Solutions for sustained expertise in project-based organizations: Organizing for disciplinary leadership or disciplinary community

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ABSTRACT

A prerequisite for effective knowledge integration is access to differentiated and specialized knowledge bases. Knowledge integration often takes place in interdisciplinary project teams, where members spend most of their time working closely with members of opposing disciplinary domains in problem-solving processes. The disciplinary knowledge of individual team members is therefore key to the quality and outcome of the knowledge integration in organizations relying on interdisciplinary project work. This paper returns to a challenge well-described in previous research into project-based organizing, namely how to sustain and develop disciplinary expertise in the long run in an organization that promotes dispersal of disciplinary peers and an increased cross-learning across disciplines. So far, only a few studies have contributed to developing insights into how these challenges can be met, and how different organizational solutions might counteract the risks of losing disciplinary depth. Based on a comparative study of three cases, this study sets out to identify and analyze solutions that emerge in project-based organizations as a response to the challenge of sustaining and developing disciplinary expertise. The paper centers on structural solutions, and identifies two main types of expert structures that in different ways support disciplinary expertise: Expert structures for disciplinary leadership or for disciplinary community. These two types are further analyzed in relation to how they support disciplinary expertise.

INTRODUCTION

Integration of complementary knowledge to develop innovative solutions and solve complex problems is often organized by the means of projects and interdisciplinary project teams. Projects are considered to allow firms to combine and integrate different disciplinary domains of knowledge in an efficient way (e.g. Sydow *et al.*, 2004). By some, this way of organizing work has even been heralded as 'the solution' to the challenges that face contemporary organizations (e.g. Leonard-Barton *et al.*, 1994). However, the seemingly most efficient way to organize for knowledge integration – interdisciplinary projects – also seems to inherently create an organization that in a longer perspective actually runs the risk of losing depth in key disciplinary domains of knowledge (see e.g. Hatchuel *et al.*, 2002; Lenfle and Midler, 2002).

Knowledge integration requires the existence of idiosyncratic knowledge domains to integrate. This is clearly argued by, for example Grant (1996:p115), who states that the "mechanisms for knowledge integration are necessitated by the differentiation of individuals' stock of knowledge". Similarly, Leonard-Barton (1995) argues that having diversity of specialized knowledge bases and finding synergies across these knowledge bases is a key in

order to achieve "creative abrasion" and innovative solutions: "Specialization leads to expertise, of course, and therefore the availability of deep knowledge to apply to problems" (Leonard-Barton, 1995:65).

Hence, these idiosyncrasies need to be sustained and developed over time and the knowledge domains need to maintain their edge. This also means that the disciplinary expertise among individual project members has to be nurtured in order to stay valuable in knowledge integration activities. A work organization based on interdisciplinary project teams, in which individual project members work primarily in interdisciplinary constellations, rather than in a functionally/disciplinary-based organization constitutes an arena with two characteristics that seem to counteract the possibilities to sustain disciplinary expertise: (1) dispersal of disciplinary peers, and (2) increased cross-learning across disciplines.

Firstly, the interdisciplinary set-up inherently creates a dispersal of members within the same knowledge domain, which also diminishes the sense of community among disciplinary peers (Grabher, 2004; Charue-Duboc and Midler, 2002; Bredin and Söderlund, 2011). This, according to Charue-Duboc and Midler (2002) poses a long term threat to the organization's ability to retain disciplinary expertise. One central aspect that the authors point at is the lack of situations in which tacit knowledge is articulated and transmitted among members within the same disciplinary domain. This can be compared with the discussion on communities-of-practice that Brown and Duguid (1991) has based on the ethnographical study by Orr (1990; see also Orr, 1996). Here, story-telling and collaboration are described as central aspects to construct a shared understanding within a community, develop the community members' knowledge and abilities, and also to strengthen their disciplinary identities. Brown and Duguid (1991) refers to the important role of community stories and narratives as repositories of accumulated wisdom that the members trade back and forth, and that enhances their abilities to deal with future problem-solving. The authors also point to the importance of collaboration among disciplinary peers in solving particular problems, since this furthers the knowledge of all the community members: "The insight accumulated is not a private substance, but socially constructed and distributed" (Brown and Duguid, 1991:46).

Secondly, specialists who work on an everyday-basis in interdisciplinary teams naturally learn some of the disciplinary domains of their team members (Lindkvist, 2004). As argued by for example Grant (1996) and Leonard-Barton. (1995), developing a certain degree of common knowledge is pivotal in order to be able to communicate and integrate what is *not* common. Iansiti (1995) and Leonard-Barton (1995) discusses this in terms of "T-shaped skills", where

the stem of the T symbolizes functional/disciplinary skills and the crossbar symbolizes the ability to apply knowledge across situations. The crossbar is described as the common knowledge needed to integrate, and requires learning a certain amount of the opposing knowledge domains. However, there is also a recognized risk that this broadening of knowledge comes at the expense of depth in specialized knowledge, and maintaining the balance is something that needs careful attention by managers and individuals themselves:

> *Creative problem-solving requires to manage the balance between rewarding*
> *only deep functional knowledge and rewarding only application or integration*
> *skills. /.../ Of course, a risk is creating a class of generalists with no deep*
> *knowledge of any particular specialty but only possessing the crossbar of the T."*
> *(Leonard-Barton, 1995: p 76-77)*

This challenge is also described by Grant (1996), who stresses that knowledge integration is *not* the same as knowledge transfer, and that knowledge transfer between individuals with differentiated knowledge bases should not be aimed at but rather kept to a minimum, in order to maintain the differentiation in specialist knowledge:

> *"If production requires the integration of many people's specialist knowledge, the*
> *key to efficiency is to achieve effective integration while minimizing knowledge*
> *transfer through cross-learning by organizational members." as clearly explained*
> *by Grant (1996:114):*

The difficulties of sustaining and developing disciplinary expertise in project-based organizations have been identified and discussed in a number of previous studies – thus, the problem is well-known (see e.g.Midler, 1995; Clark and Wheelwright, 1992). However, more empirical work is needed with regards to organizational solutions that have emerged as a response to the risks of losing disciplinary knowledge depth. A few studies provide examples of attempts to address the issue, for example, by the application of "*horizontal knowledge overlays*" (Nesheim *et al.*, 2011:837) such as competence networks and knowledge communities among project members with similar disciplinary identities (Lindkvist, 2004; Nesheim *et al.*, 2011) or informal measures such as disciplinary peers moving their desks together (Sapsed, 2005). However, in these studies, such complementary organizational solutions have not been the main focus of analysis nor have they been discussed in terms of their potential to counteract the risk for lost disciplinary knowledge depth.

Hence, there is a need for additional research to identify and examine such organizational solutions and analyze their potential to sustain and develop disciplinary expertise while relying on interdisciplinary projects teams for knowledge integration in the long run. This paper aims at making such a contribution.

In the following, we give a brief account of the concept of disciplinary expertise, to clarify the definition used in this paper, and to introduce the main framework applied regarding central elements in disciplinary expertise. We also further describe what we mean by "organizational" solutions, and specify the type of solutions in focus for this paper. After describing and explaining the comparative-case study approach applied in the study, we present the empirical findings regarding organizational solutions to sustain and develop disciplinary expertise in the three cases involved in the study. Then follows a discussion and concluding remarks, in which we outline two main types of solutions regarding structures that in different ways support disciplinary expertise.

DISCIPLINARY EXPERTISE

Disciplinary expertise is often regarded as scientific and/or technical knowledge within a certain domain that enables particular individuals to conduct particular tasks, i.e. which gives them abilities and skills that distinguish them from individuals within other domains of knowledge (c.f. Collinson, 2001). For the purposes of this paper, the concept needs to be further examined. Only then can the identified solutions be analyzed based on their potential to support disciplinary expertise.

A common question in the stream of research on knowledge work in knowledge-intensive organizations is that of "*what should be known*" by knowledge workers (Spender and Grant, 1996:5). In search for an answer to this question, various researchers have built on different epistemologies and different distinctions of knowledge types. For example, Cook and Seely-Brown (1999) make a distinction between an epistemology of possession and an epistemology of practice.

The epistemology of possession implies a view of knowledge as something which people possess in their heads, i.e. knowledge is cognitive (see also, e.g. Alvesson, 2001; Spender, 2007). The epistemology of practice, on the other hand, underlines that not all of what is known exists in people's heads but some of it is part of practice as people act on the world by solving particular problems (see e.g. Schön, 1991; Blackler, 1995). Cook and Seely-Brown (1991) suggest the words "knowledge" and "knowing" to separate the epistemologies when

discussing knowledge work. They further suggest that they are "*mutually enabling*" as "*knowledge is a tool for knowing*". (p.381).

In this paper, we draw on these distinctions to clarify the concept disciplinary expertise, which is here seen as consisting of both "knowledge" and "knowing" within a specific disciplinary domain. A disciplinary domain is suggested to be confined and idiosyncratic scientific and/or technical field, clarified empirically as it is identified as a separate knowledge base in knowledge integration activities. Since both knowledge and knowing when applied are situated in a particular practice, for example related to a particular product, system, or customer (see e.g. Morris and Empson, 1998), and in a particular institutional and organizational context (see e.g. Robertson *et al.*, 2003), disciplinary expertise is also understood as including "contextualizing" abilities that enable the disciplinary expert to set and solve the problems at hand in a skilful way, that is in a way that makes sense taking the wider context into account, e.g. how the customer will use the product under development.

ORGANIZATIONAL SOLUTIONS

This paper sets out to identify and examine organizational solutions for sustaining and developing disciplinary expertise in project-based organizations. Organizational solutions is here understood as a variety of measures an organization takes in order to address a certain challenge, and they come in many forms. In this paper, we depart from a distinction of four main aspects that can be used to describe organizational solutions.

First, the solutions could be of a *structural* character, that is, that they are found in the choice of organizational structure. This could be, for instance, the choice of a certain form of matrix structure (see e.g. Hobday, 2000), restructurings, or the creation or abolishment of units. Alternatively, the solutions could be in the form of *activities and practices* that have emerged or have been implemented, such as the competence networks described by Lindkvist (2004), or the practice of putting the desks together as described by Sapsed (2005). Second, organizational solutions could be either *intended*, that is consciously developed to address a certain challenge, or they could be *emergent,* in other words developed over time, molded by the organizational setting and its members but without an a priori intention. Third, organizational solutions could be either *internal* to the organization, or they could take place *externally*, or across organizational borders. And fourth, the solutions could be *formal* in the sense that they are implemented by managers or support functions, or they could be *informal*, meaning that they are created by employees independent of hierarchical level without impetus

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from above. This paper centers on structural solutions that are intended rather than emerged, internal in their character, and that have been formally implemented by management.

METHODOLOGY

The research reported here is based on a qualitative comparative case study of three firms which all rely heavily on interdisciplinary and co-located project teams in R&D work. The cases are presented with the fictive names Software Inc., Sentio, and Medtech, operating within the areas of software development, sensor systems, and medical technology respectively. In all cases, the project management logic has recently been heavily influenced by agile project management principles, which has led to a set-up where the interdisciplinary project teams were intended to be stable over time. In other words, the teams are not dissolved after closing a project and so, project members do not have their permanent belonging to a line-organization with disciplinary peers (cf. Midler, 1995). This made the cases particularly interesting for the purpose of this study, since such an organization accentuates the dispersal of members within the same disciplinary domain, which also highlights the challenges with maintaining and developing disciplinary expertise.

The data was collected in 2012 and 2013, and is based on qualitative interviews with R&D managers, first-line managers and disciplinary specialists. In total, 35 interviews were conducted. Preliminary results have been presented to and discussed with all the participating firms, and the case studies are presented in more detail in Enberg & Bredin (2015, forthcoming). All the quotations have been translated from Swedish into English by the authors.

Software Inc. produces advanced software-based products and systems and is among the top three companies worldwide within its industry. The company offers a wide range of customized software-based products and systems for their customers, which include companies in the media, transport, automotive, and utilities industries. Software Inc. has more than 100,000 employees around the world. The study presented here was conducted at a development unit responsible for the long-term development of one of the software-based systems which Software Inc. develops. The unit employs around 2,200 people, most of whom have a master's degree in engineering while some also hold a licentiate or PhD.

Sentio is a world-leading developer and manufacturer of sensor systems. The company offers a wide range of vision products for industrial applications such as vision sensors, smart cameras, and 3D cameras. These vision products are customized and integrated as parts of

customers' existing production systems to, among other things, identify, detect, measure, or position different objects, liquids, or gases and thereby enable factory logistics and process automation. Sentio's customers are found worldwide in industries with various needs and demands, for example in the mining, pulp and paper, and food industries, but their products can also be found in ports and airports as well as in power plants. Sentio has around 5,500 employees at 40 different locations worldwide. The study presented here was conducted at one of Sentio's R&D units, employing approximately 55 people. Most of the employees at the R&D unit have master's degrees in engineering, while some hold a licentiate or PhD.

MedTech is a market-leading developer and seller of products and services in the area of medical IT. The company offers a wide range of products, comprising IT solutions, software licenses, service, and upgrading agreements, consultancy services, and training courses and has delivered some of the largest radiology IT installations worldwide to customers in the health care sector. MedTech's medical IT products are integrated with customers' existing systems and are therefore developed in close collaboration with customers. MedTech employs approximately 500 people, most of whom have engineering degrees and some of whom hold a doctorate. This study was undertaken at MedTech's R&D unit, which employs approximately 70 people at two sites. Of these, around 60 people work at the site at which this study was undertaken.

All the interviews were transcribed, and the analysis of the empirical data was then done in three steps. First, extended case descriptions, rich in details, were written for each case, in line with the approach to the case-based research promoted by Dyer and Wilkins (1991). This allowed us to first make a within-case analysis, followed by the second step – to identify similarities and differences across our three cases. Finally, these similarities and differences were analyzed. The rich case descriptions made it possible to pay attention to the specific context in which the organizational solutions and activities were taking place, which also allowed us to reveal "deep structures" of each case and thereby more comprehensive cross-case comparisons (Dyer and Wilkins, 1991). For example, as a consequence of the rich case descriptions, it became obvious that what first appeared as similar organizational solutions had different content and different implications at the different companies. This paper reports on the findings regarding the structural solutions identified, which in different ways addressed the challenge of sustaining and developing disciplinary expertise in the three cases.

In the following, the empirical results regarding these structural solutions are presented case by case.

Software Inc.

At Software Inc. the basic "producing units" are permanent cross-functional teams consisting of system design, design, and test specialists. All these teams should be able to take on the development of *any* feature wished for in *any* part of the product. This feature-driven organization has as an explicit aim to tear down the wall between individuals with different specialisms, whether related to technical knowledge around system design, design, and testing or knowledge of specific components and subsystems of the product. In order to make these teams high-performing, there is an explicit aim to broaden their product knowledge and to create overlapping disciplinary knowledge in each team in order to make each team less vulnerable to sick leaves and the like.

There is a perceived risk that the cross-functional teams and the individuals who constitute them will lose knowledge depth over time. One manager expresses the following:

> *What we're saying now is that OK, you're expected to stretch a bit beyond your current position and you have to do that to make sure that we get a result. […] But a consequence is that you lose depth, you know a bit about everything but lack knowledge depth. And I don't believe… I mean we need the depth if we are to manage what we're supposed to. (Manager, Software Inc.)*

One way of counteracting this risk is a unit called "technical management office". The technical management office consists of eight engineers who have been assigned the title "Specialist" in the career ladder for engineers at Software Inc. These eight are specialists in areas such as software development, modeling, product architecture, and testing. They assume responsibility for technology strategies and their implications and are involved in pre-studies, technical analyses, and education of individuals in the cross-functional teams.

The main responsibility for the specialists at the technical management office is to work for maintaining and developing the knowledge within their particular disciplinary domain. This entails for example holding technical stand-up meetings with the cross-functional teams, where they inform the teams about new ways of working, and also developing and directing courses within their disciplinary domain. They are also involved in problem solving when the cross-functional teams face complex problems that they are not able to resolve on their own. This means that specialists from the technical management office are occasionally co-located with the cross-functional teams. The head of department explains:

Half of their time they are expected to spend on what we would call 'useful work',
which is giving an added customer value, and then the other half is more to work
with their specialisms. So, approximately half-time they always spend on some
kind of more long-term issues. Then sometimes, they are 100% dedicated to take a
look at something new or 100% dedicated to a team, doing trouble-shooting or
something. (Head of department, Software Inc.)

Sentio

At Sentio, the R&D unit is organized along three product groups: vision cameras, smart cameras, and 3D cameras. For each product group, there is a permanent cross-functional development team with the responsibility of maintaining and developing the products.

Hence, most of the daily work for a regular engineer at the R&D unit is conducted in cross-functional teams, working together with people who are not within their own technical knowledge domain. The knowledge domains represented in the cross-functional teams are software development, FPGA (Field Programmable Gate Array) development and programming, testing, systems architecture, and project management. There are usually several software development engineers on each team, although they are further specialized within a number of different sub-disciplines, while there are usually only one, or in some case two, from each of the other knowledge domains. Thus, while there are quite a few software developers in the R&D unit, there are for example only two people with knowledge of FPGA development, and therefore the preconditions for knowledge and experience sharing varies not only within the cross-functional teams but also across teams.

One of the principal aims when the cross-functional teams were created was that each one of them would be self-supportive in terms of the competences needed for the further development and maintenance of each product group. The R&D manager explains:

Each cross-functional team is more or less […] self-supportive when it comes to
the competences [they need]. […]They are supposed to deal with their own
business quite extensively. (R&D manager, Sentio)

For the teams to be self-supportive, team members need to broaden their competence to include other knowledge domains and an ability to take on different roles depending on the situation. For example, it is suggested that test leaders broaden their knowledge to include basic programming or that FPGA developers broaden their knowledge to be able to do

embedded programming. One of the line managers makes a comment on the need for individuals to broaden their knowledge:

I mean, in an interdisciplinary team it's more important to be able to do a bit of everything, and that is also a kind of competence. […] If you take a look at the problems that need to be solved […] then you can see that the people who are most valuable are those who can swiftly identify and solve the problem. Is that a generalist or a specialist competence? …I'm not afraid of generalists. I mean, if a generalist is very good at taking on something new and solv[ing] that problem, then it's as valuable as having long experience in a particular knowledge domain. (Manager, Sentio)

However, there is one knowledge domain that is not allocated in the permanent cross-functional teams: the image processing specialists. These specialists are instead allocated in a centralized unit called the "core design team".

Image processing is considered key to Sentio, and the core design team therefore has a strategic, long-term assignment to develop and implement new image processing technology. When describing the organizational setup and the core design team more specifically, one of the managers explicitly makes reference to a need for sustaining the competence of the image processing specialists, as this knowledge is considered essential to Sentio:

They contribute with their specialist competence, and the reason why we've chosen this particular solution is that we want some kind of critical mass so that the specialist competence doesn't become too dispersed throughout the organization and weakened. (Manager, Sentio)

It is suggested that though image processing competence is essential, it is also a more generic competence that does not increase in value when tightly tied to a particular product or group of products. Furthermore, as expressed by another manager, image processing specialists are more dependent on their peers to solve technical problems:

We've chosen this setup because we think that knowledge of image processing is rather special and quite a part of our core activity and that they [the specialists on image processing] have the most to gain from exchanges with their own group, so to speak. Because image processing is the basis of all our products but it's not

really tightly bound to a particular product after all [...] the difficult thing is the image processing stuff. [...]We could have chosen to assign them to the product teams, but then they would have fewer exchanges between each other. They have their own forum and solve quite a few problems there. They rely on their group in solving problems in a different way [than other disciplinary experts], I think. (Manager, Sentio)

Although the image processing specialists, organizationally, belong to the core design team and are suggested to hold a competence that is essential and should not be scattered around the organization, they share with other specialists the fact that they conduct an overwhelming part of their daily work in the cross-functional teams.

Well, I would say that they spend 85–90% of their time in the cross-functional teams, the development teams, and a relatively small share of it together as an image processing team. At the same time however, their way of working is such that even if they work in four different projects, they will gather to discuss each other's problems and solve problems together quite extensively [...] and then, when they work intensively in a project, we expect them to sit together with the cross-functional team working. But when they work more, how should I say, single activities or when they work together in another project, then we would try to co-locate them. (R&D manager, Sentio)

MedTech

MedTech's R&D unit is divided into three different units: software development, deployment, and integration, where software development constitutes the product development unit. Software development is further divided into two departments, one focusing on Server, General, and Database (SGD) and the other one on Client, Workflow, and Usability (CWU), or "back-end" and "front-end," as our respondents refer to the departments. The departments are resource owners, and the line managers take on HR responsibilities for the people at their department. The daily work, however, is undertaken by cross-functional teams spanning both departments.

In contrast to the other two cases, the cross-functional teams at MedTech are not intended to be permanent. Adjustments to the teams take place continuously. For example, every six months, when there is a release of new features in the products, the teams are also upgraded, such that some people leave for another team while others join. This is done to optimize the

teams with respect to the knowledge requirements for the next cycle of feature development and product upgrades. Although the cross-functional teams are not of a permanent nature, they are not traditional project teams either, which dissolves after the project ends. There is instead a continuous "upgrading" of the teams, with small adjustments along the way. And, the average engineer is always co-located in cross-functional teams, and there exists no functionally-based line organization to which they return after a project is finished.

In the cross-functional teams, some disciplinary specialists are able to cover for each other, although this is not always the case. Furthermore, both department managers emphasize that there are no intentions to increase the substitutability between individuals or teams, although it is desirable for a team to be able to keep working even if someone is absent.

> *Nothing here builds on the idea that we want everybody to be similar because we absolutely do not want that. However, what we do want is that the team as a whole would be able to manage if someone is on leave for a short period of time. (Line manager, SGD, MedTech)*

At Medtech, the increased focus on cross-functional teamwork soon led to experiences of loss in knowledge depth and feelings of "ownership" of central aspects of the product.

> *I think we took it a bit too seriously, that each team would be cross-functional and able to deal with any task, and I think that somehow took the edge off the expertise we had. What we lost was a feeling of ownership, "this part is mine, I know exactly how it functions and if there are any problems I can easily solve them," (Line manager, CWU, MedTech)*

One way of addressing the problem was to abandon the idea that all teams would be able to deal with most assignments, and instead develop teams with certain profiles or specializations, particularly within strategically important areas. Two such examples concerns server specialists and 3D visualization software specialists:

> *We're taking steps toward giving the teams more distinct knowledge profiles. For example, we have one team which is constituted by a bunch of senior backbone people [server specialists], simply because that's an area where the problems are often tricky and it's very important for the robustness and standard of our products to have the same people dealing with these issues all the time, people*

who know that they know what happens if they make a mistake and they know how it should work. (Line manager, SGD, MedTech)

We have one team that only works with 3D visualization, which has a strong profile in that respect. The members in this team are very similar – they have an interest in client programming […]. They think it's fun with 3D, which also involves a lot of mathematics, so they have that competence. […] They have been allocated in other teams before, but we have now chosen to focus more on 3D software, not only as any part of our product portfolio, but we want to give it an extra push. And therefore we have separated a special team that only focuses on this area in order to get continuity and with that a power to actually get things to happen more quickly. (Line manager CWU, MedTech)

A second way of addressing the risk with loosing depth is to secure that the teams have access to senior specialists within various knowledge areas. This was done by the establishment of a central team called "cross-team support team".

The cross-team support team consists of people with extensive experience and includes an expert on work processes, an expert on design architecture, a usability expert, an expert on server and database testing, and a test coach. The team is considered to be a resource to call upon when needed by the cross-functional teams, either to get an expert's view on a tricky problem, or if someone on the team is absent. Overall, the experts on the cross-team support team are expected to work 50% with the cross-functional teams, sometimes being co-located with the team and sometimes not, while 50% of their time should be allocated to improving operations and making the cross-functional teams more efficient.

It has been up to them to decide how they're going about doing it. Some of them, of course, are working with process development, how we should change our ways of working to become more efficient, and they are out in the teams supporting them. It might be that they are co-located with a team or it might be that they are keeping an eye on them, emailing, or just passing by at the daily Scrum meeting or whatever they are doing. But to a certain extent, they are also involved in competence development: 'We feel that this team needs to learn these things, perhaps I can be the one who studies and prepares and then offers an internal course?' It differs. They might also buy a course from an external supplier. So, they interact quite a lot with these cross-functional teams and reflect

upon, "Shouldn't this person take this course?" and so on, but it's not their
primary aim. Their aim is to make us more efficient but of course, if you think
short term or long term, competence development is part of such work. (Line
manager, SGD, MedTech)

A third structural solution, which is applied at MedTech, is the career ladder for disciplinary specialists. Senior specialists are appointed, not by the managers but by colleagues who nominate and vote for candidates. Those who get a certain number of nominations and votes are then appointed for a period of four years, during which they get a salary increase and better opportunities for competence development. . They still did most of their work in the interdisciplinary teams, albeit with more time allocated for undertaking studies and development activities on their own. After the period of four years, they can be reappointed. The line manager at SGD describes some of the additional favors granted to the senior specialists:

If you become a senior specialist, then you get a lot of things. You get to
participate at conferences and you get a week each year, Senior's week, when you
can do whatever you want to—trying something out, testing something, or just
playing around. And then, afterwards, maybe it turns into something useful. (Line
Manager, SGD, MedTech)

ANALYSIS: EXPERT STRUCTURES FOR DISCIPLINARY LEADERSHIP OR COMMUNITY

The three case studies show that the dilemma of sustaining and developing disciplinary expertise while relying on interdisciplinary project teams for knowledge integration is a highly relevant topic that engages managers as well as individual experts. The risks that come with dispersing disciplinary peers and over-emphazising cross-learning within the interdisciplinary teams were in many ways living discussion topics in all the organizations, but with some differences in approaches and solutions.

The analysis revealed that the most prominent structural solution implemented to deal with issues regarding disciplinary expertise was the establishment of expert structures for a limited number of individuals within particular disciplinary domains. Experts belonging to such structures participated less in interdisciplinary project teams, and focused more on maintenance and development of a particular disciplinary expertise by keeping up to date with the recent developments within their respective domain and supporting the project teams with their expertise when needed. However, the empirical study revealed that the expert structures

could have quite different character and fulfil different purposes. Two distinct forms of expert structure solutions were identified; one form that uses the expert structures to enhance *disciplinary leadership* and one that uses them to establish *disciplinary community*.

Expert structures for disciplinary leadership

At Software Inc. and MedTech, experts were appointed and expert units were established with the main purpose of securing disciplinary leadership within core disciplinary domains. At Software Inc., the "technical management office" included individuals from different disciplinary domains that had been assigned the title of specialist. Their responsibilities included working with technology strategies, pre-studies and analyses, but also working with training and education of their disciplinary peers, as well as coaching and trouble-shooting when needed in the project teams. At MedTech, the "cross-team support team" was made up by experts within separate disciplinary domains and served as a resource to be called upon when needed by the project teams. Even though these experts actually did not have a formal responsibility for their respective knowledge domain and its development, most of them assumed such a responsibility on their own initiative.

At MedTech, another example of an expert structure for disciplinary leadership was the temporary positions as senior specialists. These senior specialists got more opportunities for own competence development during a limited period of time. They still did most of their work in the interdisciplinary teams, albeit with more time allocated for undertaking studies on their own, conferences and courses, and a week every year when they were free to work with anything they wanted in order to try out new ideas.

In the following, the potential of expert structures for disciplinary leadership to sustain and develop disciplinary expertise will be further examined based on their focus on knowledge, knowing and/or contextualizing.

Firstly, these disciplinary leaders get an increased opportunity to participate in courses and conferences, learning about new models and theories, and getting updated on the development within the field. Hence, this structure most likely supports the development of *knowledge*, particularly when it comes to the appointed individuals who get increased opportunities for individual development. Moreover, the disciplinary leaders disseminate knowledge among their disciplinary peers, so these structures might also support the development of knowledge within the knowledge domain beyond the individual disciplinary leaders.

Secondly, the disciplinary leadership is to some extent done on the expense of day-to-day practice in knowledge integration processes in the teams, which could have an impact on the development of *knowing*. However, in the cases presented here, the disciplinary leaders maintained a considerable share of practice, particularly by supporting their peers in the project teams. This provided a continuous opportunity for the disciplinary leaders to collaborate with disciplinary peers, which, drawing on Grabher (2004), is crucial for the continuous upgrading of skills and specific know-how (see also Brown and Duguid, 1991). Thus, the structures for disciplinary leadership might actually increase collaboration among peers. Not primarily by increasing the collaboration among all members in the disciplinary domain, but at least between the disciplinary leader and other peers. This could also make the disciplinary leader a central figure in sharing and passing on "stories" and experiences among the dispersed members within the domain (cf. Brown and Duguid, 1991), and thereby support the knowing dimension of disciplinary expertise.

Finally, expert structures for disciplinary leadership most likely do not substantially influence the *contextualizing* abilities, and has no spelled out purpose to do so. To some extent, the disciplinary leaders are distanced from the work that is directly connected to products and markets. However, as seen in the cases, their own studies are often driven by certain products, clients or signals from the market.

Expert structures for disciplinary community

At Sentio, a new unit was established to enhance the collaboration and knowledge sharing among peers within a specific domain that was considered to be of strategic importance – image processing. Management feared that this discipline would erode if the experts on image processing were dispersed and co-located with interdisciplinary teams. Moreover, in comparison with other knowledge domains, image processing was more generic and less tied to the product or customer context, and had more to gain from collaboration among disciplinary peers. In a similar vein, at MedTech, teams with a particular profile were created, such as the server specialist team and the team for 3D visualization software. These knowledge areas were considered to be either key for the core functioning of the products, or a strategic development area. Therefore, employees with these competences were given the opportunity to further establish and develop their profile, in order to get continuity in common practices and to get a faster pace in the development with these areas. The primary aim of these types of expert structures at Sentio and MedTech was hence to build a stronger community among the members of a particular discipline.

The establishment of expert structures for disciplinary community hence implies identifying knowledge domains of particular strategic importance and hosting these in separate units with the aim of enhancing the collaboration among the disciplinary peers. These experts still contribute to interdisciplinary teams to a great extent, but the logic more resembles that of a balanced or matrix structure (Hobday, 2000) in which the same type of expertise is grouped in a line unit which make deliveries to projects. However, here the logic only applies to some disciplinary domains, while members of other disciplinary domains are organized in interdisciplinary teams.

The expert structures for disciplinary community identified in our case did not have the explicit purpose to develop *knowledge*. However, the structure most likely have the potential of developing and strengthening knowledge since the co-located disciplinary peers can easily communicate and interact with each other regarding the problems to be solved in the teams, changes in tools, methods, technology and other novelties within their domain of expertise.

Nevertheless, this type of expert structure can foremost be understood as supporting the development of *knowing*. By working together in problem-solving processes, the experts not only practice their disciplinary expertise; they practice it in collaboration with peers – both junior and senior – which gives an opportunity to observe, discuss and learn from each other's way of dealing with different situations and problems. As pointed out by Brown & Duguid (1991) this joint problem-solving makes the new insights constructed collectively within the community, rather than a private matter of an individual. Hence, such a structure enhances the opportunity for revealing and observing disciplinary knowing-in-action (cf. Schön, 1991), and thereby it has the potential to sustain and develop knowing within the disciplinary domain. Moreover, since the disciplinary peers also participate in interdisciplinary team work, they can bring in experiences from their different assignments, share stories, and over time build a "repository of accumulated wisdom" that Brown & Duguid (1991:45) refers to, and a shared understanding of common practices among the members of the disciplinary community.

With respect to *contextualizing*, this type of expert structure does not have any purpose to enhance such abilities, and it is hard to examine its potential. It might diminish the contextualizing abilities, since the members are less integrated in the interdisciplinary teamwork, which provides direct contact with the products and an insight into the context for the application of the products developed. However, since these experts collaborate within the disciplinary community in solving particular problems, most members are exposed to different products, different clients, etc. Borrowing Iansiti's model of "T-shaped skills"

(1995) as an illustration for contextualizing abilities, one might say that these experts probably grow the crossbar of the T, since they learn to apply their specialized knowledge in a variety of contexts. At the same time, they will probably not grow a deep "stem" regarding any specific context.

Table 1.1 below outlines the main characteristics for the two types of expert structures.

Table 1.1: Expert structures for disciplinary leadership or for disciplinary community – A comparison

	Solutions for disciplinary leadership	Solutions for disciplinary community
Aim	More effective and valuable use of the most skilled disciplinary specialists	Guarding a strategically important disciplinary domain
Members	The most skilled specialists	Peers from the same disciplinary domain
Function	Allocate time and opportunity for individual studies and competence development	Allocate time and opportunity for collaboration among peers.
	Provide expert support to the interdisciplinary teams and to disciplinary peers	Provide disciplinary expertise to the teams
	Enhance strategic knowledge development within the main disciplines	Enhance knowledge sharing and "story-telling" among disciplinary peers
	Recognition of skilled co-workers	Recognition of certain disciplinary domains as holding a strategically important expertise
	Career opportunity: Motivation for individuals to sustain and develop their disciplinary expertise	Arena for development of knowledge, continuity and common practices development within a certain

		strategically important discipline
Element in disciplinary expertise	Supports primarily Knowledge, and to some extent Knowing	Supports primarily Knowing, and to some extent Knowledge.

CONCLUDING REMARKS

This paper has identified the establishment of expert structures as a complement to interdisciplinary project team structures as one way of sustaining and developing disciplinary expertise in the long-run. Such expert structures decrease certain individuals' involvement in interdisciplinary teamwork in favor for an increased focus on the disciplinary expertise. Furthermore, the study identifies two types of expert structures:

Expert structures for disciplinary leadership include appointed "experts" within key disciplinary domains, which assume disciplinary leadership in that they drive the development within the domain and disseminate knowledge and knowing among the dispersed disciplinary peers. In this paper, it is suggested that such structures has the potential to sustain and develop disciplinary expertise in that they support knowledge and to some extent knowing. Since such structures are foremost directed towards a limited group of disciplinary experts, they need to integrate practices for knowledge sharing among experts and disciplinary peers in the interdisciplinary teams in order for them to sustain and develop disciplinary expertise across the whole disciplinary domain.

Expert structures for disciplinary community, in contrast, include members of a disciplinary domain that is identified as strategically important, and that runs the risk of erosion if the members are dispersed without continuous collaboration among each other. Such structures, we suggest, has the potential to sustain and develop disciplinary expertise primarily in the knowing dimension. Nevertheless, also this solution is limited to a particular group of disciplinary experts. Other solutions might be needed to sustain and develop expertise within other disciplinary domains.

More research is also needed to substantiate and develop the findings of this study, for example by further examining the long-term effects of these structural solutions on disciplinary expertise. Also, the empirical findings in presented here includes one case, MedTech, which had a higher variety of structural solutions in place, in comparison to the

others. MedTech had implemented expert structures for disciplinary leadership as well as for disciplinary community which, we argue, would give them better opportunities to sustain and develop disciplinary expertise over time. This since their combination of solutions supports more than one element of disciplinary expertise. However, since this study cannot draw any conclusions regarding the performance and success of the cases regarding sustaining and developing disciplinary expertise over time, the potential strength in strategically combining organizational solutions for this purpose can only be speculated about at this stage. Additional research, with a longitudinal approach, is needed to substantiate this argument.

Nevertheless, the conceptualization of expert structures for disciplinary leadership or community developed in this paper contributes to furthering the understanding of organizational aspects influencing knowledge integration processes on a micro-level, and how complementary structures might create ways to address the dilemma of sustaining disciplinary expertise while relying on interdisciplinary teamwork for knowledge integration.

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