Organisation of multi-professional teamwork in technology-mediated environments

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Abstract

Multi-professional collaboration is assumed to tackle ambiguous and difficult challenges with innovative teamwork. First, expertise from many fields is needed for solving difficult problems in society and organisations, which emerge from a complicated reality. Second, tasks in working life encompass many fields, meaning that multi-professional expertise is needed. Third, the expertise has to be organised as interactive teamwork for approaching ambiguous questions. However, multi-professional collaboration is challenging, due to different knowledge bases and related working methods of each professional grouping involved, but, with digitalisation, multi-professional collaboration could become more commonplace, as the technology-mediated work environment is shared by all professional groupings in the workplace. Technology tends to mainstream working patterns and practices, which could be assumed to reshape professional work and multi-professional collaboration. The article studies how multi-professional teamwork is organised in firms with an advanced technology-mediated work environment in the new media and high-technology industry. The methodological approach is qualitative, and three case studies are presented. The outcome of the analysis reveals variations in the patterns of organising multi-professional teamwork, which is related to the function and position of the teams and the rationality of the firm.

Keywords: multi-professional teamwork, technology and work, work organisation, management, innovative teamwork

Introduction

Multi-professional collaboration has attracted the attention of academics and practitioners interested in working life. First, expertise from many fields is needed for solving difficult problems in society and organisations, which emerge from a complicated reality. Second,

tasks in working life encompass many fields, meaning that multi-professional expertise is needed. Third, this kind of teamwork is considered as challenging by management.

According to previous studies, multi-professional collaboration is compromised by different epistemologies, knowledge bodies, and related social and cultural working patterns and practices (Abbott, 2018; Ackroyd, 1996). Professions approach tasks or problems from particular perspectives and apply knowledge and working methods which are profession-specific. Understanding and adjusting to other professional approaches requires extra time and efforts, but profession-specific social and cultural hierarchies may impose obstacles on open communication (Haapakorpi, 2009). However, the studies in this field also report positive outcomes from multi-professional collaborative work.

Technology-mediated work environments can be assumed to shape multi-professional teamwork, as there is evidence that working methods and practices are mainstreamed with shared technology (Björn & Österlund, 2014). However, work organisation is not determined by technology; rather, technology is designed and implemented by humans in line with their interests and circumstances. The introduction of new technology is related to managerial strategies, institutional and market environments, and sometimes the contribution of employees. Thus, the introduction of a technology-mediated work environment is interrelated with work organisation, with the utilization of technology being social by nature (Orlikowski, 2007).

A common target for business firms is profit-making, which is promoted by efficiency and economy when organising work and implementing technology (see Lengwiler, 2006). Other interests and objectives may be applied, such that rationality overall exceeds the most basic economic motives (Holtgrewe, 2007, 2014). For example, the interests of professional employees may be considered when participatory management strategies are applied.

This study focuses on the work organisation of professional employees in the new media industry and engineering professionals in high-technology industry with different disciplinary backgrounds. Working in these firms has been exposed to the markets, the introduction of new technologies, and firm-specific particularities.

The study contributes to the discussion on multi-professional teamwork, new technology and work organisation by asking, how is multi-professional collaborative work organised, considering the different epistemologies, working methods and practices of professions? To answer this question, a case study approach is applied. The case studies come from firms with technology-mediated work environments whose business takes place in highly competitive market environments. The case studies are a new media firm and two high-technology firms.

The study starts with a theoretical discussion, first, on professions and multi-professional relations and, second, on technology and work organisation. The research design includes

the research problem and questions, the setting of the research subject, and the data and methodology. The conclusions and discussion follow the results section.

Theoretical background

Professions and multi-professional collaboration

Professional specialisation is based on particular knowledge bodies, epistemological approaches, and related working methods and practices, which are institutionalised. Institutionalisation refers to higher education systems, self-referring activities, such as publications, and institutionalised networks. (Abbott, 1989; Haapakorpi, 2009). Higher education institutions are structured according to a disciplinary system, whose education programmes are discipline- or profession-based, while the students are socialised into the profession during their studies. Despite the differences in epistemologies and related working methods and practices, professions are interrelated in labour markets and in workplaces (Evetts, 2006; Abbott, 1988). Labour division and job descriptions are related to professional qualifications, but the boundaries may be blurred.

With the specialisation of professions, knowledge bodies and related epistemologies, working methods and practices are developed and adopted. Specialisation often promotes enhancement of the quality of knowledge, but the differentiation may be an obstacle for multi-professional collaborative work. It requires extra work and time, for the differences of professions may complicate mutual understanding, particularly those related to epistemologies (Karn, 2008). In addition, hierarchies in relation to professions may impose obstacles on (equal) collaboration (Haapakorpi, 2009).

The studies dealing with multi-professional work highlight challenges and problems; for example, Buch and Andersen report that multi-professional work organisation does not take into account professional traditions (2013). One explanation for this is that, too often, there is a tight schedule for economic reasons. According to Lengwiler (2006), a multi-professional teamwork pattern is related to organisational and institutional conditions and goals, while professional status impacts on the design of work organisation. When the collaborative work pattern is adapted to market requirements, efficiency and economy are emphasised. Timesaving working methods and simple problem-solving are means to organise work under time and budget pressures: profound multi-professional interaction focusing on epistemological questions would require too much time. Multi-professional collaborative work can also be positive, innovative and successful. The positive outcomes are related, for example, to an appropriate work organisation and sufficient time resources (van der Vegt & Bunderson, 2005).

The study deals with firms in business industries, which have to work on functional but innovative patterns of work organisation for coping in the highly competitive environment.

The study focuses on professions in digitalised environments, which are assumed to have an influence on multi-professional teamwork, given that the relationship between human action and technology is interactive (Orlikowski, 2007; Björn & Österlund, 2014). In a technology-mediated work environment, employees are interconnected with technology, and the working patterns and practices tend to become mainstreamed (Björn & Österlund, 2014), which is supposed to support technology-mediated interaction and networking. In addition, computing, with its communal mind and memory, enhances the human capacity for social organisation (Hayler, 2015), which may promote efficient multi-professional collaborative work.

Technology and work organisation

Technology is related to work organisation; for management, the design of equipment and work organisation is crucial in terms of economy and efficiency (Grimshaw et al., 2012). However, rationality overall is not limited to these motives, for business is also related to other spheres of human action, such as values and beliefs (see Holtgrewe, 2014). Technology is social by nature, as it is developed, introduced and utilised by humans in social interaction (Orlikowski, 2007; Holtgrewe, 2014). According to Holtgrewe (2014), managers usually follow a shared pattern in the business field when introducing new technology and a related work organisation pattern. Institutional theory explains the similarities as follows: organisations in the same institutional field apply similar patterns and practices of work organisation, which is related to the institutional logic based on coercion, meanings and norms (Scott 2008a; Scott 2008b). Coercion in the business field mostly refers to laws and economic reasons, while the "soft" elements of meanings and norms imply the interaction and communication of human beings in organisational environments. In firms whose goal is profit-making, the economic terms are embedded in the ways of thinking (meanings) and acting (norms), although they may not totally dominate them.

Within the institutionalised business field, the similarities in work are promoted with the shared environment, professional networks and relations in the organisations (Powell & DiMaggio, 1991). Institutional theory emphasises path dependency, the cumulation of repeated patterns and practices, in order to explain the mainstreamed working patterns and practices in the institutional field (Scott, 2008b). However, the similarity is not linear and mechanical for various reasons. First, working patterns and practices, although generally applied in organisations in the institutional field, are reshaped for particular organisational contexts and strategies (Scott, 2008a; Czarniawska & Joerges, 1996). Second, the more mature the institutional field, in terms of the growth of its sub-fields, the more there are alternatives for organising work (Reay & Hinings , 2005). Third, the actors who are connected to many fields in the institution recognise conflicts in institutional logic and may promote reforms (Greenwood & Suddaby, 2006). The actors promoting reforms may be organisations or individuals, for institutionalisation takes place at different levels of institutions and organisations and involves those individuals who interact with them (see Greenwood & Suddaby, 2006).

The studies on work organisation in technology-specific firms also reveal variations in HR strategies despite the similarities in management. For example, manual work can be replaced with technology by simplifying the tasks into monitoring automated production (Wall, Jackson, & Davids, 1992); conversely, the tasks and work organisation can be reshaped in a way which promotes learning new demanding competences, such as problem-solving skills (Bayo, Bello-Pintado, & Merino-Díaz-de-Cerio, 2010). These variations may be related to different values or terms set by the environment of the firm, such as markets and labour force supply (see Holtgrewe, 2014). For example, the markets of high-technology products may apply the latter alternative, particularly when the labour force is qualified.

This article applies the concept of "technology-mediated work environment" to emphasize the all-encompassing nature of a newly digitalised work environment, which is interrelated with the work organisation. It is assumed that the patterns for organising multi-professional teamwork are designed to combine different work processes or outcomes into products or promote multi-professional collaborative work.

Research design

Industry 4.0 builds on the state-of-the-art research which acknowledges that Industry 4.0 technologies will have a deep and disruptive impact on society. However, there is an increasing number of contradicting studies about the exact impact, especially with regards to quality of working life, organisational performance and employment relationships. It is yet unclear how Industry 4.0 technology could foster societal aims, while at the same time cradle high performance organisations.

Research problem and questions

The research problem focuses on multi-professional teamwork in advanced technology-mediated work environments by determining: i) what kinds of work organisation patterns are applied in order to promote multi-professional collaborative work in advanced technology-mediated work environments and in rapidly changing market-based firms; and ii) what kinds of rationalities motivate the patterns.

The degree of multi-professional collaborative work varies, and two rough ideal types are applied for the purpose of this analysis. First, the outcome of collaborative work may be a simple combination of many single professional groupings' work performance, which is here referred to as "the combination pattern". Second, the collaborative work may result in the integration of knowledge, working methods and/or practices, which is here referred to as "the integrated pattern".

The pattern of organising work may vary and is related to a particular rationality. In addition to the institutionalised targets of profit-making, the rationality refers to meanings and social

values related to industrial relations and the institutional and market environment. The rationality cannot be reduced to a solid collection of official decisions and targets, but a changing set of decisions and patterns of thinking and action.

Work organisation implies the patterns of organising employees, functions and their relations. The elements of work organisation are the following:

- job descriptions and roles, and expertise
- labour division by functions
- interrelatedness and interaction between functions and employees
- position of the unit (team) in the firm (value chain/work process)

The research questions are as follows:
1. What is the pattern for organising multi-professional teamwork?
2. What is the rationality behind the work organisation pattern?

Research setting

The new media industry and the case-study firm
During the time of data collection, in the 2000s, new media as an industry and as a profession combined information and communication technology (ICT) with a new field of communication and art. The common definition for new media was "computer-based and interactive communication". New media, as art, was used for profit or non-profit purposes, and new media professionals worked in the fields of business and the arts (Tarkka, 2002a; Tarkka, 2002b). New media professionals were not part of an institutionalised profession, because their educational backgrounds and tasks were ambiguous. In a fast-changing industry with firm-specific, undefined tasks, strengthening the position was a challenge for professional employees (Christopherson, 2002; Pratt, Gill & Spelthann, 2007).

The professional employees in the new media industry were programmers and content providers in the audiovisual field, while, in the writing field, the content providers were graphic designers, audiovisual designers and scriptwriters. Their professional background varied regarding knowledge bodies and epistemologies and related social and cultural practices, but they shared a technology-mediated environment, with its computer-based and interactive communication.

Before 2000, professional job descriptions and professional qualifications were rather loose. The expertise was defined as being in-between institutionalised disciplines and regarded as an integration outcome of media and content (Haapakorpi, 2012). New media productions in business and the arts were interlinked, and the professionals worked in both areas. The new media culture was expanded in the market, which in turn took advantage of this media culture (Tarkka, 2002a, Tarkka, 2002b). Since 2000, the business and the arts in this industry differentiated, and the interconnection became weaker. In the business field, effectiveness

and economy were implemented in the work organisation, whereas artistic production followed a less strict schedule (Tarkka, 2002a).

In the 2000s, there were 330 firms in the business sector, with most of them being small or medium-sized and typically having a short history. With the institutionalisation of business-style management and work organisation, the firms started to make profit (Pohto & Wiren 2001). Since the time of collecting data, the new media industry has undergone a profound change as the functions are dispersed across different industries, with programming taking place in software houses and the content design taking place on social media.

The high-technology metals industry
In Finland, the number of employees in the high-technology industry sector was 295,000 in 2012, with an equal number abroad (Federation of Finnish Technology Industry 2014). In Finland, the proportion of R&D employees was 35%, the proportion of production employees 32% and the rest were in client support and services, management, administration and marketing. Roughly 56% of personnel held a degree from a higher education institution (Federation of Finnish Technology Industry 2014). The high-technology metals industry is globally distributed, and its activities are technologically mediated. The global division of labour is motivated by cost-effectiveness and the highest value-adding factors accrued from high-technology innovations, products and services.

The business strategy for high-technology industry firms is R&D-based and the goal is to produce high-quality and expensive systems of production for the markets of advanced technology. Simple production is often outsourced to countries with low labour costs, while planning, testing, support activities (marketing etc.) and services take place in Finland or in another European country. The case studies followed this business strategy.

The development and growth of high-technology industry are related to the reshaping of the engineering profession. With the commercialisation of science (Barley & Orr, 1997) and technologised science (Alvargonzález, 2011), professional fields in engineering have increased (Barley & Orr, 1997). The specialisation of engineering professionals is regarded as important, because of the automated systems. In general, the engineering profession is independent and knowledge-intensive, with a high status and employee position within the business environment, where engineering professionals have operational, but not strategic, autonomy (Gleadle, Hodgson & Storey, 2012).

The technology-mediated work environments in the case-study firms were built in such a way that engineers and expertise from many different branches. Convergence is the basis of the whole value chain, from R&D and planning to the services that refer to multi-professional teamwork. In high-technology industry, high-technology equipment becomes the environment and condition for the development of products, while computer-aided and interactive technologies are adopted. With this systematisation, engineering professionals from different branches synthetised their knowledge in new ways, which was supposed to be

converted into products and processes that fulfilled the needs of client (see also Hansen 2010). The technological system is structured when the branches of industry converge: Integrated mechanics and electronics and hydraulics with embedded computing systems which consist of various sub-systems (Curran, Bröring & Leker, 2010).

The converged automated system in high-technology industry is a special technology-mediated work environment, with its embedded computing. Engineering professionals with different disciplinary backgrounds are needed for planning and remote services (Haapakorpi, 2018). Given the embedded nature of computing, engineering professionals with a specialisation in programming were the largest professional group in the industry, while engineers with different backgrounds acquired sufficient expertise in ICT and computing. The technology-mediated work environment in high-technology industry is interrelated with the knowledge body of engineering, for the engineering discipline is 'technologised' (Alvargonzález, 2011). In other words, the engineering discipline and technology are prerequisites for each other.

Data and methodology

The analysis is based on two studies, which have been reported in three articles (Haapakorpi, 2012, 2017, 2018). The first study (Haapakorpi , 2012) focused on a new media firm and the study was carried out in the 2000s, which was a turning point in the business field from small informal workshops to institutionalized firms. The second study focused on high-technology metals industry, and the study was carried out with two case studies from 2013 to 2015 (Haapakorpi, 2017, 2018).

Case study: New Media Firm– data and methods

The new media firm was a medium-sized organisation and, according to the information available on its webpages and brochures, it provided "multimedia and Internet-based service solutions supporting customer's business activities". The firm employed 100 professional employees with various disciplinary backgrounds: management, programming and content-providing study fields.

The data consisted of 10 interviews and complementary texts (brochures, customer magazines, the annual report from 2000). Interviews were carried out with one personnel manager, two graphic designers, one audiovisual designer, two programmers, two scriptwriters and two project managers. The content providers were found in the groups of the graphic designers, the audiovisual designer and the scriptwriters. The length of each interview was approximately one hour.

The interview with the personnel manager focused on the firm's vision, as well as her perspective, given her position as the representative of management. The remaining interviewees focused mainly on their own work. The ages ranged from 25 to 47 years; the

programmers and the audiovisual designer were male, and the personnel manager was female. In the groups of graphic designers, scriptwriters and project managers, the share of men and women was equal. The themes in the interviews were work and career motives, work orientation, management of the company, work culture, work organisation, and the balance between work and family life. Most of the interviewed persons were university and polytechnic students, but only some of them had completed their degrees. The study fields were media studies, data processing, literature and the arts, social sciences, administration and philosophy.

The interviews with the personnel manager, the project managers, and the programmers and content providers were analysed in separate units, as the content of these interviews was profession-specific to some degree. The professional groupings' positions reflected the division of labour, while their relation to customers and management was dissimilar. The programmers and content providers carried out their tasks somewhat independently, relying on their half-institutionalised professional competence. The project managers assumed responsibility for the teams and co-ordinated with other teams and customer relations, while the personnel manager focused on managerial duties.

The data were analysed by applying grounded theory (Strauss and Corbin 1998). The analysis for this research article is based on the analysis and results presented by Haapakorpi (2012), but the focus is different. This article (Haapakorpi, 2012) dealt with professionalisation and work organisation. On the basis of the data analysis, the main category was the tension between business-related efficiency and professional creativity-based identity. The categories of causal, structural, and intermediate conditions were combined into one category representing the relation to the organisational environment as it was not meaningful to separate them in the analysis. The category was "from hype to profit-making". The theme of multi-professional collaborative work came out in cases where there were problems related to a lack of or insufficient multi-professional collaboration and job description redesigns.

Case studies 2 and 3: the high-technology metals industry

This study is based on a research project (2014-2015) and its data sources (Haapakorpi, 2017, 2018). The data collection process was as follows:

First, two leading experts from employee and employer trade unions were interviewed in order to obtain information and views on the business, markets, labour force and work organisation in the metals industry. The interviews were semi-structured. The experts also provided information concerning high-technology firms, which was utilized in order to search for research subjects. Two functions were considered important in the choice of the firms to be included in the research: R&D and remote services. On the basis of this information, firms with these functions were contacted for data collection.

The interviews were conducted with six members of staff from two firms, which were both large transnational corporations. Firm 1 was a large firm in the cargo-handling and related

services industry. At the time of the interviews, it employed 11,000 people in 100 countries and its production mostly took place in Asia. Three managers in R&D and the management of client projects, all male and aged between 40 and 60 years, were interviewed.

Firm 2 was a transnational firm providing the following services and products: manufacturing and supplying flexible manufacturing systems (FMS) and robot cells to the metal-cutting industries to automate the manufacturing and finishing processes. The staff from firm 2 comprised 530 employees worldwide at the time the data collection took place. The three interviewees hailed from the remote services team, which, in total, consisted of six engineering professionals. The ages of the three interviewees ranged from 25 to 35 years and one was female. The remote service employees helped clients to find faults in their automated production systems by applying ICT-aided methods, in particular, with a specialised computer programme. The remote services experts examined clients' computer-aided production system by investigating the different parts of the system and reading the information, which, for example, dealt with the components.

All of the interviewees from the firms were engineering professionals but their disciplinary background varied. Most had studied computing, while the rest were specialized in automatised systems, mechanics and electronics.

The interviews were semi-structured, and the themes were as follows:
- Industry: trends and prospects, management strategy, and HR policy and recruitment
- Firms and professional employees: work organisation, professional work and related changes

The interview questions and interaction were adjusted to reflect the interviewees; thus, they were semi-structured. The data were analysed by applying content analysis (Silverman, 2006). The main categories were, first, work organisation and, second, professional work and competences. The category of work organisation comprised the sub-categories of the division of labour and work, functions and their relations, and management. The category of professional work and competence consisted of the following sub-categories: working methods and knowledge body, and disciplinary/professional background and competence. In this article, the multi-professional collaboration theme is studied by employing a special approach when analysing the main categories. The approach focuses on the tension between the specialisation of engineering professionals and multi-professional teamwork when striving for a common outcome in the same technology-mediated work environment.

Results: Case studies

New Media Firm: simple combination pattern

In the new media firm, there was a strong tendency toward the traditional and hierarchical organisation of work, with a clear division between labour and professional areas. With the

changing market environment and differentiation in the arts and business, the company was transformed from a small workshop to a medium-sized company in a few years. A business-like pattern for organising production was adopted in an environment of increasing competition, along with strategies for profit-making. Organising schedules, space, and activities were aimed at commensurable and controlled work. Economy and efficiency were applied to the work organisation.

For streamlining functions, employees and work, a matrix methodological approach to work organisation was applied in the company (for more on matrix-based organisation, see Scott and Davis 2007). The employees and work were organised into professionally specialised departments; but, for the work assignments from customers, teams consisting of professionals representing different competence areas were established. The team members were experts in content provision and programming.

The job descriptions for professional employees were defined and related to each other. The establishment of the new organisational pattern changed the previous work division, which was loose, as the employees also carried out some minor tasks belonging to the neighbouring profession, such as graphic design and programming. With the new pattern of labour division, the job descriptions for professional groupings were clearly and tightly prescribed, while the work organisation became more transparent and controllable. The working methods and practices were standardised, with project management following a prescribed pattern, which was applied to all projects. One interviewee described the change as follows:

> "This job is totally different from the previous work I had, with the constant budgeting and calculating. Everything is estimated. These hours for this project and these for that. Processes are prescribed. All the activities are calculated." (Male, scriptwriter)

In a way, the division of labour promoted the professionalization of personnel as they were recognised as experts in their specialised niches, while their organisational units (departments) were profession-specific. Collegial and intra-organisational learning was promoted for enhancing the professional profile of the firm and establishing a quality system for production. The improvement in professional competence was related to organisational competence and particular firm-specific technology. The standardisation of competences promoted efficiency and economy, given that, with insufficient competence, there was a risk of uneven work quality.

The technological environment was shared by professionals with different competences, which determined their contribution to each project. Team members worked together only at the beginning of projects, while the professional employees on the team carried out their duties independently and without interaction, which reinforced profession-specific work areas and the boundaries between them.

With goals centred on efficiency and economy, the opportunity for fulfilling professional ambitions in work was in fact decreased. The strict time schedules and the requirements from customers standardized the work:

> "I'd like to say that my work demands creativity, but it does not. This is just a job. There are standardised solutions and professional competence means that you can do proper work. A very small proportion of the total work provides an opportunity for creativity. Most often, it is about updating Internet sites." (Male, graphic designer)

The work organisation pattern, based on strict professional tasks and boundaries, divided the personnel regarding the need for collaborative work and the quality of work. According to a female graphic designer, the strict work division improved efficiency. She commented: 'We all have our own duties and tasks, and I think this makes it work. You take care of your own business and there's no conflict.' However, most of the other interviewed professionals disagreed with this view and reported conflicts between employees with different professional approaches. 'Conflicts are common, for example, between scriptwriters and programmers. The content and technology do not match' (female, scriptwriter). The interpretation of the different views regarding the strict division of work is based on variations in work-related interests and ambitions.

The conflicts due to combining different professional performance standards were related to a lack of collaboration, as it was stated that there was not enough time for planning and discussing the assignment and the methods for integrating the contributions of team members. In addition, the poor resources available for multi-professional collaborative work did not provide them with learning opportunities, a finding which is in line with that of other studies, for example, Pratt, Gill and Spelthann (2007).

The work organisation pattern for multi-professional work was a simple combination of the outcomes of professionals with different backgrounds. There were only minor multi-professional activities due to the strict division of professional labour.

High-technology Firm 1: two-tier integration pattern

The project teams developed and designed automated cargo-handling systems for customers. The project managers were responsible for conducting the projects and the teams consisted of engineering professionals with different disciplinary backgrounds, such as mechanics, electronics, hydraulics and computing. The experts had higher education degrees in subjects relevant to the industrial branches concerned, while the integration of knowledge from different professional fields was the working method.

The engineering professionals focused on their own specialist areas, despite having some knowledge of associate engineering professions. Teamwork was assumed to result in

integrated systems or products, and the team members had to adapt their work to reflect the shared technological environment and the limits and conditions set by other team members.

Teamwork followed the combination pattern of multi-professional collaborative work, but not in the simplest way, as there was some integration with associate engineers' contribution. They had to design their performance in such a way that it took account of other team members' contribution and the expected outcome. The project managers were assumed to have a basic knowledge of all the branches of engineering on the team: basic concepts and epistemologies and some basic understanding of the content of the branches. To some extent, they were expected to display competence in working according to the integration pattern of multi-professional teamwork. The competence of integrating the outcome of team members with different disciplinary backgrounds varied substantially, and in turn the quality of the outcome, i.e., the automated system.

The project managers carried out their responsibilities by promoting smooth work processes and monitoring the professional employees on the teams. This monitoring was motivated by economy and efficiency, as reflected in the following quote from one of the R&D and project managers.

> "Most important for the integrating person (project manager) and his [or] her role, is not so much related to planning but to interaction and leadership of the teams, by which I mean engineers with different backgrounds: mechanics, programming, electronics and so on. So how do the project managers know, for example, when a programmer exaggerates his workload? [For this reason, they must know] how much [work] there really is to do (High Tech Firm 2, senior R&D manager)."

High-technology Firm 2: integrated pattern based on a mixture of profession- and firm-specific competence

The remote services team was established in order to promote profit-making, as the team was expected to expand the range of services. As the new service also supported economy and efficiency, planning engineers, with their higher salaries, were released from service work. The increase in less competent, but qualified assistant engineers is typical for high-technology firms with a specialisation in R&D-based technologies (Barley & Orr, 1997). The team comprised six professional employees, one of whom was the head. The division of labour was small as the head functioned as one of the team members.

The remote services experts examined clients' computer-aided production systems by investigating their different parts and reading system information, for example, on components. The firm-specific program was incorporated into other computer programs, and the unified system was embedded in clients' automated factory systems. The engineers

of the team interpreted and solved complex and abstract problems derived from interdependent software, hardware and user-interface factors. They worked individually but utilised intra-team interactive learning, which is common for this type of work (see also Hansen 2010). With the intra-team interactive learning, they learnt together how to use the computer programs and the clients' automated systems.

Although the educational careers of the remote service team employees were rooted in different engineering branches, their expertise was supposed to focus on the expertise of the remoted service. The remote team worked on this kind of contextual knowledge, while the work of the professionals in Firm 1 was specialised into the niches related to their educational background (see Gleadle, Hodgson & Storey, 2012).

> "Although I don't have knowledge of all the systems and programs, I can conceptualise how machines function, what automation is, and how to utilise, for example, basic computer systems [and the] structures of folders. That's way I am able to search for jams. When a client calls me, I have to map the [entire] system, to know something about every part of the system. Sometimes, they need help from an expert who is specialised in one particular part, for example, [the] computing system. But nobody is [an] expert on everything (High Tech Firm 2, team member) ."

The remote services team followed the integration pattern of multi-professional teamwork, as they had knowledge to a small extent of every industrial branch and the converged automated system. However, the integration was a mixture of professional and firm-specific knowledge, as the subject of work was limited to the faults in automated systems and only a narrow range of core professional knowledge was applied to the work. The contextual knowledge was derived from overlapping professional and firm-specific knowledge. The contextual knowledge could not rely on professional knowledge bodies. The special integration pattern, based on multi-professional and firm-specific knowledge, was related to the target of expanding the profit-making business and applying economy and efficiency to the work organisation.

Conclusions and discussion

All the work organisation patterns followed the idea of multi-professional teamwork, although the applications and team organisation in the frame of the whole firm (matrix organisation or stable teams) varied. The teamwork organisation pattern was related to a technology-mediated work environment, while the multi-professional work was carried out in shared technology-mediated work environments. The teamwork organisation patterns varied with the position and function of the multi-professional team and the business strategy. The professional profile of the firms emphasised services and products, which were professional by nature and produced by professional experts. To conclude, the work organisation patterns followed specific rationalities of the firms, which were mixtures of i) formal managerial targets

for profit-making by applying economy and efficiency to the work organisation, ii) the design of the professional profile of the firm and iii) the function and position of the multi-professional team.

New Media Firm: The division of labour was strict and clear: every member of the multi-professional team independently carried out his/her duties and collaborative teamwork was minimised in order to save working hours. The simple combination pattern of multi-professional teamwork was managerially, not professionally, coordinated. However, more multi-professional collaboration would have been necessary for an acceptable collaborative outcome, as the shared technology-mediated work environment set terms and conditions for the outcomes of individual and profession-specific work.

The new media firm followed the target of profit-making, with a non-specified strategy regarding the quality of services. The strategy was not explicitly expressed in interviews and in other data, but implicitly reflected in the tight schedules and simplified working patterns. The competence in new media was becoming more commonplace among the lay public during the year of data collection, and there was a diminishing demand for the services provided by the new media firm. The lay public learned how to design Internet pages themselves, and the firm did not systematically develop new products with high professional quality. The management of the new media firm pursued a form of rationality which emphasised economy and efficiency by producing simple standardised products with relatively low prices.

Immediately after the year of data collection, the new media industry was spread across differing branches, and it may be that there were actually no options for developing the business in a sustainable and professional way. With this history, one might ask, would R&D and Internet-based, high-quality products with a proper multi-professional teamwork have saved the firm? That may be possible; however, new media firms no longer exist in the very same shape, which implies the restructuring of the whole industry.

High-technology Firms 1 and 2: Both based their rationality on economy and efficiency in profit-making, but the actualisation method produced innovative, R&D-based products and services. The markets were transnational, and the opportunities for profit-making were new innovative products and life cycle professional services, given that the market for simple products did not promise a bright future for the business. This strategy was related to the high professional profile of the firms and qualified professional labour force.

High-technology firm 1 applied a two-tier pattern for organising multi-professional teamwork, which promoted the combination and integration of profession-specific outcomes. The engineers with different disciplinary backgrounds carried out their contribution in their own niches when planning the products, while the teamwork was coordinated by a project manager with an engineering competence. The integration pattern was as follows. First, the engineering professionals of the team had some basic knowledge of the associate

professionals who adapted their performance to the technological environment, which was a converged automatic system. Second, the project manager integrated the outcomes of the team-members' work. The project manager had basic knowledge of all branches of engineering and, in addition, knowledge of how to integrate them.

The project manager followed two rationalities, profit-making and innovation-based business, which were interrelated in a specific way. The innovation-based professional work made profit-making possible, with the innovation-based working methods shaped by profit-related goals.

In High-technology Firm 2, the rationality behind the work organisation pattern was based on economy and efficiency, as the remote services had been established for expanding the business services. The remote services team in High-technology Firm 2 applied an integrative pattern of organising teamwork, which was based on professional and firm-specific knowledge. The engineering professionals came from different engineering disciplines but shared the same tasks. They had some knowledge of all the branches of industries, but the ICT competence and problem-solving competence were of primary importance. The knowledge was a mixture of interrelated professional and firm-specific knowledge. However, from a professional perspective, the pattern did not strengthen professional competence, as the applied contextual knowledge could not revert to professional knowledge.

The organisational pattern was related to the function and position of the team which came after the production. As the production system was already converged, excellent integrated professional knowledge interrelated with firm-specific expertise, rather than branch-specific expertise, was needed.

Although integrated and firm-specific multi-professional work does not revert to its disciplinary root, it may be linked to a professional knowledge system as follows. In high-technology R&D, professional, discipline-specific knowledge and industry-/firm-specific knowledge are interrelated and are prerequisites for each other. It may be that the pattern applied in high-technology firm 2 may be absorbed by the study programmes of higher education institutions to some extent, particularly because where there is collaborative work involving the firm and the local higher education institution specialising in technology.

Table 1. Multi-professional collaboration: the degree of integration, the patterns of work organisation, the position of the team and the rationality of the firm

Pattern	Simple combination pattern	Two-tier combination-integration pattern	Integrated professional and interrelated to firm-specific expertise - pattern
Organisation of teamwork	Minor multi-prof. interaction, team members' independency, non-professional project management	Specialised niches of team members and some inter-professional approach, integration by the professional manager	Small team, similar job descriptions, peer learning and low hierarchy
Position of the team	Matrix organisation and project-based teams	Stable team, the position of the team at the beginning in value chain	Stable team, the position of the team after the planning and production in value chain
Rationality of the firm	Efficiency with simple and relatively cheap services with qualified professional labour force	Efficiency with high profile and expensive products and highly qualified professional employees	Efficiency with new and relatively expensive services, qualified professional labour force

The organisation of multi-professional collaborative work varied from the simple combination pattern to the integrated pattern. In addition, the integrated pattern included two sub-patterns: the integration of different outcomes of team members and the inter-professional competence interrelated with firm-specific expertise.

The shared technology-mediated work environment dominated the work and performance of the multi-professional teams in the case-study firms, which resulted in fluent, but also uneven and conflicting, teamwork. The patterns of organising the work either took into account the challenges included in multi-professional work, with respect to the shared technology-mediated work environment or did not pay attention to them for economic reasons.

The patterns for organising multi-professional work were motivated by the rationality in the firms. The rationality of the firms followed the logic of the business field, i.e., profit-making with efficiency and economy in the work organisation. However, the rationalities for

organising multi-professional teamwork in the case studies were different regarding the design of the professional profiles of the firms and the specialisation of professional teams' functions and position.

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