Organizational E-learning Readiness for Technology Enhanced Competence initiatives in the Manufacturing Industry

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Abstract—The manufacturing industry constantly strive to develop the competencies of their expert production engineers in order to achieve and maintain a competitive advantage. Research shows that the absorptive capacity of a firm is central in order to reach such a goal. The absorptive capacity of a firm is their ability to recognize the value of new external information, assimilate it, and apply it to commercial ends, and thereby exploit the conditions for innovation. In this paper we explore the rationales of organizations in the manufacturing industry for taking part in technology-enhanced competence development projects in collaboration with universities. Through interviews with key informants in 15 manufacturing industries we study the capabilities that organizations’ need for participation in e-learning initiatives. We present a framework for technology enhanced learning readiness comprised of awareness, e-learning maturity, dynamic capability and co-creativity.

Index Terms—absorptive capacity, e-learning readiness, technology enhanced competence development, work-integrated learning.

I. INTRODUCTION

Competence development initiatives within the industrial contexts have widely been researched and reported as success stories. However, many initiatives fail due to firms lacking capabilities to absorb new knowledge through learning initiatives [1, 2]. This case study draw on earlier studies which show that e-learning initiatives within educational contexts are more successful than in the workplace. Reasons for this are because other conditions cause dilemmas in the work organization, on management levels, in the user interface and in the system development process [3, 4]. As we shift from traditional educational models into technology enhanced learning as e-learning courses integrated in the workplace, we need to rethink companies’ abilities to gain new knowledge to sustain a competitive and innovative advantage.

Viewing the workplace as a learning arena implies a knowledge-based view of the firm and also capabilities to manage information and knowledge throughout the whole organization [5]. To clarify the relationship between knowledge acquisition and firm innovation, the concept of absorptive capacity, can be used to define the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends as critical to its innovative capacity [6]. Over the years researchers have reconceptualized and extended their description and applied absorptive capacity to different organizational contexts or studies of phenomena [7, 8, 9, 10].

In this paper we build our reasoning on absorptive capacity from an overall level, but also extend the discussion on companies’ abilities to learn as crucial for their knowledge creation and innovative capability. We suggest that new constructs will shed light on manufacturing companies’ abilities to foresee their readiness for taking part in e-learning initiatives here described as technology enhanced competence development initiatives. Assimilation of knowledge and learning from e-learning initiatives cannot only be understood from a firm’s absorptive capacity, but also need to be deliberated with deeper knowledge on what other conditions prepossess learning and knowledge creation [11, 12]. Information technology (IT) gives new opportunities to learn, and formalized education as e-learning courses in an industrial context is increasingly diffusing in corporate settings [13]. E-learning readiness instruments have evolved criteria to assess a firm’s readiness for implementing e-learning [12, 13, 14]. These instruments can give insight into how firms are able to assess readiness for e-learning participation and implementation. Absorptive capacity and e-learning readiness categories together present a framework of constructs that a firm can apply to accomplish a valuable participation within competence development initiatives.

Therefore we aim to present a wider understanding of manufacturing industry readiness for e-learning initiatives by combining constructs based on theoretical concepts from absorptive capacity and e-learning readiness categories in relation to a study of 15 manufacturing firms located in the western part of Sweden. We present a reconceptualized framework of constructs that builds on our analysis of qualitative interview data in the case study that is part of the MERIT project. The overall aim of the MERIT project is to design and offer e-learning courses with knowledge content that are co-created between University West and the collaborating manufacturing industries.

In the following section, theories of absorptive capacity and e-learning readiness are discussed. Thereafter the study, including the context, methodology and analytical framework is presented. The final section describe the content of the framework of e-learning readiness in relation to the results from the case study.
II. THEORETICAL FRAMEWORK

Production technology is an interdisciplinary field and presents a wide area of knowledge that employees in the manufacturing industry need to acquire. Knowledge work within in this field is multifaceted and both expert knowledge and general know how are necessary. Effective industrial work also emphasizes capabilities to handle knowledge divers [15]. Knowledge to absorb and adopt are of various kinds, within humans and within machines and technology, and thus advanced expert knowledge in engineering work, can mostly be explained as systematic comparison undertaken for various reasons [15]. Communicating knowledge is not a process of sending information from sender to receiver. As information flows through different media, and passes through different technologies, on distance and at different times and space, information tend to differ. This means that information is not automatically knowledge. Innovation is often a kind of bricolage, a reconfiguration of knowledge’s that results from an encounter between cultures.

A. Absorptive capacity

Absorptive capacity was originally introduced by Cohen and Levinthal as a concept to label a firm’s capability “to recognize the value of new information, assimilate it, and apply it to commercial ends” [6, 16]. The absorptive capacity depends on prior related knowledge and diversity background, and they therefore focus on investments in R&D as central for development of the concept. They emphasize absorptive capacity as cumulative, due to that it is easier for firms to continuously invest instead of investing punctually. However, R&D not only generates new knowledge for innovation purposes, but also enhances the learning ability of the firm [6].

The concept has been reconceptualized and extended by various researchers, mainly through empirically studies [7, 10]. Different definitions and outcomes of the original construct have emerged to a heterogeneous variety both empirically and theoretically [17]. Some research areas that use and develop absorptive capacity is knowledge management [18], human resources [19], organizational learning [20], the resource-based view [9] and dynamic capabilities [21]. Most research studies apply absorptive capacity on the organizational level, even if the original construct by Cohen and Levinthal, meant that an organizations absorptive capacity depends on its individual members and viewing learning as cumulative.

Zahra and George extended absorptive capacity with a new definition, i.e.; “a set of organizational routines and processes by which firms acquire, assimilate, transforms and exploit knowledge to produce a dynamic organizational capability” [7]. They introduced two dimensions, potential absorptive capacity and realized absorptive capacity. The first dimension focuses on acquisition and assimilation of new knowledge and the second focuses on the transformation and exploitation of capabilities. Regardless of the different use of absorptive capacity mentioned above, this and other conceptualizations understand the construct as a capability to address rapidly changing environments. Barney also relates to capabilities as competences on a higher level that prevail on different individual capabilities building on each other to yield absorptive capacity giving the firm a foundation on which to achieve a competitive advantage [22]. Grant highlights that capabilities represent productivity and firm-specific skills and should also to be understood as how to use resources and not only as nonspecific input units [23].

B. Absorptive capacity and case study

From the perspective that absorptive capacity still is a heterogeneous construct and that available methods are used with diverse operationalization’s, Duchek presents a more practice-based approach of absorptive capacity [17]. With a critical review of the construct of absorptive capacity, a framework of methods for measuring absorptive capacity is presented [17]. The framework is divided into research studies that perform either quantitative or qualitative methods.

Quantitative methods are classified into studies using indicators or questionnaires. Studies using indicators usually measure R&D efforts and R&D human capital. Limitation of this method is that we cannot assume that the indicators tell us anything about the knowledge absorption process within a firm.

Furthermore, studies using questionnaires measure mainly absorptive capacity at the operational level or as multiple components (instruments) of absorptive capacity. These studies are the most common for the construct [7, 10, 11].

Duchek argues that by using quantitative research methods only standardized and predefined items are visualized and new flexible data will be missed during the research process [17]. Instead a practice-based approach from a German case study is outlined that consist of three components, technology scouting – a practice of knowledge acquisition, face-to-face communication – meetings with intense knowledge sharing, ongoing feedback between partners and informal promotion of new ideas. Accordingly, the practice-based approach of the construct will aid in open up and uncover the black box of absorptive capacity.

In this paper we share Duchek’s view in line with other researcher [8, 24]. These authors suggest a broad spectrum of other factors that can be studied by ethnographic methods using observations or with interviews. Jones and Craven studied how work routines and organizational activities could grasp the process of how new knowledge was acquired rather than the nature of knowledge in a manufacturing firm [24]. This study concluded that to improve a firm’s absorptive capacity development of new coordination capabilities that help codify tacit knowledge is required.

C. E-learning readiness

We define e-learning as learning tools and systems that are intended to serve as a support and stimulus for learning in and between the participating actors, i.e. employees, academic teachers/researchers and other research institutions. Examples of applications and systems that support courses on-line are web meeting systems (audio and video), learning management systems, wikis and blogs. These applications aim to support communication and interaction through both synchronous as asynchronous systems [25].

Another stream of research is e-learning instruments that assess firms’ readiness for e-learning investments and
IT-adoption [12, 13, 14]. These instruments are mostly developed as quantitative surveys with questionnaires.

Haney argue for assessment of organizational readiness for e-learning and has developed 70 questions divided into ten top aspects involved in e-learning assessment for professional groups in the whole organization [14]. These top aspects are; human resource, Learning Management System (LMS), learners, content, IT, finance and vendor. The approach to this assessment is performative and system oriented such as implementing any type of IT system, e.g. enterprise information system. Each question requires managers to choose levels of importance with “not very”, “moderate” or “very” important.

Aydin and Tasci present a questionnaire with 83 questions that analyze the resources a firm possesses and the skills and attitudes of the employees and managers, targeted for Turkish firms (i.e. three constructs – resources, skills and attitudes) [13]. Four factors are correlated with these three constructs and these are technology, innovation, people and self-development. However, this survey is very similar to Haney’s approach, even though learning styles and self-assessment also are included.

Another framework for e-learning assimilation and adoption is recently presented by a Canadian research group [12]. They raise the contradiction between a rapid growth in the e-learning market, but still a slow adoption among firms. The integrative framework they present is therefore built on the need of a deeper insight into sense-making of technological and organizational factors in relation to e-learning context and for shaping organizational competencies leading to e-learning adoption and assimilation. They propose that technological and environmental factors indirectly affect e-learning adoption through the result they have on these factors i.e. organizational structures and information technology maturity.

III. THE STUDY

A. Context in the manufacturing industry

The manufacturing industry faces high pressure from the global market and must adjust the production system to consumer demands. This pressures engineers and industry firm to assess new expert knowledge and adapt to changes that imply short term flexibility instead of long term perspectives. The production system in general is highly automated and most work therefore focus on monitoring and controlling the production system. Engineering work is problem solving, technological development and continuous improvement among other things.

An increasingly important part in engineering sciences such as production technology is knowledge of concurrent and complex phenomenon and also about development of industrial modeling and simulation. The techniques and the skills required to master the underlying theories are often limited in the industry, while experience-based expertise and practical skills are often high. To be a learning organization with capacities to absorb new knowledge is important to survive international competition. Collaboration between different professions and skills in the production chain can reinforce knowledge development but conditions for this collaboration can also be understood from different angles [26]. Accordingly, when companies are performing challenging tasks interfirm collaboration is not always a feasible solution due to inherent risks of bringing out valuable knowledge. Instead they suggest that knowledge can be found internally through use of technology. This may be true if the firm have high internal knowledge or a R&D department. Though we believe that interaction between academia and a network of industry have a potential of a jointly collaboration where both parties together co-produce knowledge content for expertise and innovation.

B. Methodology

The longitudinal research case study is part of an ongoing project MERIT (Manufacturing Education and Research with Information Technology). The research aim is to describe conditions for design and implementation of technology enhanced courses on postgraduate level to support work-integrated learning for employees in the manufacturing industry. The overall aim of the MERIT project is to test that flexible e-learning courses will provide opportunities for the firms to gain new knowledge, and support them as a learning organization. University West, located in the west of Sweden, run the MERIT project during 2013-2015 and is collaborating with manufacturing industries in the region. Together industry and academia will co-produce knowledge in the courses within the fields of industrial automation, virtual manufacturing, robotics and applied simulation of manufacturing processes.

When we appointed informants for this initial case study our preconception was that perceived management support give better readiness and performance for individuals taking part in e-learning competence initiatives [27]. We wanted to grasp management view on how different knowledge flow through the organization and what capabilities for learning and knowledge there is within the organizations.

As a part of other collaborative activities in the study, 16 interview sessions with 15 manufacturing industries were conducted during 2013 (in one firm, two interview sessions took part). The target informants were the top level production manager (or plant manager) and the top human resource managers, who were interviewed simultaneously for about one and a half hours sessions. In total 27 informants participated, because in some firms only production manager/CEO participated in some companies, due to lack of time. The sessions were carried out as a meeting and we used a semi-structured interview guide that was sent out at least one week before the meeting. During the sessions we discussed what key knowledge within the production field is needed for competence development among experts in the firm in relation to the organization effectiveness, business goals and innovative capabilities. We also discussed the process of handling knowledge and the level of readiness for e-learning initiatives integrated in the workplace.

C. Analytical framework

A qualitative data analysis approach on the interview data was used [27]. Through an iterative and thematic approach we identified four constructs that are presented in the framework in table 1. These constructs are mainly developed from the interpretation of the managers’ perceptions and knowledge of their process work within
their organization. Furthermore, the analysis is influenced by concepts from absorptive capacity and some e-learning readiness categories [13, 14] and is reconceptualized into a framework that builds on our new findings from a process oriented view on industry firms’ readiness for technology enhanced competence development initiatives. The constructs in table 1 are described in the next section. We used three levels of categories for each construct, low, medium and high level of readiness. The result show variations between the firms in relation to these constructs which is shortly presented by some figures and quotations in the next section.

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<th>TABLE 1 - FRAMEWORK TECHNOLOGY ENHANCED COMPETENCE DEVELOPMENT</th>
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IV. RESULTS

Below some basic facts of the firms are presented. Thereafter we describe the different constructs and their implications in relation to the study.

A. Basic facts of the manufacturing industries

Ten of 15 firms are international corporate industries. Five are Scandinavian industries. All of the 15 firms have a production plant or an office in the western part of Sweden. A categorization of the firms in terms of number of employees, number of university-educated employees, type of industry, local or international business and if they have their own R&D department are presented in table 2.

B. Awareness

Awareness refers to a firm’s capability to identify and describe internal knowledge need and content, in line with absorptive capacity [6]. The attention to continuously define their own competence needs on different levels and also to be aware of and describe expert knowledge needed in critical production is part of an internal knowledge base. How are firms able to commission the right type of knowledge? What knowledge do the employees have? Many firms ask for the same knowledge areas according to daily production, but what knowledge can a firm capitalize on long term?

Results show that all firms have routines and work flows for internal competence mapping and can define competence need for operators. Though, only six firms can define expert knowledge on a high level, six firms on medium level and three firms were not able to answer the question. These informants’ quotations show the variation, by describing:

General competence need

High level; ”...in the work performance dialogue, we talk about both formal education and informal learning, how we work with structured work processes (Lean), and then we make GAP analyzes at the group level, department level, etc.” (Manufacturing firm in aerospace, international corp., 300 employees)

Expert competence need

High level; “We attain the technology management conference in January to see how we can use expert skills ... other activities is the project ‘Combination Forces’ aiming for meetings between top competences, to build new innovation...” (Consulting firm in aerospace, 130 employees)

Low level; "...we are a small unit, so all our skills are critical, it is difficult to have duplicates in such a small organization. When there are problems, we need to call a supplier, so we have the skills outside the plant..."
haven’t discussed critical expert skills. At the operator level, there is no problem, but it is harder on the engineering side…” (Manufacturing firm in automotive, international corp., 130 employees)

Competence development as strategy in business plans

High level; “…we engage in something called critical and functional competencies... thus we have a mapping within each function. We map our training needs and our activities to close the gaps ... the change process is that we also show the importance of our work with competence challenges ... and continuously we managers request for information internally to strategic goals.” (Manufacturing firm in aerospace, international corp., 2,200 employees)

C. E-learning maturity

Questions referring to this construct aimed to identify IT and e-learning usability and maturity. Also the internal IT infrastructure for e-learning systems were discussed, which is in line with other authors e-learning measurement tools [13, 14]. Results show that only three companies have high level of e-learning use including their own e-learning system. Five companies are defined at medium level, i.e. they use some e-learning system but do not have their own system. Seven firms do not regularly use e-learning tools at all for competence development activities.

Experience of e-learning use and own e-learning system

High level; “…XX Learning Lab and IT is included in our courses. Here, we offer full training concept for business and individual courses... We have chosen to not have any teachers, but our teachers are our own consultants in everyday work...” (Consulting firm in aerospace, 130 employees)

Low/medium level; “…we use an internal system NFS for distance collaboration, mostly we use teleconference and just use web conference systems to share displays...” (Consulting firm in aerospace, 130 employees)

Low level; “…we bring in the teacher, have a center that we use for training, mostly we go away and have education... very little on the web...” (Manufacturing firm in other branches, 320 employees)

D. Dynamic capability

Dynamic capabilities in the organizational context is complex. Zahra and George describes it as…”we propose a reconceptualization of ACAP (absorptive capacity) as a dynamic capability pertaining to knowledge creation and utilization that enhances a firm’s ability to sustain a competitive advantage” [7]. Other researchers’ points to a broad set of skills needed to deal with tacit component of transferred knowledge [28] and also to the capacity to learn and to solve problems. Influenced by these definitions we widen the construct and also include the two contradictions; stability on the one hand and change on the other. Firms can adapt more or less to pressure and concurrency in the surrounding world. How well-inclined they are depend on the ability to adjust to external requirements of market pressure and to capture and use new knowledge. How to build knowledge, and at the same time be a flexible organization varies between industry branches. The first analysis indicates that automotive branches in comparison with aerospace manufacturers differ in their abilities to quickly adjust to market pressure and change. The automotive firms in this study, seems to be more dynamic and flexible to external pressure than the aerospace firms. These quotations give some variation of what we mean:

Experience based and developmental learning as part of innovative capability

Developmental learning, high level; “…we discuss a lot about creating innovation and create the right products and production processes…” (Manufacturing firm in automotive, international corp., 200 employees)

Experience based learning, low level; “…we do not discuss expertise and innovation naturally. I mean what we use the competences for... we might NOT talk about it in that way, rather we talk more about how effective learning we did, in a more reproductive way of learning…” (Manufacturing firm in aerospace, international corp., 2,200 employees)

Learning capability, low level; “we do not talk in that way. It is a severely interpreted question. ... We want to grow five percent in the corporate group, but through an acquisition strategy of another company…” (Manufacturing firm in automotive, international corp., 500 employees)

E. Co-creativity

This construct refers to collaboration outside the own firm and especially with other organizations e.g. research centers/institutes and higher education and also other industry sectors. Co-creation of knowledge is meaningful when the cooperation is based on differences found between two or more organizations, in which each actor mainly concentrates on its contribution to the project, based on their goals. Herein lays the dynamics, challenges and potential of collaborative actions conducted in co-creation. There must be trust between the different parties if they will share knowledge and thus imply co-creativity of new knowledge will gain all parties.

Co-creation between manufacturing industry and higher education

High level; “…when we write the competence plan together. Take it a step further and to have a continuity between our company and your university.” (Manufacturing firm in aerospace, international corp., 2,200 employees)

High level; “yes last year we lowered production cost with one-third by last year's theses on bachelor level. This year, we the lowered the cost of 450 000 SEK (71 000 US dollars)...” (Manufacturing firm in other branches, 190 employees)

Medium level; “I think we need to describe this ourselves first so we can promote it internally, I mean how we work on competence mapping and co-creation of knowledge...” (Manufacturing firm in automotive, international corp., 2000 employees)

F. Summary of findings

The number of employees with higher education in the firm is generally low, only the largest aerospace firm (2200 employees) have almost 500 engineers with higher education. The other large automotive firm (appox. 2,000 employees) only have 50 employees with an academic engineering degree. Their ability to participate in competence initiatives on university level, will therefore be harder. Thus, the analysis show that even if most of the firms have a relative low level of formalized high educated engineers (between 5-10 %), they do have capabilities for learning. The level of awareness for
defining competence needs are high among all, but is much lower for definition of expert knowledge needs. The e-learning maturity also varies. The two largest firms and the two consultancy firms, have significant e-learning system experiences, and also a high degree of academic educated employees. It could be concluded that high educated personnel emphasize technology implementation and use.

Another result is that firms within the aerospace sector, do have high competence awareness, their own R&D, are working with competence strategically implementing competence goals in the business plan, but these firms show rather low level of dynamic capabilities to quickly adjust to external market pressure. In comparison with the automotive sector which have generally higher dynamic capabilities, meaning that they are faster and more dynamic in relation to learn from external pressure and concurrency. An explanation could be that aerospace industries usually have long-term orders in a more stable concurrency. An explanation could be that aerospace industries usually have long-term orders in a more stable branch, in comparison to the automotive branch. The automotive firms on the other hand have a lower level of organized competence work, both for individuals and strategically in the business plans.

Seven of the firms show great interest in co-creation of knowledge with the academia. Among other activities these firms have participated in co-creation of content knowledge in the first academic e-learning course that will run during April-May 2014, which show a potential for co-creativity.

V. CONCLUSION

As presented in this paper absorptive capacity and e-learning readiness assessment instruments, generally consist of indicators and/or survey questions that focus on the cost and benefit of the whole organization. These measurements provide good insight into what routines and processes that exists in firms which constitute a propitious knowledge base. But, how activities and work flows is acted upon situated in the workplace, is depicted and consequently knowledge and learning capabilities will be hard to study from the inside of a firm. In line with researchers as Duchek and Jones and Craven, we have used a qualitative approach to our case study research aiming for in-depth understanding on what conditions absorptive capacity means in regard to managers perceptions of their manufacturing firms [17, 24].

As a result we suggest a framework of four constructs for analyzing and understanding the firms’ e-learning readiness. In general, all firms show high level of awareness, seven firms have high level of e-learning maturity, the rest have low. Only four firms show dynamic capability, so further research within this complex construct needs to be developed. Half of the firms are co-creative, but all of them realize that they could benefit from co-creation activities. Further analysis and research with the framework will be conducted.

In conclusion, the framework give us knowledge of the manufacturing industry readiness in order to participate in technology enhanced competence development initiatives. This knowledge will inform the design and implementation of e-learning courses conducted in the workplace.

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