions of this work and offers conclusions.

THEORETICAL FRAMEWORK

This section introduces the problems that industries encounter in transformative digitalized manufacturing and the need for competence development, work-integrated learning and co-production of knowledge. Thereafter, the premises of e-learning design that face the university are outlined. We use boundary crossing as a theoretical lens applied to the overall results of the six studies (Hardy, Phillips, & Lawrence, 2003).

Work-Integrated Learning and Co-Production of Knowledge

Digital transformation is forcing the manufacturing industry (as cited in Hattinger, 2018a; Hattinger et al., 2014) to adapt to Industry 4.0 applications such as artificial intelligence and interconnected machines (Hattinger & Eriksson, 2015). Digital transformation further pressures industry practitioners to expand their skills and to develop the new professions needed to facilitate production systems, digital applications, and new types of services (Hattinger & Eriksson, 2018b). These transformative changes of re-configuring factory plants are affecting everyday production work, driving management and practitioners to embrace the need to constantly to learn and re-learn knowledge that is not even there yet, which is highlighted by Engeström (Hattinger, 2018c).

Thus, digital transformations of industry as shown by Ingram (2017), affect even shop-floor practitioners with traditionally low levels of formal academic education. Even if they have both deep and long work-based experience and knowledge (as cited in Jasanoff, 2004; Jacoby & Ochs, 1995), they need to be supported with new types of knowledge and learning that formal education can offer. Along these lines, Tynjälä (as cited in Kahiigi et al., 2008) put forward that education should adopt specific features of workplace learning and development of expertise.

Combining experience-based knowledge with scientific knowledge tends to be key for practitioners' advancement. Therefore, companies need to actively engage in improving their practitioners' competences through new methods of formalised education that can be integrated in work practice, described here as work-integrated learning (WIL) (Kvale, 2006). WIL is defined for our purposes as a combination of education and practice that must be understood from an inter-organizational perspective. It is an umbrella term for a range of approaches and strategies that integrate theoretical knowledge with the practice of work. In formal education, such perspectives should be purposefully designed within curriculum to address the needs of industry (Kvale, 2006; Kirkwood & Price, 2014).

A growing body of research has defined the concept of co-production in user and technology centered studies (Kohlbacher, 2006). Jasanoff (as cited in Kohlbacher, 2006) stresses that co-production includes wide areas, such as making identities, institutions, discourses, and presentations. This means that co-production encapsulates activities (of mutual interest) of learning, design, and knowledge-sharing between multiple stakeholders. Jacoby and Ochs (as cited in Koren, 2010) further highlight the interactional approach to explore how co-production is facilitated from a process-oriented view. With this in mind, the following sections seek an understanding of how processes of knowledge are constructed, rather than defining their ends. The processes of co-production include both subjects and tools and the cultural practice of science and technology in which meaning and learning are delineated among stakeholders (Lahn, 2004; Lasi et al., 2014; Lindgren, Henfridsson, & Schultze, 2004).

E-learning Design

Traditional university programs are typically regularly designed for individual purposes, for full-time on-campus education, and generally have long planning horizons for developing curricula, course content, and routines. University courses are traditionally not specifically designed for the needs of industry, and not adjusted to new target groups' needs and flexible on-line forms (Majchrzak, Jarvenpaa, & Bagherzadeh, 2015; Mathiassen, 2002; Mathiassen & Nielsen, 2008). The strategies and actions required for a course to have an immediate capacity to meet practitioners' specific knowledge needs are often problematic in the sense of meeting practices of problem solving and learning (Nelson & Stolterman, 2003).

Hence, universities and teachers need to readjust their educational programs and courses from the delivery paradigm toward education targeting new types of learners. They need to find new ways of approaching, designing and implementing blended e-learning courses supporting both individuals' needs purposes and work organizations' need for increased competence development among their workers (Olson, Balmer, & Mejicano, 2011).

Digitizing engineering knowledge and integrating experience-based engineering know-how are tasks that are both pedagogically and technically hard (Davies, Coole, & Smith, 2017; Parahakaran, 2016; Patrick et al., 2008; Porter et al., 2014; Rice, 2002). Examples of such tasks include digitizing engineering knowledge (e.g., laboratory- and machine-dependent tasks) and broadcasting 3D applications (Sein et al., 2011). E-learning technologies, applications, digital learning material, web-conferencing systems, videos, etc. create complexity, and the new digital frameworks do not lend themselves to qualitative learning (Servage, 2005).

Technology continues to provide us with more and more options of flexible e-learning design; however, making such options work in dispersed environments and when integrated within work contexts may entail difficulties among and between learners and teachers (Majchrzak, Jarvenpaa, & Bagherzadeh, 2015; Mathiassen, 2002; Parahakaran, 2016; Svensson, 2004). Designing e-learning materials, examinations, instructions, and digitalization of lectures entails complexity for the university's staff. Teachers' technological knowledge is a key factor for aligning their pedagogical ideas as an integrated part in a digitized course, through various digital communication tools, and applied to company needs (Svensson, 2004).

Learning While Crossing Boundaries

Boundary crossing can be used as a theoretical lens to understand learning that aligns with professional practices outside the university, and to implement workplace experiences and expertise as a mutual design process of engineering e-learning education (Hardy, Phillips, & Lawrence, 2003).

Akkerman and Bakker (as cited in Hardy, Phillips, & Lawrence, 2003) draw attention to boundaries, indicating that the potential of learning at the boundary and by crossing boundaries is a dialogical phenomenon that reveals certain mechanisms of learning that can develop various sociocultural differences. That is, these discontinuities serve functions for identity and practices. They outline four *dialogical learning mechanisms* that may appear through boundary crossing: identification, coordination, reflection and transformation. *Identification* concerns how the individual experiences the differences of diverse practices. *Coordination* handles collaborative and routinized exchanges. *Reflection* expands one's perspective on practices. *Transformation* is about collaboration and handles co-development for new practices.

Boundary crossing can entail movements between institutionalized practices such as school and work. As such, boundary crossing can cause discontinuities in interactions between actors, and thereby offer the potential for learning. We argue that boundaries are crossed between higher education in engineering and the context of the engineering industry. Hence, to contribute to our understanding of teachers' and practitioners' identities in complex learning situations, boundaries and boundary crossing may apply a dialogical viewpoint that conceptualizes the movements of practitioners' and teachers' identities and coordination activities of technology, pedagogy and learning (R. Susskind & D. Susskind, 2015).

THE ProdEx PROJECT

The ProdEx project began in spring 2013 and will continue through the end of 2020. The overall aim of this inter-organizational collaborative project between university and industry is the co-production of competence activities for practitioners and workplaces.

A network of 40 different industry companies within the automotive and aerospace sector are collaborating with one Swedish university. The joint activities are competence mapping of industry´s engineering knowledge needs and content, e-learning design technologies and learning forms towards developing professional skills for a future digitalized industrial work practice.

The project is situated at a Production Technology Centre (PTC) affiliated with the university. Research at the PTC focuses on engineering areas such as robotics and automation, cutting processes, sheet metal forming, welding, and additive manufacturing. Within these subject areas, a total of 30 different five-week flexible e-learning courses, each offering 2.5 European Credits (ECTS), have been designed within the ProdEx project. At the end of the project in 2020, 82 instances of the courses will have been completed.

During the start of the project in spring 2013, a project organization was organically developed and run by an internal project group at the university. This *university project group* consists of action researchers (the authors and other university researchers), teachers, information and communication pedagogues, IT technicians, administrators, and a program manager. They meet continuously and work at co-producing the courses, mapping knowledge needs and designing curricula and e-learning pedagogy and technology, scheduling and evaluating courses. This group specifically supports individual teachers participating in the program.

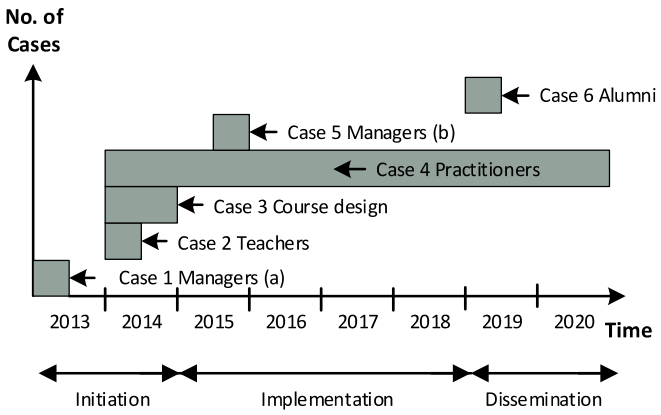
The *company network group* comprises actors from the manufacturing industry with members including CEOs, production managers, human resource managers, technicians, etc., with various knowledge and experiences of engineering work practices. They meet around future competence needs and requirements, flexible e-learning design and work-integrated pedagogy. These two groups participate in joint activities including network seminars, co-production of course content with key experts, and course evaluation.

RESEARCH METHOD

The overall methodology used for the project is a *collaborative practice research* approach. It is used to organize and conduct research on e-learning activities based on the close relationship between teachers and practitioners (Goldstein, 1999). This approach is a pluralist research methodology that allows for combining AR with conventional qualitative and design-related studies that emphasize research activities. This approach advances science while simultaneously informing professional practice by emphasizing research activities that advance science while at the same time inform professional practice (Engeström, 2015; Goldstein, 1999; Tavangarian et al., 2004). A collaborative practice research method acknowledges activities and interventions in close relationship to the on-going practice, embracing *practice research* with a focus on *understanding* the practice, *design research* with a focus on *designing* artifacts (e.g., e-learning courses and technologies), and *action research* focuses on *changing* the practice of work (Tavangarian et al., 2004). Hence, the choice on method approach was based on the nature of the project: longitudinal, with different systemic levels, multiple actors, and a study of changes over time, with the goal of exploring, designing, evaluating and making interventions and suggesting possible changes.

Throughout the research process, the perspective of AR has been applied to the overall research project (as cited in Goldstein, 1999; Tavangarian et al., 2004), covering six case studies, including one ADR case (Engeström, 2015). Data collection throughout the process has been a combination of 1) informal data collection through participation in the project group and the company network group, and 2) formal data collection from the six cases (Figure 2).

FIGURE 2
TIMELINE OF CASES



Informal data collection was conducted through participation in meetings, including discussion, making suggestions, intervening in forthcoming decisions, giving feedback to the project group/company group, etc. Notes were taken and/or audio recorded as part of the data continuously collected

Formal data was collected from qualitative interviews (managers and teachers) and focus group sessions and questionnaires (course participants). Additional data collection included the study of design and learning content, video materials, instructions on the Learning Management System (LMS), course plans, and observing web-conferencing during on-going courses over time (as part of the ADR case).

For both interviews and focus group sessions, a semi-structured thematic interview guide was used. All sessions were audio recorded and participants provided informed consent before taking part. Each interview and focus group session lasted from one- to one and a half hours and were recorded and transcribed verbatim. The researchers (the authors of this paper, among others) were aware of the power dynamics between interviewees and researchers (as cited in Thompson, 2016) and considered the potential effects, especially when asking sensitive questions about the companies (i.e., product knowledge and/or managerial structures), or the respondents' experiences of sensitive information (i.e., course experiences of Information and Communication, ICT, problems).

The data analysis for all interviews (Cases 1, 2, 5) and focus groups (Case 4) occurred over four years and was conducted iteratively. The general method used was qualitative content analysis to interpret text data from the transcripts. We used open coding of manifest meanings and categorized the data into the unit of analysis, codes, categories and themes (Thune, 2011; Trede, 2012). The analysis focused on individuals' (managers, teachers, and industry practitioners') expressions of their knowledge experiences and the on-going collective social interaction around the competence activities, e-learning design, and co-construction of knowledge. Various theories were chosen and applied to each dataset to shed light on the results. Activity theory (as cited in Hattinger, 2018c) was applied as an overall theoretical approach to understand how the project changed in cycles over time (Govaerts & Baert, 2011).

COMPETENCE ACTIVITIES AND FINDINGS

Here, we outline key research findings from each of the six individual cases during the six years (2013–2019 and on-going) of the ProdEx project, with an overall total of 547 respondents (Table 1). The overarching aim of the project advancement toward a sustainable collaborative competence e-learning model, the CCeModel. Built on the extensive data collection we ask in this article: *"What are the critical factors facilitating inter-organizational collaborative e-learning design and co-production between university and industry?"*

TABLE 1
OVERVIEW OF PHASES, STUDIES, AND OBJECTIVES

Project phases	Cases	Objectives
Initiation	**Case 1** Industry Managers (a) ***Interviews***	Manufacturing industry e-learning readiness and learning conditions. **Time frame:** 2013 **No. of respondents:** 27
	Case 2 Teachers ***Interviews***	Design plans for e-learning. **Time frame:** 2014 **No. of respondents**: 5
Implementation	**Case 3** Course design ***ADR***	Action Design Research in iterations of three courses. **Time frame:** 2014–2015 **No. of respondents:** 36
	Case 4 Practitioners ***Focus groups***	Practitioners' co-production and learning from courses. **Time frame:** 2014–2019 **No. of respondents:** 367
	Case 5 Industry Managers (b) ***Interviews***	Managers' co-production toward transformation in the workplace. **Time frame:** 2015 **No. of respondents:** 35
Dissemi-nation	**Case 6** Alumni ***Questionnaire***	Course effects and transformation in the workplace. **Time frame:** 2019–2020 **No. of respondents:** 77 **Response rate:** 12%

Initiation Phase

Case 1 – Managers

This case aimed to define e-learning readiness for competence initiatives in collaboration with the university. Its initial phase started with identifying the manufacturing companies' knowledge needs and the university's ability to meet those needs. This entailed an inter-organizational process of *competence mapping*. Competence activities were regular company meetings and interview case 1, with Human Resource and Production managers of 15 manufacturing companies (27 respondents).

The findings show broad variation of practices and routines used by various companies to define expert competences, long-term competence strategies, and external organizational networking with research institutes and higher education. The case resulted in four new constructs: awareness, e-learning maturity, dynamic capability, and co-creativeness. Only two global companies had strategies for strategic collaboration outside their own company. High *e-learning readiness* and *absorptive capacity* are the major concepts that organizations need in order to capitalize on e-learning initiatives (Tynjälä, 2008).

Case 2 – Teachers

In spring 2014, the second year of the project, the course plans were postponed, and no courses had yet been designed or implemented. During this rather stressful time, it was decided to perform a teacher study, case 2, which explored teachers' *design plans* for e-learning courses prior to actual implementation.

The findings show that teachers' identities and perceptions of e-learning design were related to their pedagogical experiences and technical knowledge. They found it challenging to develop strategies and plans to meet practitioners' expectations of both practical and theoretical knowledge related to their work practice—that is, to find pedagogical concepts, technical cases and learning material to include practitioners' experiences and engineering expertise. Digitizing engineering learning content such as labs, programming, and drilling and milling cases that align with workplace needs was hard. Overall, the findings indicated that teachers need to cross boundaries between university and industry (as cited in Hardy, Phillips, & Lawrence, 2003) to have insight in both practices when designing concepts that connect workplace experiences with theoretical learning content, i.e., through work-integrated case methodology (R. Susskind & D. Susskind, 2015).

Implementation Phase

Case 3 – Course Design

ADR was used for designing the courses and summarizing the lessons learned from the learning activities in the three initial courses and from the company meetings during 2014–2015. The case included activities applied to the four stages of the ADR method as shown in Engeström (2015): 1) problem formulation; 2) building, intervention and evaluation (BIE); 3) reflection and learning; and 4) formalization of learning. Stage 1 included both competence mapping activities from both case 1 and course participants' interactions. The BIE stage was specifically helpful to design principles towards a generative course model meaning evaluate the IT artifact into a realized design.

Three iterations of the general design principles resulted in instantiations of the three courses in the first pilot case in 2014 with varying results (Tynjälä & Häkkinen, 2005). A formalized e-learning course model was designed, consisting of 2.5 European credits, 5–6 weeks with a maximum of 2–4 lecture days at PTC (including a final examination day), and additional web conferences between the lectures (online seminars, lab presentations, etc.). The ADR cycles, with BIE (stage 2), reflection and learning (stage 3), and formalization (stage 4), set the course design agenda for further courses. However, there was a need for continued BIE of repeated courses, due to the teachers' varying use of e-learning tools, case methodologies, and online materials (Govaerts & Baert, 2011). Hence, continuous design work for the e-learning courses is ongoing. At the time of writing, there are 52 implemented courses and three or four university-industry co-production meetings per year.

Case 4 – Practitioners

This case includes continuous *focus group sessions* at the end of each course unit. It became clear that practitioners are interested in co-producing knowledge both through actively engaging during the course as well as during the focus group sessions. Many practitioners also enroll in a range of courses in machining, industrial automation, negotiation skills for businesses, additive manufacturing, industry 4.0, etc. This case explores practitioners' perspectives and knowledge construction in order to delineate forms and content of both e-learning design and mutual knowledge co-production as a type of learning trajectory (Wallin, Nokelainen, & Mikkonen, 2018). It also includes examination of the relations between the practitioners and the teachers. The focus group sessions are part of the last design phase of the BIE, conducted in case 3, and as explained above, this activity is on-going.

The findings from this case show that practitioners have different personal motives for competence development than their companies. Even if companies are eager to support competence development, they do not provide enough time and daily support for such initiatives. Practitioners feel their own motives for learning are key to their participation.

Case 5 – Managers (II)

This case was a follow-up interview study on manager perspectives that took the form of interviews with six new industry companies. The aim was to examine industry management's efforts regarding competence work and support for practitioners taking part in the ProdEx project. The specific focus concerned *how and what actions* were taken in the workplace after practitioners realized extensive course

participation. We wanted to capture reasons for the varying levels of engagement in the project up to that point, and to examine why some companies only participated in occasional meetings.

The findings indicate that companies feel their participation in the project and collaboration with higher education must be related to their own competence requirements and involve finding periods for collaboration within a stressful production environment. Some companies also found it hard to encounter an academic environment for the first time through a continuous collaboration. Regarding managerial support for practitioners, the findings show a broad variety of internal company efforts supporting practitioners' knowledge-sharing and workplace transformations. Only two or three companies (both old and new ones) presented a routinized system or support models for follow-ups on practitioners' new learning from the courses. Further, practitioners themselves were found to be dependent on individual efforts to develop skills needed in a transformative practice. Hence, management's strengths in supporting knowledge transfer and integration in the workplace are low and depend on the individual. These findings align with the results in Case 4, in which practitioners discussed dilemmas related to time and money for working versus studying.

Dissemination Phase

This ongoing phase aim to enclose new course implementations and build on a long-term sustainable university organization for inter-organizational collaboration and co-production forthcoming.

Case 6 – Alumni

This case is currently being conducted via administration of a questionnaire. Its aim is to comprehend the effects of competence development by evaluating course effects and eventual transformations in the workplace. Areas included are finding opportunities to adapt the course program to other subject areas, initiating collaborations with other universities to offer a more extensive course program, extending the company network, and finding ways to optimize internal university administration for the new program.

The findings so far show that individuals apply for courses within their knowledge area and their ambition to study is built *on their own desire* (79%) or upon *curiosity to know more about a specific course subject* (56%). Only 15% of respondents claim they were encouraged to apply by their manager. Of those participating in the courses, 89% found the course content useful (or very useful) in relation to their own work. Further, 87% indicated that the courses incorporated recent research to a high (or a very high) degree.

DISCUSSION: EFFECTS OF INTER-ORGANIZATIONAL CO-PRODUCTION

This article has described and summarized findings of three phases—initialization, implementation and dissemination—toward a sustainable model for inter-organizational collaboration between university and industry that focuses on e-learning design and co-production of courses and collaboration. The research program comprised a six-year longitudinal collaborative action study of six cases, through a multiple actor perspective assessing the views of managers, teachers, practitioners, the course unit, and project group (Engeström, 2015; Goldstein, 1999; Weinberger & Fischer, 2006).

The overall findings show that increased digitalization creates both opportunities and challenges. It pushes universities and industries into new forms of collaborations as they try to build inclusive co-productions, which may create tensions, role-definitions, power-relations, cultural differences, and other issues.

In the *initialization phase*, companies stressed their low participation was related to their own competence requirements, mainly because their employees lacked former academic competences. However, the university developed forms of accreditation to join courses, enabling a broader access to courses. During the *implementation phase*, three design cycles derived general principles for a course format consisting of a five-week period of a mix of web conferences, two–three physical meetings, virtual labs, and digital material in the LMS. This phase encountered many challenging activities and e-learning design problems, such as finding useful co-production pedagogies within the courses (e.g., case

methodologies), and mapping relevant and key engineering knowledge through the co-production meetings between the project group and the manager group.

The on-going *dissemination phase* aims to maintain support for the course program within the university administration and management support for the transformation processes in the workplace. Given the research question aimed to identify *critical factors for inter-organizational collaborations*, the following challenges and resolutions are defined:

Challenge I: Matching Industry Competence Needs With University Knowledge Fields

The initial ability and awareness of companies to define expert knowledge and competences varied, and previous collaborations with higher education or research institutes were uncommon.

Resolution: The eventual acceptance of the project by management was a boundary crossing activity as shown by Hardy, Phillips, and Lawrence (2003) that occurred during joint company meetings, which engaged the insights of management to support their practitioners to join the courses.

Challenge II: Combining Practice-Related Experiences With Theoretical Knowledge

A continuing problem for the university was to find actively engaging companies and members of management; for the companies, the availability of designed courses targeting their needs from the university on an appropriate timeline was a concern. A lack of time to define competence needs before their implementation causes stressed among the university project group and the teachers.

Resolution: Disagreements and differences were resolved through continuous negotiation within the focus groups and co-production meetings.

Challenge III: Defining Course Forms and Cases

Continuous problems in defining knowledge levels and content when planning new courses expanded during the project as more course fields were implemented.

Resolution: To incorporate and strengthening the practitioners as part of the mutual knowledge construction within the courses, three different case design models were developed. They each aimed to activate co-construction of knowledge as situated learning. Even if the learning activities were unstable, and not fully developed and robust, there was general discussion generating new production technology knowledge through meta-cognitive reflections and sharing of insights between teachers and practitioners (Hardy et al., 2003).

Challenge IV: Creating Course Modalities Applicable to Workplace Demands

This challenge concerned the flexibility and blend of the course design, described as the course modality (course schedule, number of physical meetings, web-conferencing versus physical meetings), forms (e-learning technologies and pedagogical strategies), and the trajectory of course design and implementation over the years.

Resolution: Through negotiations between practitioners, teachers and AR researchers, dilemmas and conflicts in the courses and on the management, level was diminished once explicated and transitions into actionable possible solutions were developed.

Challenge VI: Lack of Useful Tools for Knowledge Transformations in Workplace Learning

An emerging challenge is a lack of commitment and follow-up of knowledge transformation of the course participants' newly acquired knowledge by management. The new knowledge was found to often stay with the individual and not leveraged within their company.

Resolution: The university has continuously (and regularly) invited managers and course participants to joint co-production dialogues. On such occasions our findings regarding the lack of knowledge transformation have been highlighted. To support the companies in developing strategies for knowledge transformation, best practice and methods for expansive transformations integrated in the workplace have been shared in the co-production dialogues towards expansive transformations integrated in the workplace.

Challenge V: Establishing a Company Network and Permanently Implementing the Courses

Formalization of the joint university–industry collaboration and establishing a solid course format (the blend) included the choice of course modalities, e-learning technologies, and pedagogical learning strategies.

Resolution: It does not suffice to merely connect people with special expertise and think interaction and knowledge sharing will happen. If mutual co-production is to occur on many levels, practitioners will also require relational expertise for knowledge building. In the future, there must be a continuation between the industry network and the university outside the course program itself.

Challenge VI: Fragmented Internal University Educational Administration Processes

University administration is not traditionally prepared to short, flexible courses, introduced over a short planning horizon, and running them outside established conventional university programs. In this research it means that there are challenges related to university administration when introducing new educational models that provide on-going short, flexible courses running outside established and regular university degree programs schedules that in addition are built from company knowledge needs.

Resolution: On-going challenges remain within the project in resolving (together with university administration and management) delays in course advertisement, slow admission processes (due to validation of real competences), low management prioritization of short courses for competence development, and inflexibility of adopting new routines. Not successfully addressing these challenges will affect long-term company relationships as well as participants' experiences of the quality of the courses.

Challenge VII: Lack of Key Teacher Competences at the University

The university's capacity to meet specific key competence needs and an increased number of applicants for new innovative courses is limited. For example, the number of applicants to a range of new courses on the subject Industry 4.0 rose to about 140 applicants for only 20 places. Due to limited teacher resources, this unexpected demand meant that the industry competence needs could not be met as fast as industry desired.

Resolution: Increased prioritization of the ProdEx course program by university management will allow teacher resources to be planned for and dedicated long-term.

Summary of Critical Factors From Three Perspectives

Given the challenges and resolutions described, a summary of critical factors from three perspectives follows:

Industry perspective

- Real cases support intertwining of theory and practice and mutual learning through co-production.
- Practitioners' goal of personal, continuous competence development at the university level creates analytical skills, high qualitative performances, and valuable engagement in the process of co-production

University perspective

- A problem-oriented and curious approach to e-learning technologies is key for both teachers and practitioners to participate in e-learning co-production.
- Insight into other organizations' rules and culture, i.e. abilities for crossing organizational boundaries, is necessary to mutual collaboration.

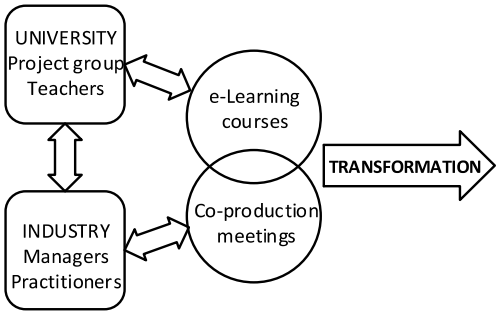
Collaborative perspective

- The courses create a key joint collaborative adventure and a mutually respected activity for co-production of knowledge.
- Stakeholders' ability to cross inter-organizational boundaries is a key activity for co-production.

- Sustainable and joint industry–university collaborations are vital for co-production in the long term.

We have outlined a trajectory of activities in a collaborative practice between university and industry. Collaborative competence programs between university and industry can have the power of emphasizing individual's engagement and strengthening their competences for new work practices. Thus, designing inter-organizational e-learning courses is a powerful way of integrating theory and practice as an intertwined co-productive process for knowledge development, as formalized in the CCeModel (Figure 3).

FIGURE 3
OVERVIEW OF THE COLLABORATIVE COMPETENCE E-LEARNING MODEL (CCEMODEL)



CONCLUSIONS

This article has outlined a collaborative practice research project that was motivated by two dominant challenges and on-going societal changes. One major challenge is the manufacturing industry's emergent need for highly qualified engineers and practitioners due to the increased digitalization, automation, and robotization that affects the sector's work practices (Hattinger & Eriksson, 2018b). As such, new competences, new professional engineering skills, and expert knowledge in production technology have emerged. The other challenge is the development of e-learning courses as a promising affair that challenges universities to become open to external collaboration and to target new groups of learners. Such challenges stress the university into readiness in handling new partners and new learning strategies, enabling design and co-production of work-integrated e-learning (Wallin, Nokelainen, & Mikkonen, 2018).

While earlier research has discussed the problems of inter-organizational collaboration, our findings show that university and industry are crossing boundaries and become aware of their different organizational work practices when they mutually co-produce knowledge in an e-learning practice (Hardy, Phillips, & Lawrence, 2003). Co-production creates a social space in and between individuals and contextualizes sharing and giving from two or more perspectives, emphasizing technological artifacts and design. This phenomenon creates excitement, resulting in new knowledge, learning and positive engagement. Co-production is much more than collaboration because of its prerequisites of mutual engagement and trust. Our main contribution is to suggest that the co-production of knowledge entails three levels of activities among actors: insight into the purposes and practices of others, the capacity to transform the problems of a practice and build common knowledge together, and finally, the capacity of mutually co-produce knowledge acted upon in practice towards knowledge transformations in the workplace (Govaerts & Baert, 2011).

REFERENCES

Akkerman, S.F., & Bakker, A. (2011a). Boundary crossing and boundary objects. *Review of Educational Research*, *81*(2), 132-169.

Argote, L., Ingram, P., Levine, J., & Moreland, R. (2000). Knowledge transfer in organizations: Learning from the experience of others. *Organizational Behavior and Human Decision Processes*, *82*(1), 1-8.

Billett, S. (2002) .Workplace pedagogic practices: Co–participation and learning. *British Journal of Educational Studies*, *50*(4), 457-481.

Bourne, J., Harris, D., & Mayadas, F. (2005). Online engineering education: Learning anywhere, anytime. *Journal of Engineering Education*, *94*(1), 131-146.

Bryman, A. (2012). *Social research methods* (4th ed.). New York: Oxford University Press.

Collin, K., & Tynjälä, P. (2003). Integrating theory and practice? Employees' and students' experiences of learning at work. *Journal of Workplace Learning*, *15*(7/8), 338-344.

Chiasson, M., Germonprez, M., & Mathiassen, L. (2008). Pluralist action research: a review of the information systems literature*. *Information Systems Journal*, *19*(1), 31-54.

Davies, R., Coole, T., & Smith, A. (2017). Review of socio-technical considerations to ensure successful implementation of Industry 4.0. *Procedia Manufacturing*, *11*, 1288-1295.

Dubois, C., & Long, L. (2012). *Improving the Design of Workplace E-Learning Research. International Journal on E-Learning*, *11*(4), 419-440.

Engeström, Y. (2015). *Learning by expanding: An activity-theoretical approach to developmental research* (2nd ed.). Cambridge University Press, United States.

Ford, M. (2015). *Rise of the Robots: Technology and the Threat of a Jobless Future*. Basic Books, London, England.

Goldstein, L.S. (1999). The relational zone: The role of caring relationships in the co-construction of mind. *American Educational Research Journal*, *36*(3), 647-673.

Govaerts, N., & Baert, H. (2011). Learning patterns in organizations: towards a typology of workplace-learning configurations. *Human Resource Development International*, *14*(5), 545-559.

Hardy, C., Phillips, N., & Lawrence, T.B. (2003). Resources, knowledge and influence: The organizational effects of interorganizational collaboration. *Journal of Management Studies*, *40*(2), 321-347.

Hattinger, M. (2018a). *Co-constructing Expertise: Competence Development through Work-Integrated e-Learning in joint Industry-University Collaboration*. University West: Trollhättan.

Hattinger, M., Eriksson, K., Malmsköld, L., & Svensson, L. (2014). E-learning Readiness and Absorptive Capacity in the Manufacturing Industry. *International Journal of Advanced Corporate Learning (iJAC)*, *7*(3), 33-40.

Hattinger, M., & Eriksson, K. (2015, August 13-15). Action Design Research: Design of e-WIL for the Manufacturing Industry. *Proceedings of the Americas Conference on Information Systems*. AMCIS 2015, Puerto Rico.

Hattinger, M., & Eriksson, K. (2018b). Co-construction of Knowledge in Work-Integrated E-learning Courses in Joint Industry-University Collaboration. *International Journal of Advanced Corporate Learning (iJAC)*, *11*(1), 10-16.

Hattinger, M. (2018c). Researchers design conceptions of e-learning courses targeting industry practitioners' competence needs. *International Journal of Continuing Engineering Education and Life-Long Learning*, *28*(3-4), 235-253.

Ingram, P. (2017). *Interorganizational Learning* (Chapter 28). Wiley Online Library.

Jasanoff, S. (2004). *States of knowledge: the co-production of science and the social order*. Routledge.

Jacoby, S., & Ochs, E. (1995). *Co-construction: An introduction*. Taylor & Francis.

Kahiigi, E.K., Ekenberg, L., Hansson, H., Tusubira, F.F., & Danielson, M. (2008). Exploring the e-Learning State of Art. *Electronic Journal of e-Learning*, *6*(2).

Kvale, S. (2006). Dominance through interviews and dialogues. *Qualitative Inquiry*, *12*(3), 480-500.

Kirkwood, A., & Price, L. (2014). Technology-enhanced learning and teaching in higher education: what is 'enhanced'and how do we know? A critical literature review. *Learning, Media and Technology*, *39*(1), 6-36.
Kohlbacher, F. (2006). The use of qualitative content analysis in case study research. In *Forum Qualitative Sozialforschung/F orum: Qualitative Social Research*.
Koren, Y. (2010). *The global manufacturing revolution: product-process-business integration and reconfigurable systems* (Vol. 80). John Wiley & Sons, Hoboken, New Jersey.
Lahn, L.C. (2004). Dilemmas in the development of e-learning at work. *Journal of Workplace Learning*, *16*(8), 466-478.
Lasi, H., Fettke, P., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & Information Systems Engineering*, *6*(4), 239-242.
Lindgren, R., Henfridsson, O., & Schultze, U. (2004). Design principles for competence management systems: a synthesis of an action research study. *MIS Quarterly*, *28*(3), 435-472.
Majchrzak, A., Jarvenpaa, S.L., & Bagherzadeh, M. (2015). A review of interorganizational collaboration dynamics. *Journal of Management*, *41*(5), 1338-1360.
Mathiassen, L. (2002). Collaborative practice research. *Information Technology & People*, *15*(4), 321-345.
Mathiassen, L., & Nielsen, P.A. (2008). Engaged scholarship in IS research. *Scandinavian Journal of Information Systems*, *20*(2), 1.
Nelson, H.G., & Stolterman, E. (2003). *The design way: Intentional change in an unpredictable world: Foundations and fundamentals of design competence*. Educational Technology.
Olson, C.A., Balmer, J.T., & Mejicano, G.C. (2011). Factors contributing to successful interorganizational collaboration: The case of CS2day. *Journal of Continuing Education in the Health Professions*, *31*, S3-S12.
Parahakaran, S. (2016). Designing and Evaluating Collaborative Projects in Learning Communities: Innovative Practices and Strategies. *International Journal of Advanced Corporate Learning*, *9*(1).
Patrick, C-J., Peach, D., Pocknee, C., Webb, F., Fletcher, M., & Pretto, G. (2008). *The WIL (Work Integrated Learning) report: a national scoping study* [Final Report]. Queensland University of Technology.
Porter, W.W., Graham, C., Spring, K.A., & Welch, K.R. (2014). Blended learning in higher education: Institutional adoption and implementation. *Computers & Education*, *75*, 185-195.
Rice, M.P. (2002). Co-production of business assistance in business incubators: an exploratory study. *Journal of Business Venturing*, *17*(2), 163-187.
Sein, M., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action design research. *MIS Quarterly*, *35*(1), 37-56.
Servage, L. (2005). Strategizing for workplace e-learning: some critical considerations. *Journal of Workplace Learning*, *17*(5/6), 304-317.
Svensson, L. (2004). Challenges for work-integrated e-learning: The case of the Swedish Academy of County Administrations. *Journal of Workplace Learning*, *16*(8), 492-502.
Susskind, R., & Susskind, D. (2015). *The future of the professions: How technology will transform the work of human experts*. Oxford University Press, USA.
Tavangarian, D., Leypold, M., Nölting, K., Röser, M., & Voigt, D. (2004). Is e-learning the Solution for Individual Learning. *Electronic Journal of e-Learning*, *2(*2), 273-280.
Thompson, T.L. (2016). Digital doings: curating work–learning practices and ecologies. *Learning, Media and Technology*, *41*(3), 480-500.
Thune, T. (2011). Success Factors in Higher Education-Industry Collaboration: A Case Study of Collaboration in the Engineering Field. *Tertiary Education and Management*, *17*(1), 31-50.
Trede, F. (2012). Role of work-integrated learning in developing professionalism and professional identity. *Asia-Pacific Journal of Cooperative Education*, *13*(3), 159-167.
Tynjälä, P. (2008). Perspectives into learning at the workplace. *Educational Research Review*, *3*(2), 130-154.

Tynjälä, P., & Häkkinen, P. (2005). E-learning at work: theoretical underpinnings and pedagogical challenges. *Journal of Workplace Learning*, *17*(5/6), 318-336.
Wallin, A., Nokelainen, P., & Mikkonen, S. (2018). How experienced professionals develop their expertise in work-based higher education: a literature review. *Higher Education*, pp. 1-20.
Weinberger, A., & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & Education*, *46*(1), 71-95.